Protection and control

Sepam range

Sepam 2000

Metering and protection functions

Merlin Gerin
Modicon
Square D
Telemecanique

Schneider Electric

Contents

Notation

■ Sepam 2000 may include several current signal acquisition boards or several voltage signal acquisition boards.

The currents, voltages and frequency related to the first acquisition board are noted **I** for current, **V** for phase voltages, **U** for system voltages and **F** for frequency.

The currents, voltages and frequency related to the second acquisition board are noted **I'** for current, **V'** for phase voltages, **U'** for system voltages and **F'** for frequency.

Example :
metering function: phase current
□ I1, I2 and I3 are the currents connected to the first current acquisition board,
□ I'1, I'2 and I'3 are the currents connected to the second current acquisition board.

■ Sepam 2000 may include several times the same function:
□ X is the identification number of a function which uses the signals acquired by the first acquisition board,
□ Y is the identification number of a function which uses the signals acquired by the second acquisition board.

Example :
protection function: phase overcurrent
□ F01X, $1 \leqslant X \leqslant 6$ means that F011, F012, F013, F014, F015 and F016 are the 6 modules which perform the overcurrent function for phases I1, I2 and I3 acquired by the first current acquisition board.
□ F02Y, $1 \leqslant Y \leqslant 2$ means that F021, F022, are the 2 modules which perform the overcurrent function for phases I'1, I'2 and I'3 acquired by the second current acquisition board.

■ In the rest of the document, the term "**pocket terminal**" refers to any terminal that can be connected to 9-pin sub-D plug on the front of Sepam 2000, namely:
□ TSM 2001 or PC equipped with the SFT 2801 software program for measurement display,
□ TSM 2001 or PC equipped with either the SFT 2801 or SFT 2821 software program for protection setting.

Contents
Metering functions

Phase current

Operation

This function gives the phase current rms values:
- I1 : phase 1 current,
- I2 : phase 2 current,
- I3 : phase 3 current,
- I1' : phase 1 current,
- I2' : phase 2 current,
- I3' : phase 3 current.

It is based on measurement of the fundamental component.

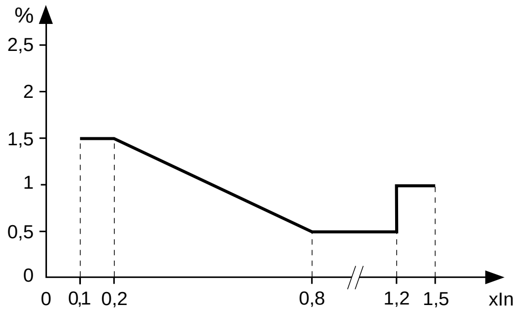
Readout

The measurements may be accessed via:
- the display unit by pressing the **A** key,
- the pocket terminal, **metering** menu, **I phase** heading,
- the communication link.

Characteristics

measurement range	0.015 In to 24 In [1]
unit	A or kA
accuracy [2]	±0.5% or ±1 digit
display unit and pocket terminal format	3 significant digits
refresh interval	1 second (typical)

[1] In rated current set in the **status** menu.
[2] at In, in reference conditions (IEC 60255-6).



Accuracy according to the measurement range

Sensors

This measurement is related to the currents in the circuits that are connected to the following connectors:

Measurement of currents I1, I2, I3

sensor	connector
CT	2B
CSP	2L1, 2L2, 2L3

Measurement of currents I1', I2', I3'

sensor	connector
TC	3B
CSP	3L1, 3L2, 3L3

Maximum demand phase currents

Operation

This function gives the greatest average rms current value for each phase that has been obtained since the last reset.
It is based on measurement of the fundamental component.
The average is refreshed after each “integration interval”.
The integration interval is set using the pocket terminal, **status** menu, **max. demand interv.** heading, IM1, IM2, IM3.

Readout

The measurements may be accessed via:
- the display unit by pressing the **A** key,
- the pocket terminal, **metering** menu, **max. current demand** heading,
- the communication link.

Resetting to zero:
- press the **clear** key on the display unit when a max. demand current is displayed,
- press the **clear** key on the pocket terminal when a max. demand is displayed,
- via program logic coil K851.

The value is saved in the event of a power supply failure.

Characteristics

measurement range	0.015 In to 24 In (1)
unit	A or kA
accuracy (2)	±0.5% or ±1 digit
resolution	0.1 A
display unit and pocket terminal format	3 significant digits
integration interval	5, 10, 15, 30, 60 minutes

(1) In rated current set in the **status** menu.
(2) at In, in reference conditions (IEC 60255-6).

Sensors

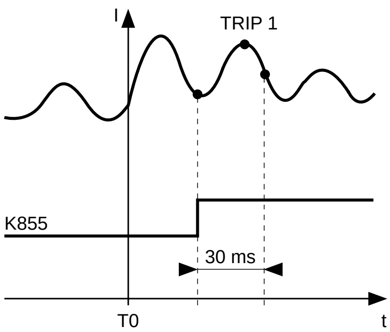
This measurement is related to the currents in the circuits that are connected to following connectors:

sensor	connector
CT	2B
CSP	2L1, 2L2, 2L3

Tripping currents

Operation

This function gives the rms value of currents at the prospective tripping time:
■ TRIP1: phase 1 current,
■ TRIP2: phase 2 current,
■ TRIP3: phase 3 current,
■ TRIP0: residual current.
It is based on measurement of the fundamental component.



This measurement is defined as the maximum rms value measured during an interval of 30 ms following activation of the K855 coil.

Readout

The measurements may be accessed via:
■ the display unit by pressing the **A** key,
■ the pocket terminal, **metering** menu, **tripping current** heading,
■ the communication link.

Resetting to zero:
■ press the **clear** key on the display unit when a TRIP value is displayed,
■ press the **clear** key on the pocket terminal when a TRIP value is displayed,
■ the communication link,
■ via program logic coil K856.

The value is saved in the event of a power supply failure.

Characteristics

measurement range (2)	phase current	0.015 In to 24 In (1)
	residual current	0.015 to 10 Ino (1)
accuracy		±5% or ±1 digit
display unit and pocket terminal format		3 significant digits
resolution		0.1 A
unit		A or kA

(1) In, Ino rated current set in the **status** menu.
(2) the display unit indicates **>** when the current is greater than the measurement range.

Sensors

This measurement is related to the currents in the circuits that are connected to following connectors:

Phase current

sensor	connector
CT	2B
CSP	2L1, 2L2, 2L3

Residual current

sensor	connector
CT	2B
CSH	2A
CT + CSH30	2A
CSP	2L1, 2L2, 2L3

Residual current

Operation

This operation gives the residual current rms value
$(\vec{I1} + \vec{I2} + \vec{I3})$:
- Io: residual current on connector 2,
- Io': residual current on connector 3,
- Io": residual current on connector 4.

It is based on measurement of the fundamental component.

Readout

These measurements may be accessed via:
- the pocket terminal, **add. reading** menu, **I residual**, **I' residual**, **I" residual** heading,
- the communication link.

Characteristics

measurement range	connection to 3 phase CTs:		0.05 In to 10 In (1)
	connection to core balance CT		
		2 A rating input	0.1 to 20 A
		30 A rating input	1.5 to 300 A
	connection to 1 CT with CSH30 interposing ring CT		0.015 to 10 Ino (1)
	connection to core balance CT with ACE 990 interface		0.015 to 10 Ino (1)
unit		A or kA	
accuracy (2)		±5% or ±1 digit	
display unit and pocket terminal format		3 significant digits	
resolution		0.1 A	
refresh interval		1 second (typical)	

(1) In, Ino rated current set in the **status** menu.
(2) in reference conditions (IEC 60255-6).

Sensors

This measurement is related to the currents in the circuits that are connected to the following connectors, according to the settings of the related SW1 microswitches:

Measurement of current Io

sensor	connector
CT	2B
CSP	2L1, 2L2, 2L3
CSH	2A
CT + CSH30	2A
core bal. CT + ACE 990	2A

Measurement of current Io'

sensor	connector
CT	3B
CSP	3L1, 3L2, 3L3
CSH	3A
CT + CSH30	3A
core bal. CT + ACE 990	3A

Measurement of current Io"

sensor	connector
CT	3B
CSH	4A
CT + CSH30	4A
core bal. CT + ACE 990	4A

* available as of version 9940 SFT2800.

Phase-neutral and phase-to-phase voltages

Operation

This function gives the rms value of:
- ■ phase-to-neutral and phase-to-phase voltages on connector 3 or 4 according to the Sepam model:
  - □ U21 voltage between phases 2 and 1,
  - □ U32 voltage between phases 3 and 2,
  - □ U13 voltage between phases 1 and 3,
  - □ V1 phase 1 phase-to-neutral voltage,
  - □ V2 phase 2 phase-to-neutral voltage,
  - □ V3 phase 3 phase-to-neutral voltage.
- ■ phase-to-neutral and phase-to-phase voltages on connector 4 of Sepam 2000 S26 and S46:
  - □ U21' voltage between phases 2 and 1,
  - □ U32' voltage between phases 3 and 2,
  - □ U13' voltage between phases 1 and 3,
  - □ V1' phase 1 phase-to-neutral voltage,
  - □ V2' phase 2 phase-to-neutral voltage,
  - □ V3' phase 3 phase-to-neutral voltage.

For Sepam S26, only the U21 and U22 voltages are measured and the U13 voltage is obtained by taking the vector sum. The phase-to-neutral voltages are obtained by the vector sum, taking into account the residual voltage.

For Sepam S36, all the phase-to-phase voltages are measured. The phase-to-neutral voltages are obtained by the vector sum, taking into account the residual voltage.

For Sepam S46, the phase-to-phase voltages are calculated according to the phase-to-neutral voltages V1, V2 and V3.

Readout

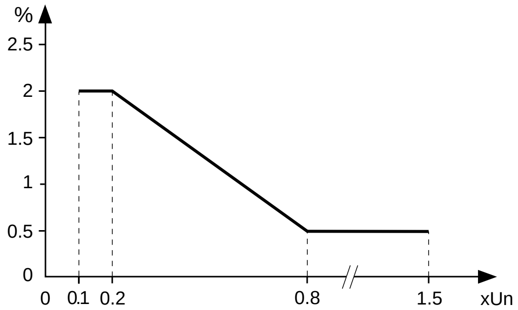
The measurements may be accessed via:
- ■ the display unit by pressing the **V** key,
- ■ the pocket terminal, **metering** menu, **U and V phase reading**,
- ■ the communication link.

If there is only one sensor (phase-to-neutral or phase-to-phase voltage), the function gives only the rms values of one phase-to-phase voltage U and one phase-to-neutral voltage V.

Characteristics

measurement range			
	phase-to-phase voltages	0.015 Un to 1.5 Un (1)	
	phase-to-neutral voltages	S26/S36**	0.015 Un to 1.5 Un (1)
		S46	0.015 Vn to 1.5 Vn (3)
unit			V or kV
accuracy (2)			±0.5% or ±1 digit
display unit and pocket terminal format			3 significant digits
resolution			1 V
refresh interval			1 second (typical)

(1) Un nominal rating set in the **status** menu.
(2) at Un in reference conditions (IEC 60255-6).
(3) Vn nominal rating set in the **status** menu.



Accuracy according to the measurement range.

Sensors

This measurement is related to the voltages in the circuits that are connected to the following connectors:

Measurement of voltages V1, V2, V3, U21, U32, U13

Sepam	connector
S36*	4A (1)
S26*	3A
S46	3 A

(1) 3A connector for S36*TR and S36TS models.

Measurement of voltages V1', V2', V3', U21', U32', U13'

Sepam	connector
S36*TR	4A
S36TS	4A

If there is only one sensor (phase-to-neutral or phase-to-phase voltage), the voltage signal is connected to terminals 4 and 5 of the connector, whatever the phase.

* S35, S25 for earlier versions.
** available as of version 9940 SFT2800.

Frequency

Operation

This function gives the frequency value.

Frequency is measured via the following:
■ U21, if only one phase-to-phase voltage is wired to the Sepam 2000,
■ positive sequence voltage, if the Sepam 2000 includes U21 and U32 measurements, in which case the number of phase-to-phase voltage set in the **VT ratio** heading of the **status** menu should be 3U,
■ based on phase-to-neutral voltage for the Sepam S46.

Frequency is not measured if:
■ the voltage U21 or V is less than 38 V on the VT secondary windings (when VT number is other than 3U),
■ the voltage U21 or V is less than 20 V on the VT secondary windings (when VT number is equal to 3U),
■ the frequency is outside the measurement range.

Readout

The measurements may be accessed via:
■ the display unit by pressing the **V/Hz** key,
■ the pocket terminal, **metering** menu, **frequency** heading,
■ the communication link.

Characteristics

rated frequency		50 Hz, 60 Hz
measurement range	50 Hz	45 Hz to 55 Hz
	60 Hz	55 Hz to 65 Hz
accuracy (1)		±0.02 Hz
display unit and pocket terminal format		4 significant digits
resolution		0,01 Hz
refresh interval		1 second (typical)

(1) at Un in reference conditions (IEC 60255-6).

Sensors

This measurement is related to the currents in the circuits that are connected to the following connector:

Sepam	connector
S36*	4A (1)
S26*	3A
S46	3A

(1) 3A connector for S36*TR and S36TS models.

Real/reactive power and power factor

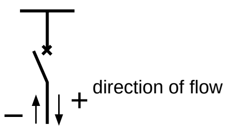
Operation

This function gives the power and power factor values:
■ P real power = $\sqrt{3}$ U.I.cos φ,
■ Q reactive power = $\sqrt{3}$ U.I.sin φ,
■ power factor (pf. or cos φ).
It is based on measurement of the fundamental component.

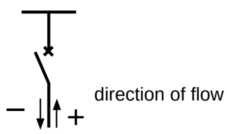
Real and reactive power
This function measures the real and reactive power in 3-wire 3-phase arrangements by means of the “two wattmeter” method. The powers are obtained from phase-to-phase voltage U21 and U32 and phase currents I1 and I3.

Whether the system is balanced or unbalanced, the power is calculated as follows:
P = U21.I1.cos(U21,I1) - U32.I3.cos(U32,I3)
Q = U21.I1.sin(U21,I1) - U32.I3.sin(U32,I3).

When only one voltage is connected, U21 or V, P and Q are calculated assuming that the phase-to-phase voltage is balanced.
The sign of the measurement indicates the direction of the flow of power.
According to standard practice, it is considered that:
■ for the outgoing circuit [(1)]:
□ power consumed by the feeder is positive,
□ power supplied to the busbar is negative.

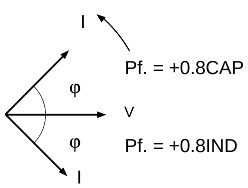


■ for the incoming circuit [(1)]:
□ power supplied to the busbar is positive,
□ power consumed by the incomer is negative.

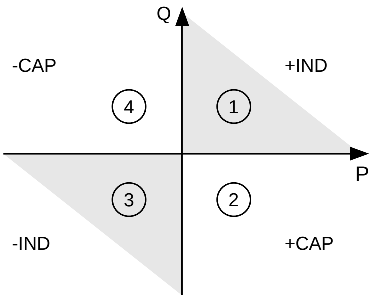


[(1)] choice to be made using the pocket terminal, **status** menu, **power flow sense**.

Power factor (PF)
The power factor is defined by:
pf. = $P/\sqrt{(P^2 + Q^2)}$
It expresses the phase unbalance between the phase currents and phase voltages.



where I = phase current,
V = phase-to-neutral voltage,
φ = delay of I with respect to V.

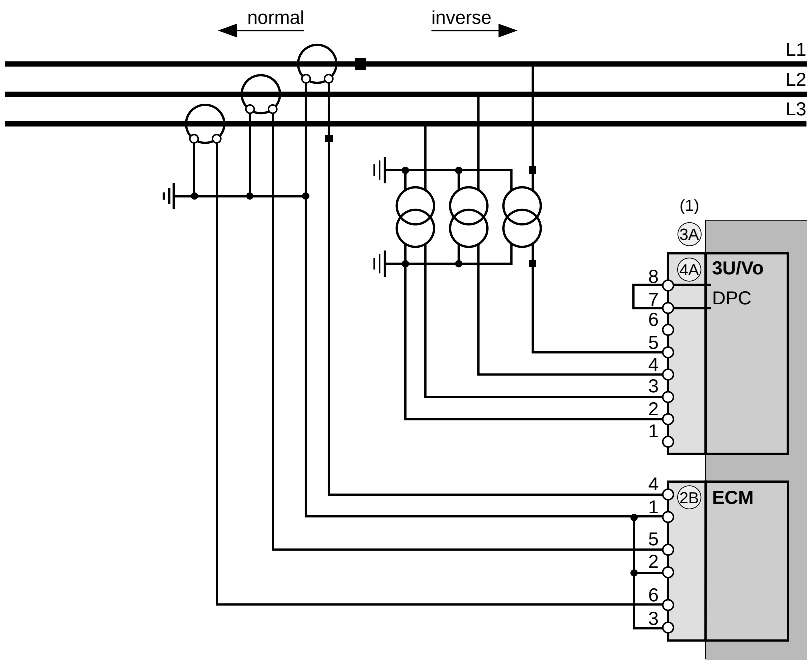


The + and - signs and **IND** (inductive) and **CAP** (capacitive) indications give the direction of power flow and the type of load.

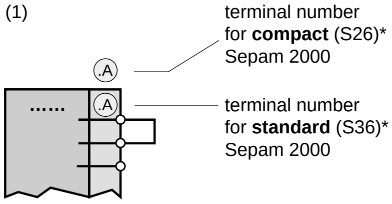
Readout

The measurements may be accessed via:
■ the display unit by pressing the **W** key,
■ the pocket terminal, **metering** menu, **power & power factor** heading,
■ the communication link.

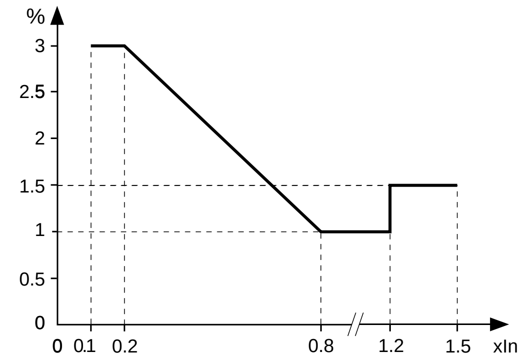
Please note:
the direction information is in accordance with the following wiring diagram:



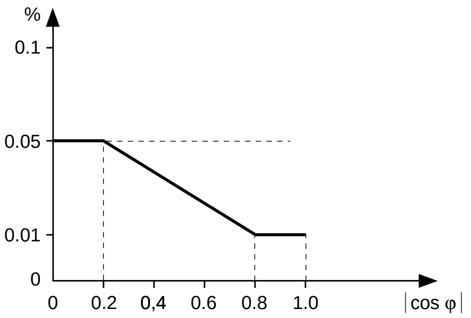
(1)



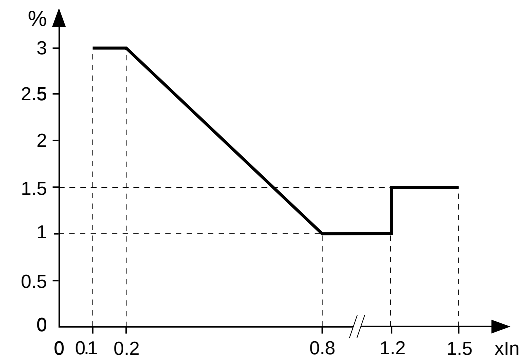
Please note: refer to the installation document for other arrangements.
* or S35, S25 for earlier versions.



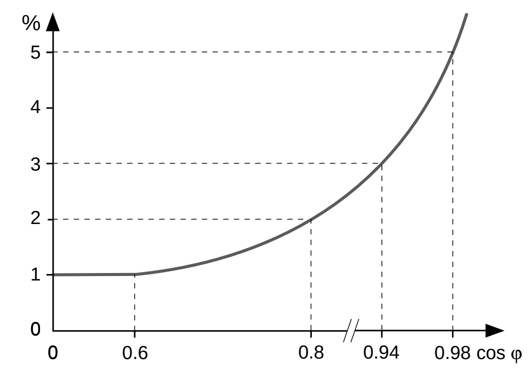
Real power function accuracy according to the current measurement range for Pf. > 0.8.



Accuracy of the Pf. measurement.



Reactive power function accuracy according to the current measurement range for Pf. < 0,6.



Reactive power function accuracy according to the current measurement range for Pf. and for current between 0.8 In and 1.2 In.

* or S35, S25 for earlier versions.

Characteristics

power	**real**	**reactive**
range [2]	1.5% Sn to 999 MW	1.5% Sn to 999 MVAr with Sn = $\sqrt{3}$. Un . In
accuracy [1]	±1% or ±1 digit (see curves)	
display unit and pocket terminal format	3 significant digits	
resolution	1 W	1 VAr
refresh interval	< 0.5 seconds	
related logic contacts	K831 = 1 if P $\geq$ 0 K831 = 0 if P < 0	K832 = 1 if Q $\geq$ 0 K832 = 0 if Q < 0
Pf.		
range	-1 to 1 IND/CAP	
accuracy [1]	0.01	
display unit and pocket terminal format	3 significant digits	
refresh interval	< 0.5 seconds (typical)	
related logic contacts	K833 = 1, if the system is inductive K833 = 0, if the system is capacitive K834 = 1, if Pf. ⩾ 0 K834 = 0, if Pf. < 0	

[1] at In, Un and at p.f. > 0.8, in reference conditions (IEC 60255-6)
[2] resolution 1 W, 1 VAr.

Sensors

These measurements are related to the circuits connected to the following connectors:

CT Sepam	current connector	voltage connector
S36*	2B	4A [1]
S26*	2B	3A
S46	2B	3A

CSP Sepam	current connector	voltage connector
S36*	2L1,2L2, 2L3	4A [1]
S26*	2L1,2L2, 2L3	3A

[1] 3A connector for S36*TR and S36TS models.

Maximum demand real and reactive power

Operation

This function gives the greatest average real or reactive power value obtained since the last reset. It is based on measurement of the fundamental component.

The time it takes to calculate the average, which is also called the integration interval, is set using the pocket terminal, **status** menu, **max. demand interv.** heading.

Characteristics

power	real	reactive
range	1.5% Sn to 999 MW	1.5% Sn to 999 MVAr (1)
accuracy	see power measurements	
display unit and pocket terminal format	3 significant digits	
integration interval	5, 10, 15, 30, 60 minutes	

(1) Sn = $\sqrt{3}$ Un.In.

Readout

The measurements may be accessed via:
■ the display unit by pressing the **W** key,
■ the pocket terminal, **metering** menu, **max. power demand** heading,
■ the communication link.

The peak demand values are saved in the event of a DC power failure.

Resetting to zero:
■ press the **clear** key on the pocket terminal if peak demands are displayed,
■ press the **clear** key on the display unit if at least one peak demand is displayed,
■ set the control logic coil K852 to 1.

Sensors

These measurements are related to the circuits connected to the following connectors:

CT Sepam	current connector	voltage connector
S36*	2B	4A (1)
S26*	2B	3A
S46	2B	3A

CSP Sepam	current connector	voltage connector
S36*	2L1, 2L2, 2L3	4A (1)
S26*	2L1, 2L2, 2L3	3A

(1) 3A connector for S36*TR and S36TS models.

* or S35, S25 for earlier versions.

Accumulated real/reactive energy

Operation

This function gives the real and reactive energy values:
■ accumulated energy conveyed in one direction,
■ accumulated energy conveyed in the other direction.
It is based on measurement of the fundamental component.

The accumulated energy values are saved in the event of a power failure.

Readout

The measurements may be accessed via:
■ the display unit by pressing the **Wh** key,
■ the pocket terminal, **metering** menu, **energy meter** heading,
■ the communication link.

To reset the accumulated energy values to zero, the cartridge needs to be reprogrammed.

Characteristics

power	real	reactive
counting capacity	2.8×10^8 MWh	2.8×10^8 MVArh [2]
display capacity: pocket terminal display unit	 2.8×10^8 MWh 99999.99 MWh	 2.8×10^8 MVArh 99999.99 MVArh
resolution	0.01 MWh	
accuracy [1]	±1% or ±1 digit	

[1] at In, Un and at Pf. > 0.8, in reference conditions (IEC 60255-6)
[2] Sn = $\sqrt{3}$ Un.In.

Sensors

These measurements are related to the circuits connected to the following connectors:

CT Sepam	current connector	voltage connector
S36*	2B	4A [1]
S26*	2B	3A
S46	2B	3A

CSP Sepam	current connector	voltage connector
S36*	2L1, 2L2, 2L3	4A [1]
S26*	2L1, 2L2, 2L3	3A

[1] 3A connector for S36*TR and S36TS models.

* or S35, S25 for earlier versions.

Temperature

Operation

This function gives the temperature value measured by RTDs (Pt100 platinum probe, 100 Ω at 0 °C) in accordance with the IEC 751 and DIN 43760 standards.

Each RTD channel gives one measurement:
tx = RTD temperature.

The function also indicates RTD faults (RTD disconnected or shorted):
■ ***/*** in the case of a disconnected RTD (or a temperature greater than 302 °C ±27 °C),
■ ******** in the case of a shorted RTD (or a temperature less than -70 °C ±10 °C).

Readout

The measurements may be accessed via:
■ the display unit by pressing the **Wh** key,
■ the pocket terminal, **metering** menu, **temperature** and **add. temperature** heading.
■ the communication link.

Characteristics

range	-50°C to 250°C
accuracy	±1°C
resolution	1°C
refresh interval	3 seconds (typical)

Accuracy derating according to wiring
■ Connection in 3-wire mode: the error Δt is proportional to the length of the wire and inversely proportional to the wire cross-section:

$$\Delta t\ (°C) = 2 \times \frac{l\ (km)}{S\ (mm^2)}$$

□ ±2.1°C/km for a cross-section of 0.93 mm^2,
□ ±1°C/km for a cross-section of 1.92 mm^2,

■ Connection in 2-wire mode: wiring resistance compensation is not ensured in this mode. This creates the following error:

$$\Delta t\ (°C) = 100 \times \frac{l\ (km)}{S\ (mm^2)}$$

Sensors

These measurements are related to the RTDs connected to the following connectors:

Sepam	connector	connector
S26* LS	3A	—
S36* LS S36* KZ	— —	8A 8A
S36* SS	3A	8A
S36* SR	3A	—
S36* ZR	3A	—
S36TS	—	8A
S46 ZR	3A	—
S46 ZM	3A	—

* or S35, S25 for earlier versions.

Residual voltage

Operation

This function gives residual voltage value
$(\vec{V1} + \vec{V2} + \vec{V3})$. It is measured by taking the internal sum of the 3 phase voltages or by a star / open delta VT.
Vo = residual voltage
Vo' = residual voltage.
It is based on measurement of the fundamental component.

Readout

This measurement may be accessed via:
■ the pocket terminal, **add. reading** menu, **V residual**, **V' residual** heading,
■ the communication link.

Characteristics

measurement range	0.015 Un to $\sqrt{3}$ Un
unit	V or kV
accuracy	±5% or ±1 digit
display unit and pocket terminal format	3 significant digits
resolution	1 V
refresh interval	1 second (typical)

Sensors

This function is related to the voltages connected to the following connectors:

Measurement of voltage Vo

Sepam	connector
S36*	4A (1)
S26*	3A

(1) 3A connector for S36*TR and S36TS models

Measurement of voltage Vo'

Sepam	connector
S36*TR	4A
S36TS	4A

* or S35, S25 for earlier versions.
** available as of version 9940 SFT2800.

Starting current and time

Operation

This function indicates the value of a current peak (Imax) and its duration (Tstart). It is based on measurement of the fundamental component.

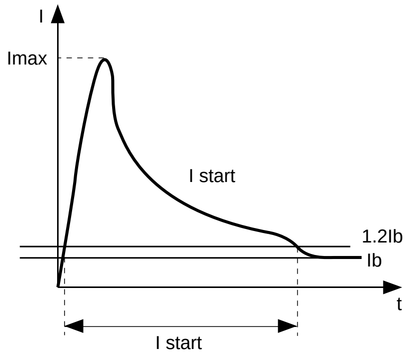
Current measurement with a quick refresh interval (Istart) enables the user to view current development during the starting phase.

The function is used especially for motor protection commissioning: it indicates the starting time and maximum rms value of the starting current.

The time Tstart is measured when the greatest of the three phase currents is greater than 1.2Ib.

Istart current is displayed whenever one of the three phase currents is greater than 1.2 Ib.

The Imax current value changes when the greatest of the three phase currents is greater than 1.2Ib.



Measurement of starting duration and current.

Readout

The starting time and current measurements may be accessed via the pocket terminal:

■ **add. reading** menu, **start current and time** heading.

Characteristics

Istart	
range	1.2 Ib to 24 In [(1)]
unit	A or kA
accuracy	±5% or ±1 digit
pocket terminal format	3 significant digits
sampling interval	50 ms (typical)
resolution	0.1 A or 1 digit
refresh interval	0.2 seconds (typical)
Tstart	
range	0.05 to 555 seconds
accuracy	±10% or 100 ms
pocket terminal format	3 significant digits
sampling interval	50 ms (typical)
resolution	10 ms or 1 digit
refresh interval	0.2 seconds (typical)

[(1)] Ib = base current.

Sensors

This measurement is related to the currents in the circuits that are connected to the following connectors:

sensor	connector
CT	2B
CSP	2L1, 2L2, 2L3

Cumulative breaking current and number of breaks

Operation

This function indicates the cumulative number of breaking operations and the cumulative breaking current in square kiloamperes $(kA)^2$ for five current ranges.
It is based on measurement of the fundamental component.

The current ranges are:
- 0 < I < 2In
- 2In < I < 5In
- 5In < I < 10In
- 10In < I < 24In
- I > 24In

The function also provides the total number of breaks and the cumulative total of breaking current in $(kA)^2$.

Refer to switchgear documentation for use of this information.
The function is activated by the control logic K855 coil.

Each value is saved in the event of a DC power failure.

Readout

The measurements may be accessed:
- via the pocket terminal, **add. reading** menu, **break. nb and (kA)²** heading.
- the communication link.

The cumulative values are reset by the **clear** button on the pocket terminal, in parameter setting mode, if the function is displayed.

Characteristics

number of breaks	
range	0 to 99999
(kA)²	
range	0 to 9999 $(kA)^2$
unit	primary $(kA)^2$
resolution	primary 0.0001 $(kA)^2$
pocket terminal format	significant digits
accuracy (1)	±10%

(1) at In, in reference conditions (IEC 60255-6).

Sensors

This measurement is related to the currents in the circuits that are connected to the following connectors:

sensor	connector
CT	2B
CSP	2L1, 2L2, 2L3

** available as of version 9940 SFT2800.

True rms current

Operation

This function gives the greatest of the following measurements:
■ rms value of the fundamental component of phase 1 current up to 24 In
■ rms value of phase 1 current up to 4 In, taking into account:
□ fundamental component,
□ harmonics.

Readout

This measurement may be accessed via:
■ the pocket terminal, **add. reading** menu, **Irms** heading.

Characteristics

true rms current I1 rms	
measurement range	0.015 In to 24 In
unit	primary A or kA
accuracy [1]	±1% or ±1 digit at Fn ±3% or ±1 digit for F < 1kHz
pocket terminal format	3 significant digits
taking into account harmonics	from 1st to 21st
resolution	0.1 A or 1 digit
refresh interval	1 second (typical)

[1] in reference conditions (IEC 60255-6).

Sensors

This function is related to the current of phase 1 connected to the following connectors:

sensor	**connector**
CT	2B
CSP	2L1

Differential current and through current

Operation

This function gives the rms value of the following currents:

■ differential currents Id of the 3 phases:
□ Id1 = I1 - I1'
□ Id2 = I2 - I2'
□ Id3 = I3 - I3'.

■ through currents It of the 3 phases:
□ $It1 = \frac{I1 + I1'}{2}$
□ $It2 = \frac{I1 + I1'}{2}$
□ $It3 = \frac{I1 + I1'}{2}$

It is based on measurement of the fundamental component. When combined with motor generator differential protection (ANSI code 87M/87G, function n° F621), this function gives the values of the differential currents and through currents for the 3 phases, measured and stored when the motor differential protection trips:
□ Trip Id1, Trip Id2, Trip Id3,
□ Trip It1, Trip It2, Trip It3.

Storage of the values is activated by the control logic K855 coil.

Readout

The measurements may be accessed via:
■ the pocket terminal, **add. reading** menu, **Idiff./Ithrough** heading.

The Trip Id and Trip It measurements are reset by:
■ the **clear** button on the pocket terminal,
■ the control logic K856 coil.

Characteristics

Id and It	
measurement range	0.015 In to 24 In [1]
unit	A or kA
accuracy [2]	±5% or ±1 digit
pocket terminal format	3 significant digits
resolution	0.1 A or 1 digit
refresh interval	1 second (typical)

[1] In nominal rating set in the **status** menu.
[2] at In, in reference conditions (IEC 60255-6).

Sensors

These measurements are related to the differential currents Id and through currents It of the I and I' currents connected to the following connectors:

sensor	connector	
	current I	current I'
CT	2B	3B

Disturbance recording

Operation

This function is used to record analog signals and logical states.

Record storage is initiated by the activation of the K865 coil by a triggering event.

The stored record begins before the triggering event and continues afterwards.

The duration of the signal recording before the triggering event may be adjusted via the pocket terminal, **status** menu, **disturbance recording** heading.

The record storage date may also bee accessed via the pocket terminal, **status** menu, **disturbance recording** heading and via the communication link (refer to "Jbus/Modbus communication" documentation). The date corresponds to the date of the triggering event.

The record comprises the following information:
■ values samples from the different signals,
■ date,
■ characteristics of the recorded channels.

The files are recorded in FIFO (First In First Out) shift storage: the oldest record is erased when a new record is triggered.

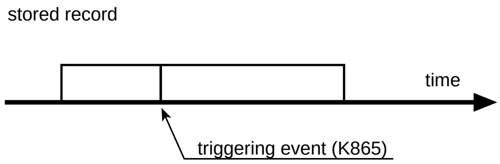
Transfer

Files may be transferred locally or remotely:
■ locally: using a PC which is connected to the pocket terminal connector and includes the SFT 2801 software package (version more recent than 9802),
■ remotely: using a software package specific to the remote monitoring and control system.

Display

The signals can be displayed from a record by means of the SFT 2826 software package.

Principle



Characteristics

record duration	86 periods
time before triggering event	adjustable from 1 to 85 periods*
record content	set-up file: date, channel characteristics, measuring transformer ratio data file: 12 values per period/recorded signal
analog signals recorded	4 to 12 according to the number of acquisition boards: 4 signals per current acquisition board 4 signals per voltage acquisition board for S36 3 signals per voltage acquisition board for S26 (U21, U32, Vo)
logical states recorded	16 logic inputs I11 to I18, I21 to I28 16 logic data items defined by program logic (Kfr1 to Kfr16)
number of stored records	2
file format	COMTRADE IEEE C37.111 - 1997 IEC 60255 - 24

Sensors

The disturbance recording function is related to the analog signals connected to the following connectors:

current	sensor	connector 2	connector 3	connector 4
	1 A or 5 A CT	2B	3B	4B
	CSH or CT + CSH30 or core bal. CT + ACE 990	2A	3A	4A
	CSP	2L1, 2L2, 2L3	3L1, 3L2, 3L3	—
voltage	**Sepam**	**connector 2**	**connector 3**	**connector 4**
	S36	—	—	4A
	S26	—	3A	—
	S36TR and S36TS	—	3A	4A

* value set to 6 periods for SFT2800 versions earlier than 9940.

Contents
Protection functions

Phase overcurrent

ANSI code	50-51	
function n°	F01X for phase overcurrent I1, I2, I3	 1 ≤ X ≤ 6
	F02Y for phase overcurrent I1', I2', I3'	 1 ≤ Y ≤ 2

Operation

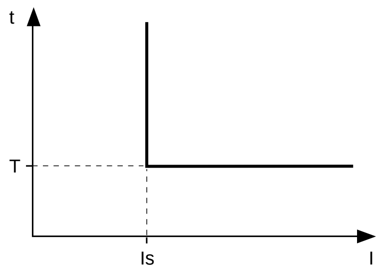
Phase overcurrent protection is three-pole.

It picks up when one, two or three of the currents reaches the set point. It is time-delayed.
The time delay may be definite (definite **DT**) or IDMT (standard inverse **SIT**, very inverse **VIT** or **LTI** [1], extremely inverse **EIT**, ultra inverse time **UIT**).
See curves in appendix.

[1] The very inverse time **VIT** delay setting range may be used to create **LTI** curves.

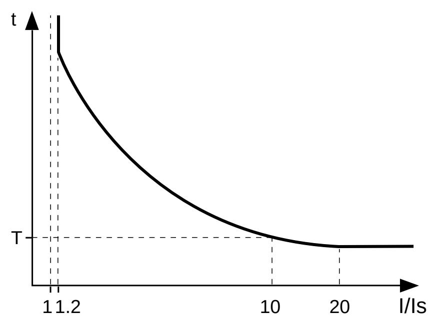
Logic data K859 = 1 may be used to inhibit start up of the time delay.
(regarding use, refer to "start-up of time delays" in appendix).

Definite time protection
Is is the set point expressed in Amps, and T is the protection time delay.



Definite time protection principle.

IDMT protection
IDMT protection operates in accordance with the IEC 60255-3 and BS 142 standards.



IDMT protection principle.

Is is the vertical asymptote of the curve, and T is the operation time delay for 10 Is.

The curve is defined according to the following equations:

■ standard inverse time **SIT**

$$t = \frac{0.14}{(I/Is)^{0.02}-1} \cdot \frac{T}{2.97}$$

■ very inverse time **VIT** or **LTI**

$$t = \frac{13.5}{(I/Is)-1} \cdot \frac{T}{1.5}$$

■ extremely inverse time **EIT**

$$t = \frac{80}{(I/Is)^{2}-1} \cdot \frac{T}{0.808}$$

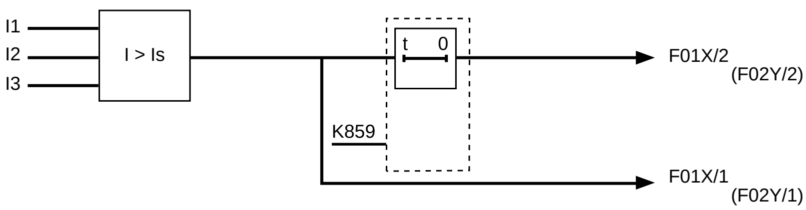
■ ultra inverse time **UIT**

$$t = \frac{315}{(I/Is)^{2.5}-1} \cdot T$$

The function also takes into account current variations during the time delay interval.

For currents with a very large amplitude, the protection has a definite time characteristic:
■ if I > 20 Is, tripping time is the time that corresponds to 20 Is,
■ if I > 24 In, tripping time is the time that corresponds to 24 In.

Block diagram



Commissioning, setting

Check:
■ the connections,
■ the positions of the microswitches SW2 associated with the current inputs,
■ the general parameters in the **status** menu.

Set the following:
■ type of time delay,
□ definite time **DT**,
□ IDMT: standard inverse time **SIT**,
very inverse time **VIT**, extremely inverse time **EIT**,
ultra inverse time **UIT**.
■ Is current: Is is set in rms, amps or kiloamps.
The 999 kA setting may be used to inhibit the protection: all the outputs are set to 0.
■ T time delay:
□ **DT**: T is the operation time delay,
□ **SIT**, **VIT**, **EIT**, **UIT**: T is the operation time delay at 10 Is.

Sensors

Phase overcurrent I1, I2, I3 protection is related to the currents connected to the following connectors:

current	sensor	connector
	1 A or 5 A CT	2B
	CSP	2L1, 2L2, 2L3

Phase overcurrent I1', I2', I3' protection is related to the currents connected to the following connectors:

current	sensor	connector
	1 A or 5 A CT	3B
	CSP	3L1, 3L2, 3L3

Characteristics

curve			
setting		definite, inverse, very inv., ext. Inv., ultra inv.	
Is set point			
setting	definite time	0.3 In ⩽ Is ⩽ 24 In expressed in amps	
	IDMT	0.3 In ⩽ Is ⩽ 2.4 In expressed in amps	
resolution		1 A or 1 digit	
accuracy [1]		±5%	
inhibition		999 kA	
drop out/pick-up ratio		93.5% ±5%	
T time delay			
setting	definite time	50 ms ⩽ T ⩽ 655 s	
	IDMT	100 ms ⩽ T ⩽ 12.5 s	
resolution		10 ms or 1 digit	
accuracy [1]	definite time	±2% or +25 ms	
	IDMT	class 5 or +25 ms	
		±12.5% at 2 Is ±7.5%, or from 0 to +25 ms at 5 Is ±5%, or from 0 to +25 ms at 10 Is ±5%, or from 0 to +25 ms at 20 Is	
characteristic times			
instantaneous tripping time		< 40 ms to 2 Is 30 ms (typical)	
time-delayed tripping time		according to time delay	
memory time		20 ms < t < 55 ms	
fault recognition time		< 25 ms	
reset time		< 70 ms	
outputs available for program logic			
instantaneous		F01X/1, F02Y/1 1 ⩽ X ⩽ 6 1 ⩽ Y ⩽ 2	
time-delayed		F01X/2, F02Y/2 1 ⩽ X ⩽ 6 1 ⩽ Y ⩽ 2	
remote reading and remote setting [2]			
function code F01, F02		01h and 02h	
identification number		X, Y [3]	
parameters		curve	unit: 0..4 [4]
(order of parameters)		Is set point	unit: A
		T time delay	unit: 10 x ms

(1) in reference conditions (IEC 60255-6).
(2) the data formats are defined in the manuals which describe each communication protocol.
(3) the number of protection function modules depends on the type of Sepam.
(4) meaning of curve index:
0: definite time,
1: inverse time,
2: very inverse time,
3: extremely inverse time,
4: ultra inverse time.

* function available as of version 9802 SFT2800.

Voltage restrained overcurrent

ANSI code	50V-51V	
function n°	F19X for voltage restrained overcurrent	
	I1, I2, I3	$1 \leqslant X \leqslant 2$
	F20Y for voltage restrained overcurrent	
	I1', I2', I3'	$1 \leqslant Y \leqslant 2$

Operation

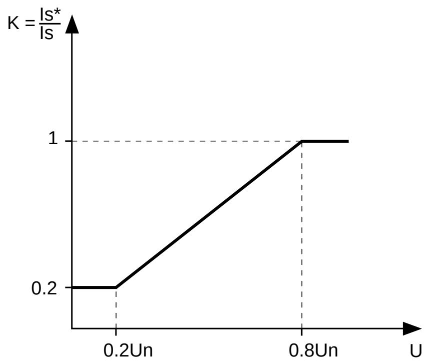
Voltage restrained overcurrent protection is three-phase.

It picks up when one, two or three of the currents reaches the voltage-adjusted set point Is*. It is time-delayed. The time delay may be definite (definite **DT**) or IDMT (standard inverse **SIT**, very inverse **VIT** or **LTI** (1), extremely inverse **EIT**, ultra inverse time **UIT**). See curves in appendix.

The set point is adjusted in accordance with the lowest measured system voltage.

The adjusted set point Is* is defined by the following equation:

$$Is^* = \left[4x\,\frac{U}{Un} - 0.2\right] x\,\frac{Is}{3}$$



Operation set point adjusted according to voltage.
(1) The very inverse time **VIT** delay setting range may be used to create **LTI** curves.

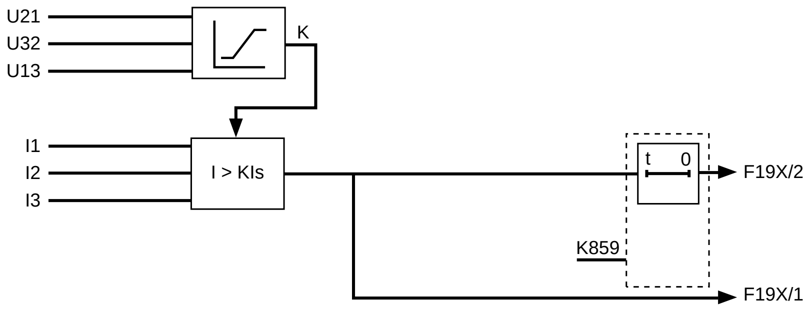
Logic data K859 = 1 may be used to inhibit start up of the time delay (regarding use, refer to “start-up of time delays” in appendix).

Definite time protection
Is is the set point expressed in Amps, and T is the protection time delay.

IDMT protection
IDMT protection operates in accordance with the IEC 60255-3 and BS 142 standards.

Is is the vertical asymptote of the curve, and T is the operation time delay for 10 Is.

Block diagram



Commissioning, setting

Check:
■ the connections,
■ the positions of the microswitches SW associated with the current and voltage inputs,
■ the general parameters in the **status** menu.

The number of voltages set up in the status menu, VT ratio heading must be different from V.

Set the following:
■ type of time delay,
□ definite time **DT**,
□ IDMT: standard inverse time **SIT**, very inverse time **VIT**, extremely inverse time **EIT**, ultra inverse time **UIT**.
■ Is current: Is is set in rms, amps or kiloamps. The 999 kA setting may be used to inhibit the protection: all the outputs are set to 0.
■ T time delay:
□ **DT**: T is the operation time delay,
□ **SIT**, **VIT**, **EIT**, **UIT**: T is the operation time delay at 10 Is.

Sensors

Voltage restrained overcurrent protection is related to the currents and voltages connected to the following connectors:

current	sensor	connector
	1A or 5A CT	2B
	CSP	2L1, 2L2, 2L3
voltage	**sensor**	**connector**
	S36*	4A [1]
	S26*	3A

[1] 3A connector for S36*TR and S36TS models.

Characteristics

curve			
setting	definite, inverse, very inv., ext. Inv., ultra inv.		
Is set point			
setting	definite time	0.5 In ⩽ Is ⩽ 24 In expressed in amps	
	IDMT	0.5 In ⩽ Is ⩽ 2.4 In expressed in amps	
resolution		1 A or 1 digit	
accuracy [1]		±5%	
inhibition		999 kA	
drop out/pick-up ratio		(93.5 ±5) %	
T time delay			
setting	definite time	50 ms ⩽ T ⩽ 655 s	
	IDMT	100 ms ⩽ T ⩽ 12.5 s	
resolution		10 ms or 1 digit	
accuracy [1]	definite time	±2% or ±25 ms	
	IDMT	class 5 or +25 ms (for U > 0.8 Un):	
		±12.5% at 2 Is ±7.5%, or from 0 to +25 ms at 5 Is ±5%, or from 0 to +25 ms at 10 Is ±5%, or from 0 to +25 ms at 20 Is	
characteristic times			
instantaneous tripping time		< 50 ms for I > 3 Is	
time-delayed tripping time		according to time delay	
memory time		50 ms < t < 95 ms	
fault recognition time		< 25 ms	
reset time		< 60 ms < t < 110 ms	
outputs available for program logic			
instantaneous		F19X/1 1 ⩽ X ⩽ 2	F20Y/1 1 ⩽ Y ⩽ 2
time-delayed		F19X/2 1 ⩽ X ⩽ 2	F20Y/2 1 ⩽ Y ⩽ 2
remote reading and remote setting [1]**			
function code F19, F20	19h and 20h		
identification number	X [2]		
parameters	curve	unit: 0..4 [3]	
(order of parameters)	Is set point	unit: A	
	T time delay	unit: 10 x ms	

[1] the data formats are defined in the manuals which describe each communication protocol.
[2] the number of protection function modules depends on the type of Sepam.
[3] meaning of curve index:
0: definite time,
1: inverse time,
2: very inverse time,
3: extremely inverse time,
4: ultra inverse time.
[4] in reference conditions (IEC 60255-6).

* or S35, S25 for earlier versions.
* * function available as of version 9802 SFT2800.

Directional phase overcurrent

ANSI code	67
function n°	F52X* $1 \leq X \leq 2$

Operation

Principle
This protection is three-phase. It includes a phase overcurrent function combined with direction detection. It picks up when the phase overcurrent function in the chosen direction (normal or inverse) is activated for at least one of the 3 phases.
It is time-delayed. The time delay may be definite (definite **DT**) or IDMT (standard inverse **SIT**, very inverse **VIT** or **LTI** (1), extremely inverse **EIT**, ultra inverse time **UIT**). See phase overcurrent protection curves in appendix.

(1) The very inverse time **VIT** delay setting range may be used to create **LTI** curves.

Logic data K859 = 1 (K860) may be used to inhibit start up of the time delay (normal zone) and K860 = 1 may be used to inhibit start up of the time delay (inverse zone)
(regarding use, refer to “start-up of time delays” in appendix).

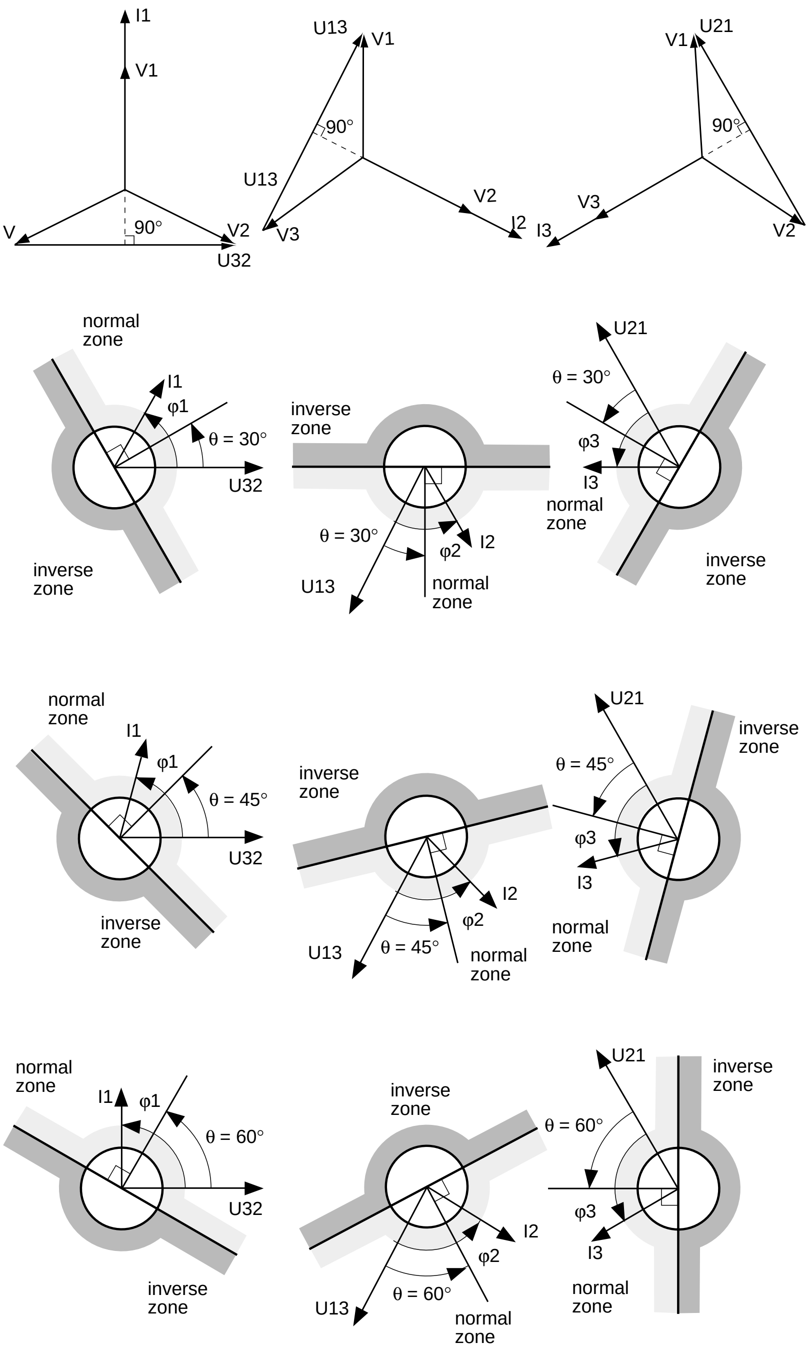
The direction of the current is determined by the phase current measurement in relation to a polarization value.

The polarization value is the system voltage in quadrature with the current for cos $\varphi = 1$ (90° connection angle).

The current vector plane of a phase is divided into 2 half-planes which correspond to the normal zone and the inverse zone. The characteristic angle θ is the angle of the line perpendicular to the boundary line between the 2 zones and the polarization value.

The protection is operational whenever the polarization voltage value is greater than 1.5% of Un.

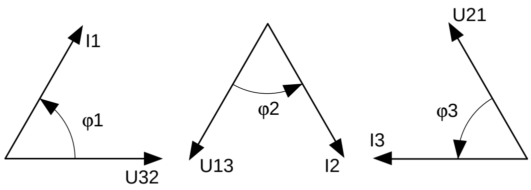
Operating principle



* for versions earlier than version 9802 SFT2800,
the function number is F51X and the protection is 2-phase (phases L1 and L3).

Measurement of phase shift with respect to the polarization value

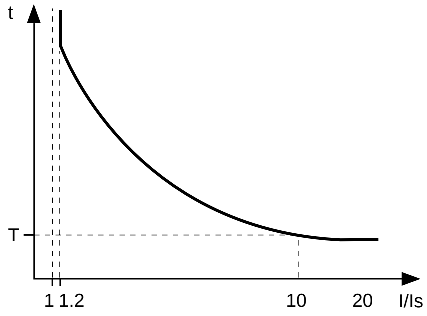
In order to facilitate commissioning, phase shifts φ1, φ2 and φ3 between currents I1, I2 and I3 and the corresponding polarization values U32, U13 and U21 may be measured using the pocket terminal or via the communication link (Jbus/Modbus)*.



IDMT protection

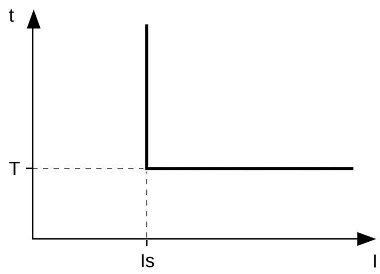
IDMT protection operates in accordance with the IEC 60255-3 and BS 142 standards.

Is is the vertical asymptote of the curve, and T is the operation time delay for 10 Is.

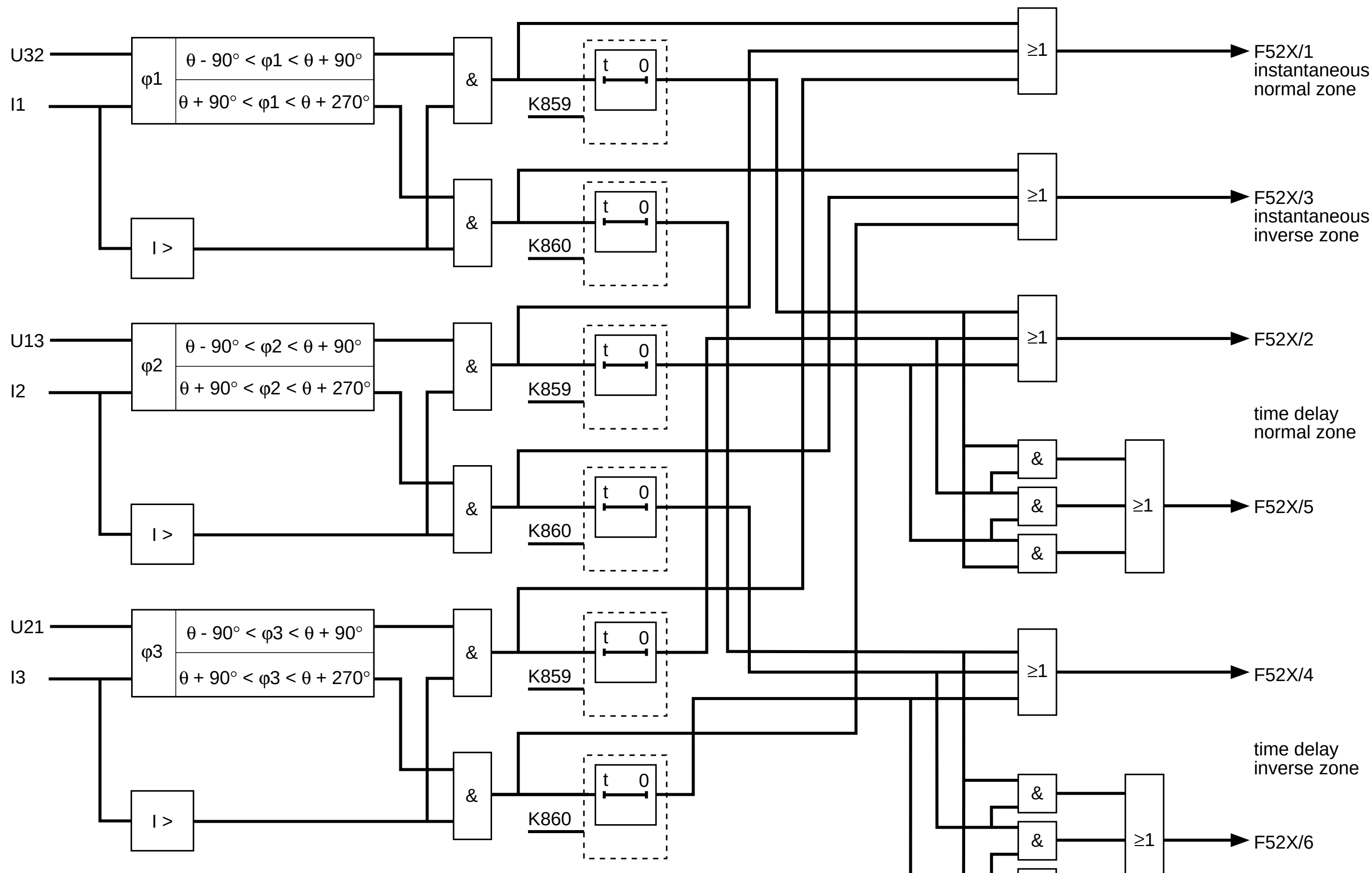


Definite time protection

Iso is the set point expressed in amps and T is the protection time delay.



Block diagram



* available as of version 9940 SFT2800.

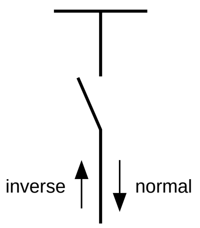
Commissioning, setting

Check:
■ the connections,
■ the positions of the microswitches SW associated with the current and voltage inputs,
■ the general parameters in the **status** menu.

Set the following:
■ type of time delay,
□ definite time **DT**,
□ IDMT: standard inverse time **SIT**, very inverse time **VIT**, extremely inverse time **EIT**, ultra inverse time **UIT**.
■ Is current: Is is set in rms, amps or kiloamps. The 999 kA setting may be used to inhibit the protection: all the outputs are set to 0.
■ T time delay:
□ **DT**: T is the operation time delay,
□ **SIT**, **VIT**, **EIT**, **UIT**: T is the operation time delay at 10 Is,
■ characteristic angle θ.

Please note
When several **directional phase overcurrent** protections are included in the same Sepam, the characteristic angle setting applies to all of them.

The **normal** and **inverse** directions correspond to the diagram below:



Protection detection direction

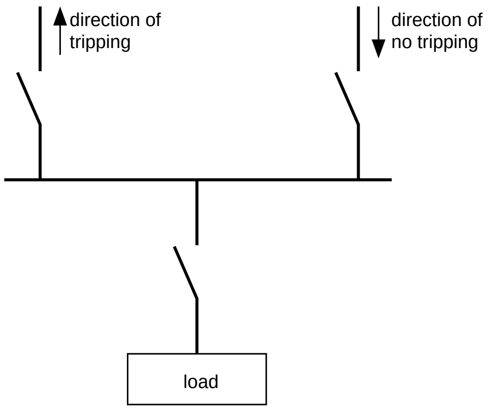
Characteristics

curve			
setting		definite, std. inv., very inv., ext. inv, ultra inv.	
characteristic angle θ			
setting (2)		30°, 45°, 60°	
acccuracy (1)		±5%	
Is set point			
setting	definite time	0.3In ⩽ Is ⩽ 24In expressed in amps	
	IDMT	0.3In ⩽ Is ⩽ 2.4In expressed in amps	
resolution		1 A or 1 digit	
accuracy (1)		±5%	
inhibition		999 kA	
drop out/pick-up ratio		(93.5 ±5)%	
T time delay			
setting	definite time	50 ms ⩽ T ⩽ 655 s	
	IDMT	100 ms ⩽ T ⩽ 12.5 s	
resolution		10 ms or 1 digit	
accuracy(1)	definite time	±2% or +25 ms	
	IDMT	class 5 or +25 ms	
		±12.5% at 2Is	
		±7.5%, or from 0 to +25 ms at 5 Is	
		±5%, or from 0 to +25 ms at 10 Is	
		±5%, or from 0 to +25 ms at 20 Is	
φ1, φ2, φ3 measurement			
measurement range		0° to 359°	
accuracy (1)		3° at In, Un	
resolution		1°	
characteristic times			
instantaneous tripping time		50 ms < t < 70 ms 60 ms typical	
time delayed tripping time		according to time delay	
memory time		20 ms < t < 55 ms	
fault recognition time		35 ms < t < 53 ms	
reset time		30 ms < t < 70 ms	
outputs available for program logic			
instantaneous		F52X/1 for normal zone F52X/3 for inverse zone	1 ⩽ X ⩽ 2
time-delayed		F52X/2 for normal zone F52X/5 for normal zone (2 out of 3 phases) F52X/4 for inverse zone F52X/6 for inverse zone (2 out of 3 phases)	1 ⩽ X ⩽ 2
remote reading and remote setting* (3)			
function code F52		52h	
identification number		X (4)	
parameters		curve	unit: 0..4 (5)
(order of parameters)		Is set point	unit: A
		T time delay	unit: 10 x ms
		characteristic angle	unit: degree

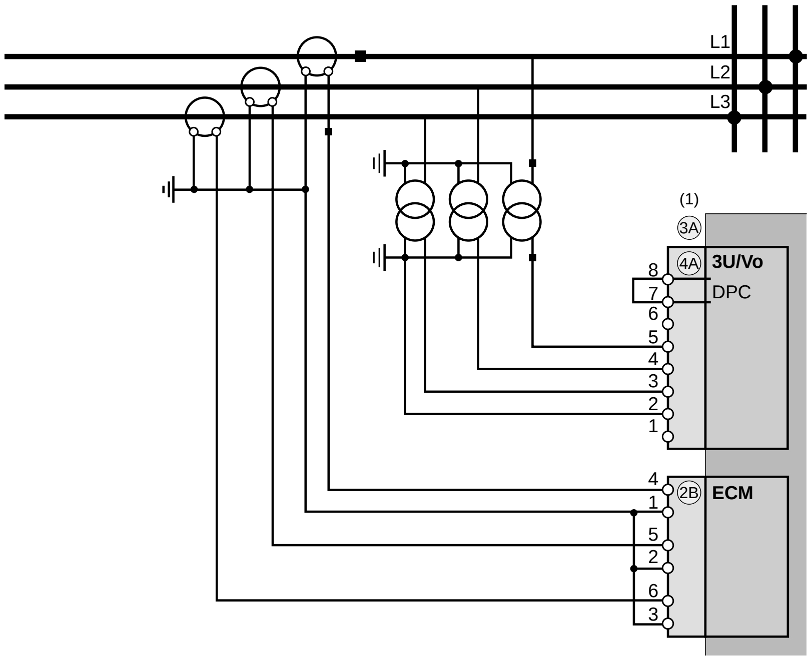
(1) in reference conditions (IEC 60255-6).
(2) setting is common to both relays.
(3) the data formats are defined in the manuals which describe each communication protocol.
(4) the number of protection functions depends on the type of Sepam.
(5) meaning of curve index:
0: definite time,
1: inverse time,
2: very inverse time,
3: extremely inverse time,
4: ultra inverse time.

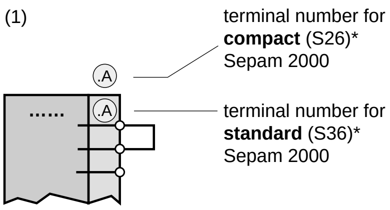
* function available as of version 9802 SFT2800.

Example of use
When the current sensors are connected (see diagram) with the index (e.g. P1) on the busbar side, the normal direction corresponds to the standard uses of the directional phase overcurrent protection.



Direction data are in accordance with the following wiring diagram:





Note: refer to the installation document for other arrangements.

Sensors

Directional phase overcurrent protection is related to the currents and voltages connected to the following connectors:

current	**sensor**	**connector**
	1A or 5A CT	2B
	CSP	2L1, 2L2, 2L3
voltage	**Sepam**	**connector**
	S36*	4A [1]
	S26*	3A

[1] 3A connector for S36*TR and S36TS models.

* or S35, S25 for earlier versions.
** function available as of version 9802 SFT2800.

Earth fault

ANSI code	50N-51N or 50G-51G
function n°	F06X, F08X for earth fault Io 1 ⩽ X ⩽ 4 F07Y, F09Y for earth fault Io' 1 ⩽ Y ⩽ 2

Operation

Earth fault protection is single-pole.

It picks up when earth fault current reaches the operation set point.
It is time-delayed. The time delay may be definite (definite **DT**) or IDMT (standard inverse **SIT**, very inverse **VIT** or **LTI** (1), extremely inverse **EIT**, ultra inverse time **UIT**) see phase current protection curves in appendix.
The F08X and F09X functions include a harmonic 2 restraint element which ensures protection stability during transformer energizing.

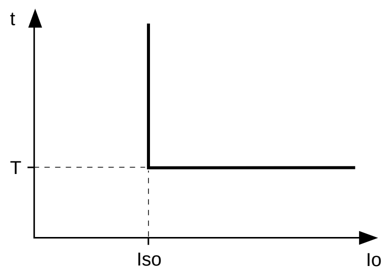
This element is calculated according to the phase currents.

It can be enabled or disable by protection setting.

(1) The very inverse time **VIT** delay setting range may be used to create **LTI** curves.

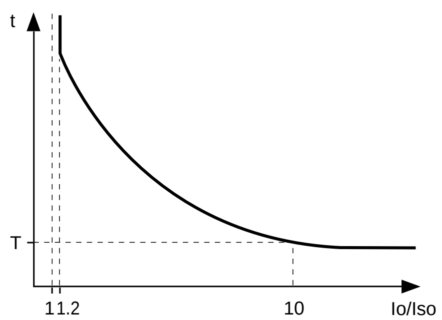
Logic data K859 = 1 may be used to inhibit start up of the time delay
(regarding use, refer to "start-up of time delays" in appendix).

Definite time protection
Iso is the set point expressed in Amps, and T is the protection time delay.



Definite time protection principle.

IDMT protection
IDMT protection operates in accordance with the IEC 60255-3 and BS 142 standards.



IDMT protection principle.

Iso is the vertical asymptote of the curve, and T is the operation time delay for 10 Iso.

The curve is defined according to the following equations:

■ standard inverse time **SIT**

$$t = \frac{0.14}{(Io/Iso)^{0.02}-1} \cdot \frac{T}{2.97}$$

■ very inverse time **VIT** or **LTI**

$$t = \frac{13.5}{(Io/Iso)-1} \cdot \frac{T}{1.5}$$

■ extremely inverse time **EIT**

$$t = \frac{80}{(Io/Iso)^{2}-1} \cdot \frac{T}{0.808}$$

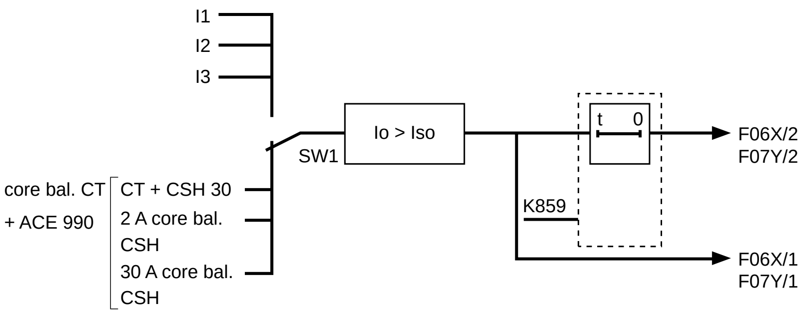
■ ultra inverse time **UIT**

$$t = \frac{315}{(Io/Iso)^{2.5}-1} \cdot T$$

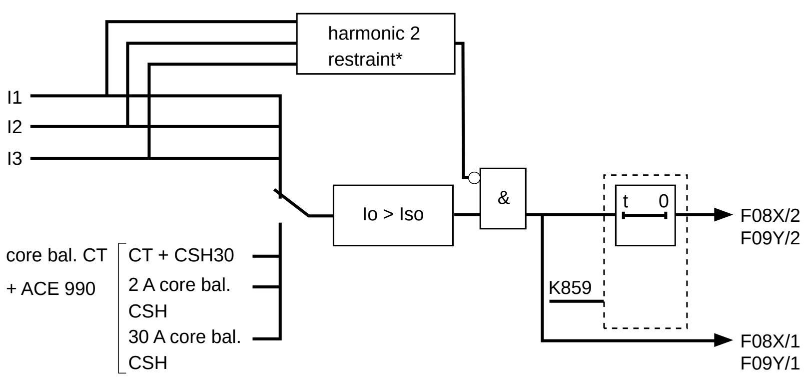
The function also takes into account current variations during the time delay interval.

For currents with a very large amplitude, the protection has a definite time characteristic:
■ si I > 20 Iso, tripping time is the time that corresponds to 20 Iso,
■ si I > 10 Ino, tripping time is the time that corresponds to 10 Ino.

Block diagram for functions F06X and F07Y



Block diagram for functions F08X and F09Y



* available as of version 9940 SFT2800.

Commissioning, setting

Earth fault current is measured:
■ by a CSH core balance CT through which 3 phase conductors pass and which directly detects the sum of the 3 currents. This solution is the most accurate one,
■ by a 1A or 5A current transformer, using a CSH30 interposing ring CT which acts as an adapter.
■ by a core balance CT with a ratio of 1/n (50 ⩽ n ⩽ 1500) using the ACE 990 interface.
■ by the phase CTs. The measurement is obtained by taking the internal vector sum of the three phase currents.

It becomes falsified when the CTs are saturated. Saturation may be due either to overcurrent or to the presence of a DC component in a transformer inrush current or in a phase-to-phase fault current.

Check:
■ the connections,
■ the positions of the microswitches SW associated with the current inputs,
■ the general parameters in the **status** menu.

Set the following:
■ type of time delay,
□ definite time **DT**,
□ IDMT: standard inverse time **SIT**, very inverse time **VIT**, extremely inverse time **EIT**, ultra inverse time **UIT**.
■ Iso current: Iso is set in rms, amps or kiloamps. The 999 kA setting may be used to inhibit the protection: all the outputs are set to 0.
■ T time delay:
□ **DT**: T is the operation time delay,
□ **SIT**, **VIT**, **EIT**, **UIT**: T is the operation time delay at 10 Iso.
■ taking into account of harmonic 2 restraint.

Sensors

Earth fault Io protection is related to the currents connected to the following connectors:

current	sensor	connector
	1A or 5A CT	2B
	CSH	2A
	CSP	2L1, 2L2, 2L3
	CT + CSH30	2A
	core bal. CT + ACE 990	2A

Earth fault Io' protection is related to the currents connected to the following connectors:

current	sensor	connector
	1A or 5A CT	3B
	CSH	3A
	CSP	3L1, 3L2, 3L3
	CT + CSH30	3A
	core bal. CT + ACE 990	3A

Characteristics

curve				
setting	definite, inverse, very inv., ext. Inv., ultra inv.			
Iso set point				
definite time setting		0.05 Ino ⩽ Iso ⩽ 10 Ino (1) expressed in amps		
	using CT sum	0.05 In to 10 In		
	with CSH core bal. CT 2 A rating input	0.1 A to 20 A		
	with CSH core bal. CT 30 A rating input	1.5 A to 300 A		
	with CT + CSH30	0.05 In ⩽ Iso ⩽ 10 In (0.1 A min.)		
	with core bal. CT + ACE 990	0.05 Ino ⩽ Iso ⩽ 10 Ino (1) (0.1 A min.)		
IDMT		0.05 Ino ⩽ Iso ⩽ Ino (1) expressed in amps		
	using CT sum	0.5 In at In		
	with CSH core bal. CT 2 A rating input	0.1 A to 20 A		
	with CSH core bal. CT 30 A rating input	1.5 A to 30 A		
	CT + CSH30	0.05 In ⩽ Iso ⩽ 1 In (0.1 A min.)		
	with core bal. CT + ACE 990	0.05 Ino ⩽ Iso ⩽ Ino (1) (0.1 A min.)		
resolution		0.1 A or 1 digit		
accuracy (2)		±5%		
inhibition		999 kA		
drop out/pick-up ratio		(93.5 ±5)% for Iso > 0.1 Ino		
T time delay				
setting	definite time	50 ms ⩽ T ⩽ 655 s		
	IDMT	100 ms ⩽ T ⩽ 12.5 s		
resolution		10 ms or 1 digit		
accuracy (2)	definite time	±2% or +25 ms		
	IDMT	class 5 or +25 ms:		
		±12.5% at 2 Is		
		±7.5%, or from 0 to +25 ms at 5 Is		
		±5%, or from 0 to +25 ms at 10 Iso		
		±5%, or from 0 to +25 ms at 20 Iso		
taking into account of harmonic 2 restraint		**F08X, F09Y**		
setting		yes / no		
characteristic times		**F08X, F09Y**	**F06X, F07Y**	
instantaneous tripping time		< 40 ms 30 ms (typical)	< 85 ms 50 ms (typical)	
instantaneous tripping time		< 4 ms 30 ms (typical)	< 85 ms 50 ms (typical)	
time-delayed tripping time		according to time delay		
memory time		< 30 ms	< 65 ms	
fault recognition time		< 30 ms	< 65 ms	
reset time		< 45 ms	< 85 ms	
outputs available for control logic				
instantaneous		F06X/1, F07Y/1 F08X/1, F09Y/1	1 ⩽ X ⩽ 4	1 ⩽ Y ⩽ 2
time-delayed		F06X/2, F07Y/2 F08X/2, F09Y/2	1 ⩽ X ⩽ 4	1 ⩽ Y ⩽ 2

(1) Ino = In if the sum of the three phase currents is used for the measurement
Ino = sensor rating if the measurement is taken by a CSH core balance CT.
Ino = In of the CT if the measurement is taken by a 1A or 5A current transformer.
Ino = core balance CT rating if the measurement is taken by a core balance CT other than CSH.
(2) in reference conditions (IEC 60255-6).

remote reading and remote setting* (1)		
function code F06, F07	06h and 07h	
identification number	X, Y (2)	
parameters	curve	unit: 0..4 (3)
(order of parameters)	Iso set point	unit: 0.1 x A
	T time delay	unit: 10 x ms
function code F08, F09	08h and 09h	
identification number	X, Y (2)	
parameters	curve	unit: 0..4 (3)
(order of parameters)	Iso set point	unit: 0.1 x A
	T time delay	unit: 10 x ms
taking into account of harmonic 2 restraint	unit: 0 or 1 (4)	

(1) the data formats are defined in the manuals which describe each communication protocol.
(2) the number of protection functions depends on the type of Sepam.
(3) meaning of curve index:
0: definite time,
1: inverse time,
2: very inverse time,
3: extremely inverse time,
4: ultra inverse time.
(4) 0: no
1: yes

* function available as of version 9802 SFT2800.

Directional earth fault

ANSI code	67N	
function n°	F50X	1 ⩽ X ⩽ 2

Operation

Principle
This protection is single-pole.
It includes an earth fault function combined with direction detection.
It picks up when the earth fault function in the chosen direction (normal or inverse) is activated.
It is time delayed.
The time delay is definite (definite time).

Logic data K859 = 1 (K860) may be used to inhibit start up of the time delay (normal zone) and K860 = 1 may be used to inhibit start up of the time delay (inverse zone)
(regarding use, refer to “start-up of time delays” in appendix).

The direction of the current is determined by the phase measurement in relation to the residual voltage.

The function determines the projection Ipo of current Io on the characteristic line, the position of which is set by the setting of the characteristic angle θo in relation to the residual voltage.

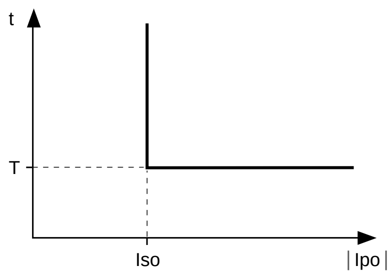
The Ipo value is compared with the Iso set point; the protection picks up in the following direction:
■ normal if Ipo ⩽ -Iso
■ inverse if Ipo ⩽ +Iso

When the characteristic angle θo = 0°, the function is activated when the phase shift between Io and Vo is:
■ ⩾ 104° or ⩽ +256° in the normal direction,
■ ⩾ -76° or ⩽ +76° in the inverse direction,
whatever the value of Io.

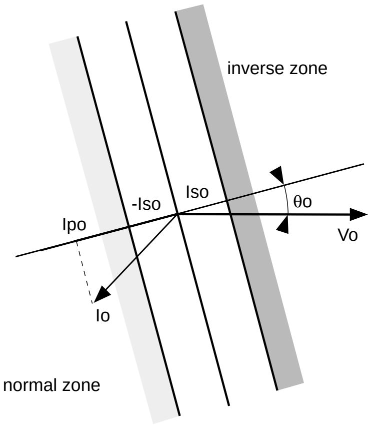
This protection is operational whenever the polarization voltage value is greater than 2.6% of Un.

This protection is appropriate for high impendance earthed and ungrounded systems. It is not appropriate for compensated neutral systems (earthed by a Petersen coil).

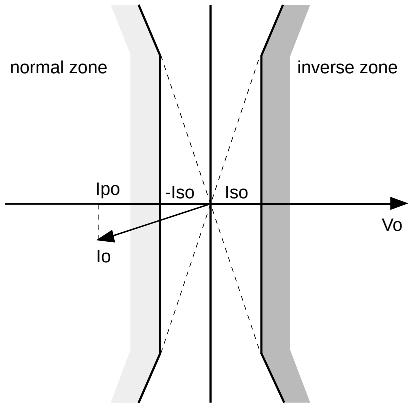
Definite time protection
Iso is the set point expressed in amps and T is the protection time delay.



Definite time protection principle.

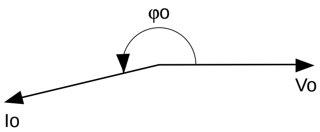


Protection operation zones

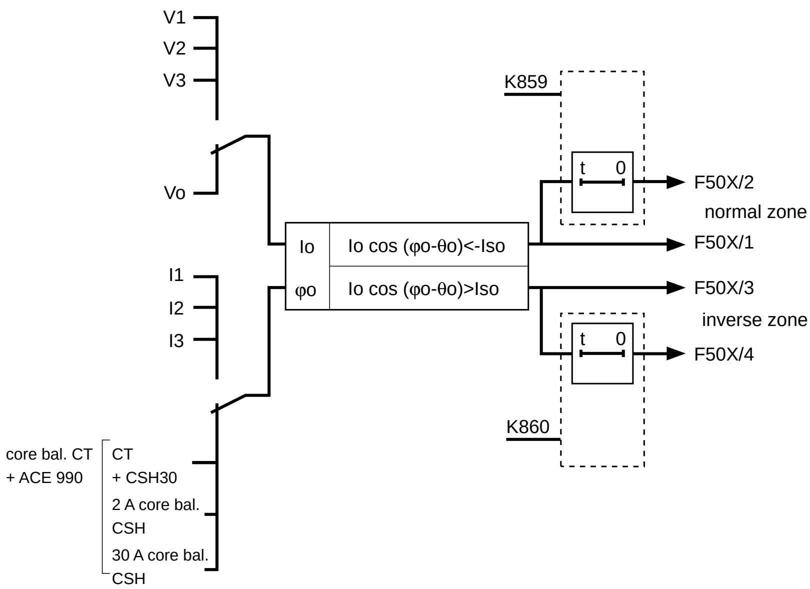


Operation with a characteristic angle equal to 0°

Measurement of Io phase shift with respect to Vo
In order to facilitate commissioning, the phase shift φo between the earth fault current Io and the residual voltage Vo may be measured:
■ using the pocket terminal,
■ via the communication link (Jbus/Modbus*).



Block diagram



* available as of version 9940 SFT2800.

Directional earth fault (cont'd)

Commissioning, setting

Earth fault current is measured:
■ by a CSH core balance CT through which 3 phase conductors pass and which directly detects the sum of the 3 currents. This solution is the most accurate one,
■ by a 1A or 5A current transformer, using a CSH30 interposing ring CT which acts as an adapter.
■ by the phase CTs. The measurement is obtained by taking the internal vector sum of the three phase currents.
■ by a core balance CT with a ratio of 1/n (50 ⩽ n ⩽ 1500) using the ACE 990 interface.

It becomes falsified when the CTs are saturated. Saturation may be due either to overcurrent or to the presence of a DC component in a transformer inrush current or in a phase-to-phase fault current.

Residual voltage is measured by:
■ 3 voltage transformers. The measurement is obtained by taking the internal vector sum of the three phase voltages,
■ 3 voltage transformers with secondary windings connected in an open delta arrangement.

Check:
■ the connections,
■ the positions of the microswitches SW1 associated with the current and voltage inputs,
■ the general parameters in the **status** menu.

Set the following using the pocket terminal:
■ Iso current: Iso is set in rms, amps or kiloamps. The 999 kA setting may be used to inhibit the protection: all the outputs are set to 0.
■ characteristic angle θo,
■ T time delay: T is the operation time delay.

The θo setting depends essentially on the earthing system:
□ ungrounded: the earth fault current is capacitive. The recommended setting is θo = 90°,
□ resistive neutral: the protection should only detect resistive earth fault current and should not be sensitive to capacitive current. The recommended setting is θo = 0°,
□ solidly grounded: the earth fault current is only limited by the cable and source induction coils. The recommended setting is θo = -45°.

Please note:
When several **directional earth fault** protections are included in the same Sepam 2000, the characteristic angle setting is common.

Characteristics

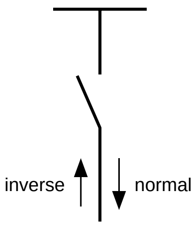
characteristic angle θo			
setting (3)		0°, 15°, 30°, 45°, 60°, 90°, -45°	
accuracy (1)		±5°	
Iso set point			
setting		0.05 Ino ⩽ Iso ⩽ 10 Ino (2) expressed in amps	
	using CT sum	0.05 In to 10 In	
	with CSH core bal. CT 2 A rating	0.1 A to 20 A	
	with CSH core bal. CT 30 A rating	1.5 A to 300 A	
	with CT + CSH30	0.05 In ⩽ Iso ⩽ 10 In (0.1 A min)	
	with core bal. CT + ACE 990	0.05 Ino ⩽ Iso ⩽ 10 Ino (2) (0.1 A min.)	
resolution		0.1 A or 1 digit	
accuracy (1)		±5%	
inhibition		999 kA	
drop out/pick-up ratio		(93.5 ±5)%	
T time delay			
setting		50 ms ⩽ T ⩽ 655 s	
accuracy (1)		±2% or -10 ms to 25 ms	
resolution		10 ms or 1 digit	
φo measurement			
measurement range		0° to 359°	
accuracy (1)		±2°	
resolution		1°	
characteristic times			
instantaneous tripping time		20 ms < t < 65 ms	
time delayed tripping time		T	
memory time time		< 40 ms	
fault recognition time		< 40 ms	
reset time		< 40 ms	
outputs available for control logic			
instantaneous		F50X/1 for normal zone F50X/3 for inverse zone	1 ⩽ X ⩽ 2
time delayed		F50X/2 for normal zone F50X/4 for inverse zone	1 ⩽ X ⩽ 2

remote reading, remote setting* (4)		
function code F50	50h	
identification number	X (5)	
parameters	Iso set point	unit : 0.1 x A
(order of parameters)	characteristic angle	unit : degree
	T time delay	unit : 10 x ms

(1) in reference conditions (IEC 60255-6).
(2) Ino = In if the sum of the three phase currents is used for the measurement.
Ino = sensor rating if the measurement is taken by a CSH core balance CT.
Ino = In of the CT is the measurement is taken by a 1 A or 5 A current transformer.
Ino = core balance CT rating if the measurement is taken by a core balance CT other than CSH.
(3) this setting is common to both modules.
(4) the data formats are defined in the manuals which describe each communication protocol.
(5) the number of protection function modules depends on the type of Sepam 2000.

* function available as of version 9802 SFT2800.

Protection detection direction
The **normal** and **inverse** directions correspond to the diagram below.



Sensors

Directional earth fault protection is related to the currents and voltages connected to the following connectors:

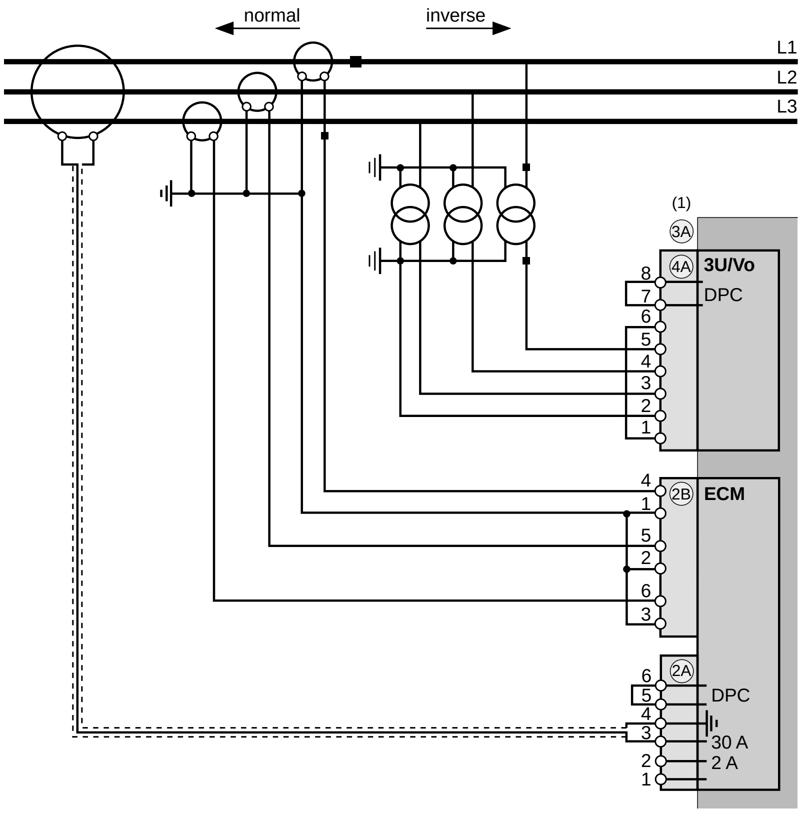
current	sensor	connector
	1A or 5A CT	2B
	CSH	2A
	CSP	2L1, 2L2, 2L3
	CT + CSH30	2A
	core bal. CT + ACE 990	2A
tvoltage	**Sepam**	**connector**
	S36*	4A [1]
	S26*	3A

[1] 3A connector for S36*TR and S36TS models.

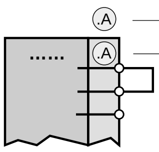
Special uses

IDMT (standard inverse **SIT**, very inverse **VIT** or **LTI**, extremely inverse **EIT**, ultra inverse **UIT**) earth fault protection may be obtained by combining:
■ directional earth fault protection
(using the instantaneous output relay and the appropriate set point and characteristic angle settings),
■ IDMT earth fault protection.

Direction data are in accordance with the following wiring diagram:



(1)



terminal number for **compact** (S26)* Sepam 2000

terminal number for **standard** (S36)* Sepam 2000

Note: refer to the installation document for other arrangements.

* or S35, S25 for earlier versions.
** function available as of version 9745 SFT 2800.

Directional earth fault for compensated neutral systems

ANSI code	67NC	
function n°	F48X	1 ⩽ X ⩽ 2*

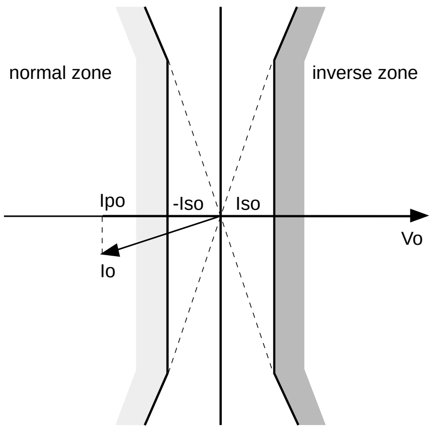
Operation

Principle
This protection is single-pole.
It picks up when the active component of the earth fault current is greater than a set point in the chosen direction (normal or inverse).
It is time delayed. The time delay is definite (definite time).
It is characterized by its capacity to detect very short, repetitive faults during the time delay (recurring faults).
The function determines the projection Ipo of current Io on the residual voltage Vo axis.

The Ipo value is compared with the Iso set point:
the protection picks up in the following direction:
- normal if Ipo ⩽ -Iso,
- inverse if Ipo ⩾ +Iso and if the earth fault vector

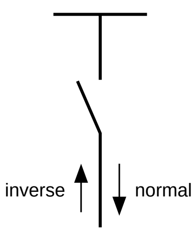
is in a sector that can be adjusted with respect to the residual voltage.

This sector makes it possible to obtain a highly sensitive and stable function.
This protection is operational whenever the residual voltage value $(\vec{V1}+\vec{V2}+\vec{V3})$ is greater than the set point Vso.
This protection is appropriate for compensated neutral systems (earthed by a Petersen coil).

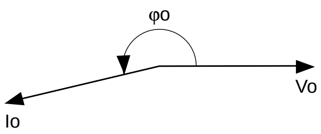


Protection operation zones

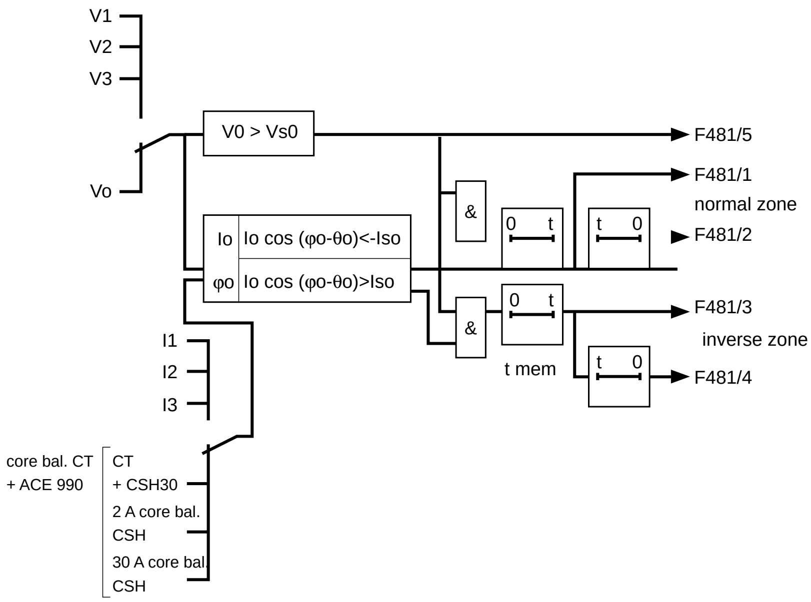
Protection detection direction
The **normal** and **inverse** directions correspond to the diagram below.



Measurement of Io phase shift with respect to Vo
In order to facilitate commissioning, the phase shift φo between the earth fault current Io and the residual voltage Vo may be measured:
- using the pocket terminal,
- via the communication link (Jbus/Modbus)*.



Block diagram



* available as of version 9940 SFT2800.

Commissioning, setting

Earth fault current is measured:
■ by a CSH core balance CT through which 3 phase conductors pass and which directly detects the sum of the 3 currents.
This solution is the most accurate one,
■ by a 1A or 5A current transformer, using a CSH30 interposing ring CT which acts as an adapter.
■ by a core balance CT with a ratio of 1/n (50 ⩽ n ⩽ 1500) using the ACE 990 interface.
■ by the phase CTs. The measurement is obtained by taking the internal vector sum of the three phase currents. It becomes falsified when the CTs are saturated. Saturation may be due either to overcurrent or to the presence of a DC component in a transformer inrush current or in a phase-to-phase fault current.

Residual voltage is measured by:
■ 3 voltage transformers. The measurement is obtained by taking the internal vector sum of the three phase voltages,
■ 3 voltage transformers with secondary windings connected in an open delta arrangement.

Check:
■ the connections,
■ the positions of the microswitches SW1 associated with the current and voltage inputs,
■ the general parameters in the **status** menu.

Set the following:
■ Iso current:
Iso is set in rms, amps or kiloamps.
The 999 kA setting may be used to inhibit the protection: all the outputs are set to 0.
■ sector:
□ 83° by default,
□ 86° for precision sensors.
■ Vso residual voltage:
Vso is set in rms, volts or kilovolts.

Recommended setting: the Vso setting must be greater than the residual voltage detected when there are no earth faults, due to system dissymmetry and measuring chain inaccuracy,
■ T time delay
T is the operation time delay,
■ Tmem time delay
Tmem is the time for which the set point overrun information is memorized after the fault has disappeared.
Recommended setting: in the range of 250 ms.

* available as of version 9802 SFT2800.

Characteristics

Iso set point			
setting		0.05Ino ⩽ Iso ⩽ 10Ino [2] expressed in amps	
	using CT sum	0.05In to 10In	
	with CSH core bal. CT 2 A rating	0.1 A to 20 A	
	with CSH core bal. CT 30 A rating	1.5 A to 300 A	
	with CT + CSH30	0,05 In ⩽ Iso ⩽ 10 In (0.1 A min)	
	with core bal. CT + ACE 990	0.05 Ino ⩽ Iso ⩽ 10 Ino [2] (0.1 A min.)	
resolution		0.1 A or 1 digit	
accuracy [1]		±5%	
inhibition		999 kA	
drop out/pick-up ratio		(93.5 ±5)%	
sector			
setting		±83°, ±86°	
accuracy [1]		±2°	
Vso set point			
value		0.02Un ⩽ Vso ⩽ 0.8Un expressed in volts	
accuracy		±2% or 0.005Un	
T time delay and Tmem/ memory time			
setting		50 ms ⩽ T ⩽ 655 s	
accuracy [1]		±2% or +25 ms	
resolution		10 ms or 1 digit	
φ measurement			
measurement range		0° to 359°	
accuracy [1]		±2°	
resolution		1°	
characteristic times			
instantaneous tripping time		< 65 ms	
time delayed tripping time		T	
memory time		Tmem	
fault recognition time		10 ms < t < 40 ms	
reset time		< Tmem + 35 ms	
outputs available for program logic			
instantaneous		F48X/1 for normal zone F48X/3 for inverse zone	1 ⩽ X ⩽ 2
time delayed		F48X/2 for normal zone F48X/4 for inverse zone	1 ⩽ X ⩽ 2
Vo ⩾ Vso		F48X/5	1 ⩽ X ⩽ 2

remote reading, remote setting* [3]		
function code F48	48h	
identification number	1	
parameters	Iso set point	unit : 0.1 x A
(order of parameters)	tripping sector	unit: index [4]
	Vso set point	unit: V
	T time delay	unit: 10 x ms
	memory time	unit: 10 x ms

(1) in reference conditions (IEC 60255-6).
(2) Ino = In if the sum of the three phase currents is used for the measurement.
Ino = sensor rating if the measurement is taken by a CSH core balance CT.
Ino = In of the CT is the measurement is taken by a 1 A or 5 A current transformer.
Ino = core balance CT rating if the measurement is taken by a core balance CT other than CSH.
(3) the data formats are defined in the manuals which describe each communication protocol.
(4) meaning of tripping index: 0: ±83° angle 2: ±86° angle.

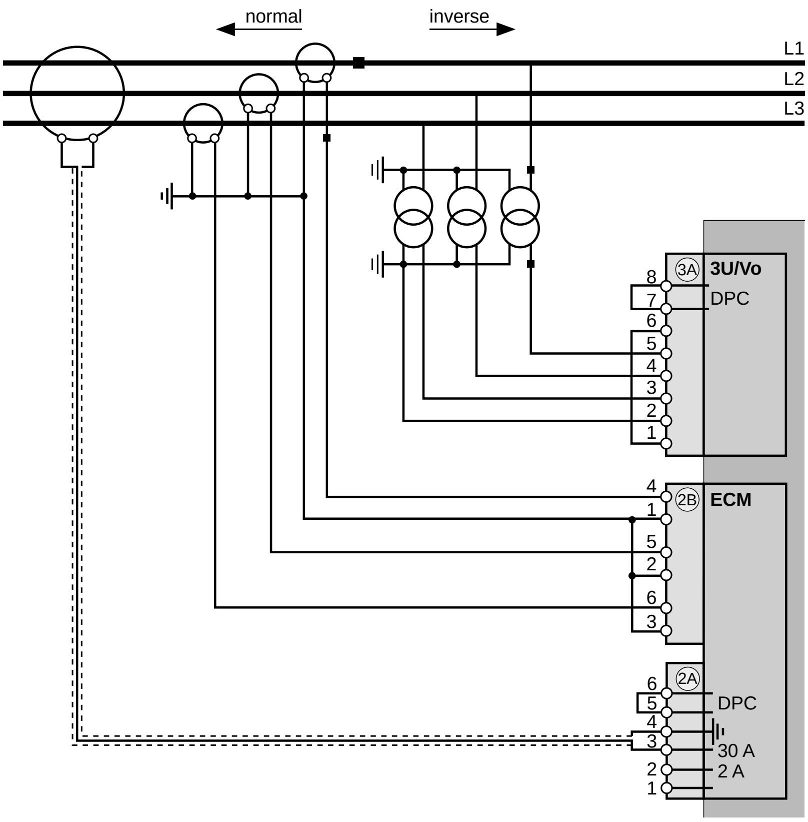
Directional earth fault for compensated neutral systems (cont'd)

Sensors

Directional earth fault protection is related to the currents and voltages connected to the following connectors:

current	sensor	connector
	1A or 5A CT	2B
	CSH	2A
	CSP	2L1, 2L2, 2L3
	CT + CSH30	2A
	core bal. CT + ACE 990	2A
voltage	**Sepam**	**connector**
	S36	4A
	S26*	3A

Direction data are in accordance with the following wiring diagram:



Note: refer to the installation document for other arrangements.

* S25 for earlier versions
(limited to systems with rated frequency 50 Hz).

Resistive earth fault

ANSI code	50G-51G
function n°	F101

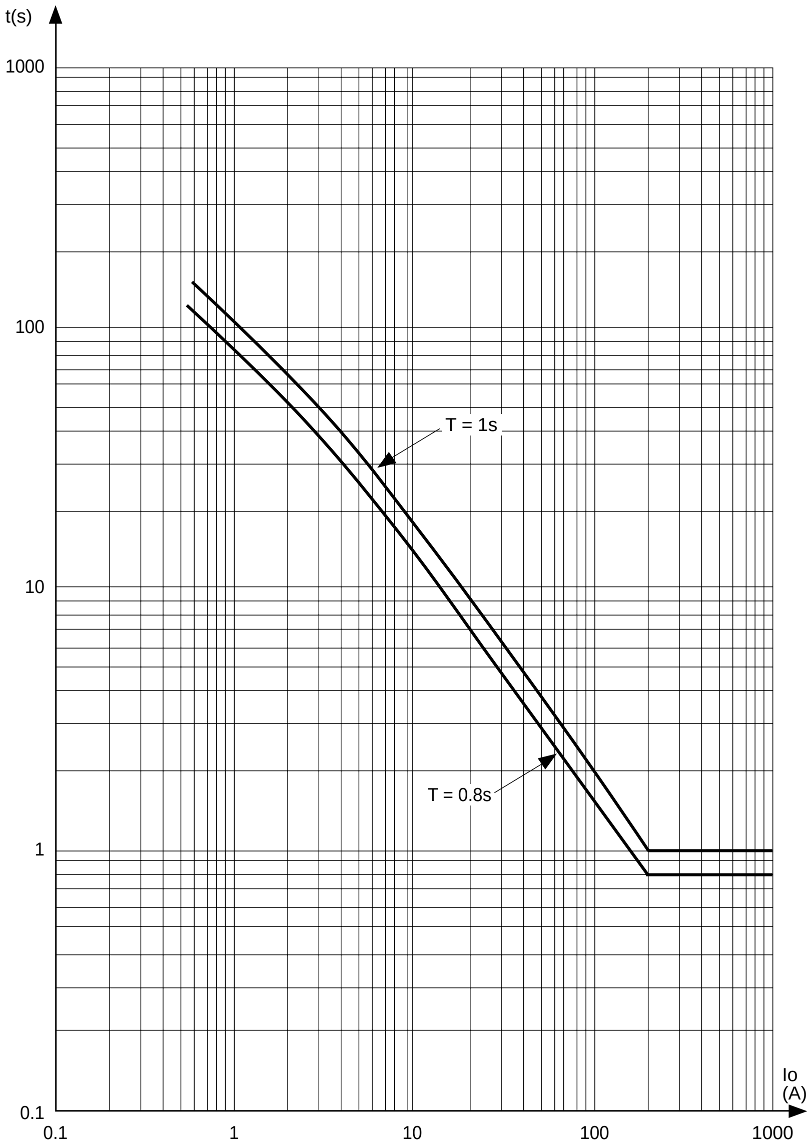
Operation

The resistive earth fault function is single-pole.
It picks up when earth fault current (measured by a CSH120 or CSH200 core balance CT connected to the 30 A rating input) reaches the operation set point. It is time-delayed. The time delay is definite (see curve) and takes into account variations in earth fault current during the time delay interval.

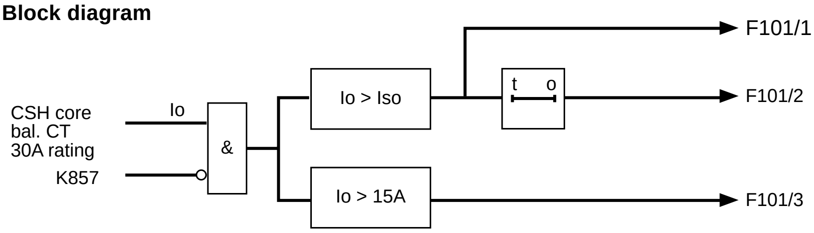
Protection operation may be inhibited by logic information input. The protection has a set point of 15 A. The function is characterized by its very high level of sensitivity and its capacity to discriminate between a faulty feeder and fault-free feeders through which capacitive earth fault current is flowing.

Definite time protection
Iso is the set point expressed in Amps, and T is the time delay for Io ⩾ 200 A. The operation times are defined by the following curves.

Resistive earth fault curves



Block diagram



Resistive earth fault (cont'd)

Sensors

Resistive earth fault protection is related to the currents connected to the following connector:

current	sensor	connector
	CSH120 or CSH200	2A

Special uses

The **resistive earth** fault function is used in public distribution networks.

The EPATR-B curve defined by Electricité de France corresponds to the time delay setting T = 0.8 s according to the following chart:

Io (A)	time delay (s) t=1s	t=0.8s	Io (A)	time delay(s) t=1s	t=0.8s
0.6	153.24	122.59	14.0	13.38	10.70
0.7	137.40	109.92	15.0	12.50	10.00
0.8	125.00	100.00	16.0	11.74	9.39
0.9	115.00	92.00	17.0	11.06	8.85
1.0	106.74	85.39	18.0	10.46	8.37
1.1	99.76	79.81	19.0	9.93	7.94
1.2	93.81	75.05	20.0	9.44	7.55
1.3	88.64	70.91	25.0	7.60	6.08
1.4	84.11	67.29	30.0	6.36	5.09
1.5	80.10	64.08	35.0	5.48	4.38
1.6	76.53	61.22	40.0	4.80	3.84
1.7	73.30	58.64	45.0	4.29	3.43
1.8	70.40	56.32	50.0	3.86	3.09
1.9	67.75	54.20	55.0	3.53	2.82
2.0	65.34	52.27	60.0	3.24	2.59
2.5	55.79	44.63	65.0	2.99	2.39
3.0	49.04	39.23	70.0	2.79	2.23
3.5	43.96	35.17	75.0	2.60	2.08
4.0	40.00	32.00	80.0	2.44	1.95
4.5	36.80	29.44	85.0	2.30	1.84
5.0	34.15	27.32	90.0	2.18	1.74
5.5	31.93	25.54	95.0	2.06	1.65
6.0	30.01	24.01	100.0	1.96	1.57
6.5	28.25	22.60	110.0	1.79	1.43
7.0	26.29	21.03	120.0	1.65	1.32
7.5	24.58	19.66	130.0	1.53	1.22
8.0	23.08	18.46	140.0	1.41	1.13
8.5	21.75	17.40	150.0	1.33	1.06
9.0	20.58	16.46	160.0	1.24	0.99
9.5	19.51	15.61	170.0	1.18	0.94
10.0	18.56	14.85	180.0	1.11	0.89
11.0	16.91	13.53	190.0	1.05	0.84
12.0	15.54	12.43	200.0	1.00	0.80
13.0	14.38	11.50	>200	1.00	0.80

* function available as of version 9802 SFT2800.

Commissioning, setting

Earth fault current is measured by a CSH120 or CSH200 core balance CT connected to the 30 A rating (terminals 3 and 4).

Settings
Check:
■ the connections,
■ the positions of the microswitches SW associated with the current inputs,
■ the general parameters in the **status** menu.

Set the following:
■ Iso current: Iso is set in rms, amps or kiloamps.
The 999 kA setting may be used to inhibit the protection: all the outputs are set to 0.
■ T time delay: T is the operation time delay for Io ≥ 200 A.

Characteristics

Is set point		
setting	0.6 A ⩽ Iso ⩽ 5 A	
resolution	0.1 A	
accuracy (1)	±5%	
inhibition	999 kA	
drop out/pick-up ratio	(93.5 ±5)% for Io ⩾ 1.5 A	
15 A set point		
setting	fixed	
accuracy (1)	±5%	
return variance	1 A	
T time delay		
setting	500 ms ⩽ T ⩽ 1 s	
resolution	10 ms or 1 digit	
accuracy (1)	±10%	
characteristic times		
instantaneous tripping time	< 50 ms	
time-delayed tripping time	see curve	
memory time	< 30 ms	
fault recognition time	< 30 ms	
reset time	< 45 ms	
inhibition input relay		
K857	1 = inhibition	
	0 = validation	
outputs available for control logic		
instantaneous	F101/1	
time-delayed	F101/2	
Io ≥ 15A	F101/3	
remote reading and remote setting* (2)		
function code F10	10h	
identification number	1	
parameters	Iso set point	unit: 0.1 x A
(order of parameters)	T time delay	unit: 10 x ms

(1) in reference conditions (IEC 60255-6).
(2) the data formats are defined in the manuals which describe each communication protocol.

Thermal overload

ANSI code	49
function n°	F431

Operation

This function simulates the heat rise in the protected equipment using the current measurements taken on two (I1 and I3) or three phases.It complies with the IEC 60255-8 standard.

It monitors the heat rise and compares it with 2 set points OL1 and OL2:
■ according to the application, the first detection set point is designed for alarm signaling (transformers, generators, capacitors) or detection of hot status which is used by the **starts per hour** function (motors),
■ the second set point is designed for protection.
The heat rise measurement may be accessed via the via the pocket terminal or the communication link (Jbus/Modbus) even if the function is disabled.

Taking into account of harmonics
Heat rise in equipment depends on the form of the current flowing through it. Measurement of the rms value of phase 1 current, which integrates the influence of harmonics up to number 21, takes into account the wave form to calculate heat rise in balanced three-phase loads.

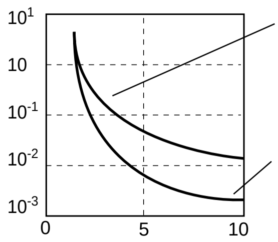
Taking into account of negative sequence current
Negative sequence current is a significant factor in calculating heat rise in rotating machines.
The rotating field that corresponds to the negative sequence current creates a double frequency rotating current that causes major losses.
This is why the **thermal overload** function takes into account the following equivalent current:
$Ieq^2 = I^2 + K.Ii^2$
I is the greatest of the following values:
I1, I2, I3 et I1rms
Ii is the current negative sequence.
Adjust is the negative sequence factor (weighting coefficient).

Operation curve
The protection gives a tripping order when the heat rise heating calculated according to the measurement of an equivalent current Ieq is greater than the OL set point.

The highest permissible continuous current is $I = Ib\sqrt{3}$.

The protection tripping time is set for the time constant T.

The heat rise calculated depends on the current absorbed and the previous heat rise status.
■ The cold curve defines the protection tripping time according to a heat rise of 100%.



cold curve

$$\frac{t}{T} = \text{Log}\,\frac{\left(\frac{Ieq}{Ib}\right)^2}{\left(\frac{Ieq}{Ib}\right)^2 - OL}$$

hot curve

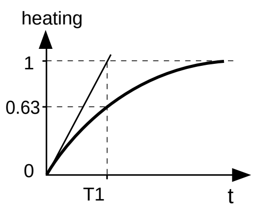
$$\frac{t}{T} = \text{Log}\,\frac{\left(\frac{Ieq}{Ib}\right)^2 - 1}{\left(\frac{Ieq}{Ib}\right)^2 - OL}$$

Influence of the time constant
The time constant depends on the equipment's thermal characteristics.
It takes heat release and cooling into account.

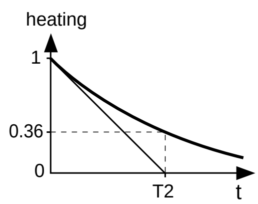
For a non-ventilated rotating machine, cooling is more effective when the machine is running than when it is stopped due to the ventilation caused by rotation.

■ Equipment running and stopping are calculated according to the current value:
□ **running** if I > 0.015Ib,
□ **stopped** if I < 0.015Ib.

Two time constants can be set:
■ T1: heat rise time constant: concerns equipment that is running.
The T1 thermal time constant is the time needed for the equipment under rated load to reach 0.63 times the rated heat rise (obtained after an infinite time).
■ T2: cooling time constant: concerns equipment that is stopped.
The T2 time constant is the time needed after stopping for the initial heat rise in the protected equipment to drop to 0.36 times the rated heat rise.

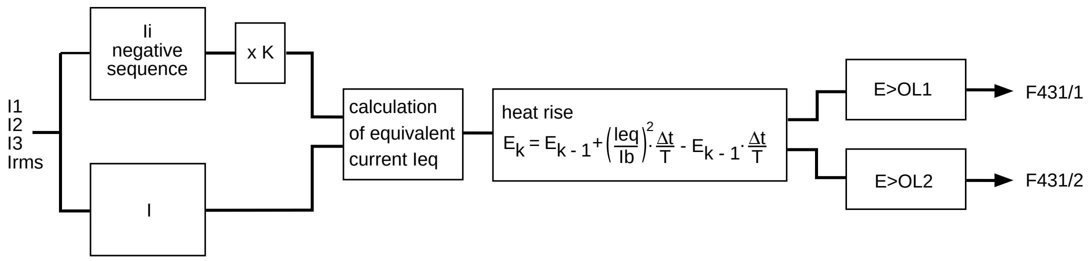


Heat rise time constant.



Cooling time constant.

Block diagram



Cold curves: t/T1 = f(OL, I/Ib)

The following charts provide the numerical values of the cold curves.

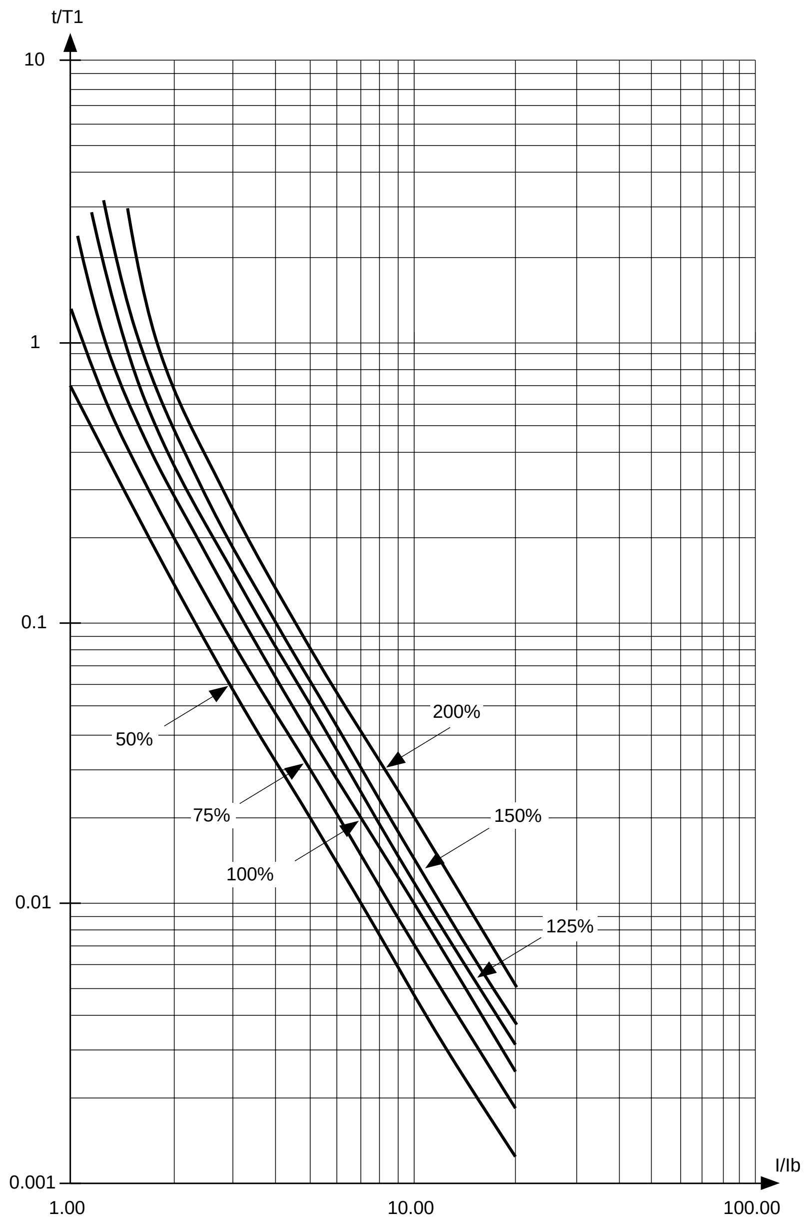
Example of chart use

For an operation set point OL of 115% with a time constant T1 of 15 mn, what is the operation time when cold at 2.6 Ib?

Using the cold curve chart:

■ read at the intersection of row OL =115 and column I/Ib = 2.6 the value t/T1 = 0.1865

■ calculate the operation time t = 0.1865 x T i.e. t = 0.1865 x 15 x 60 = 167.8s



Cold curves

I/Ib OL (%)	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80
50	0.6931	0.6042	0.5331	0.4749	0.4265	0.3857	0.3508	0.3207	0.2945	0.2716	0.2513	0.2333	0.2173	0.2029	0.1900	0.1782	0.1676
55	0.7985	0.6909	0.6061	0.5376	0.4812	0.4339	0.3937	0.3592	0.3294	0.3033	0.2803	0.2600	0.2419	0.2257	0.2111	0.1980	0.1860
60	0.9163	0.7857	0.6849	0.6046	0.5390	0.4845	0.4386	0.3993	0.3655	0.3360	0.3102	0.2873	0.2671	0.2490	0.2327	0.2181	0.2048
65	1.0498	0.8905	0.7704	0.6763	0.6004	0.5379	0.4855	0.4411	0.4029	0.3698	0.3409	0.3155	0.2929	0.2728	0.2548	0.2386	0.2239
70	1.2040	1.0076	0.8640	0.7535	0.6657	0.5942	0.5348	0.4847	0.4418	0.4049	0.3727	0.3444	0.3194	0.2972	0.2774	0.2595	0.2434
75	1.3863	1.1403	0.9671	0.8373	0.7357	0.6539	0.5866	0.5302	0.4823	0.4412	0.4055	0.3742	0.3467	0.3222	0.3005	0.2809	0.2633
80	1.6094	1.2933	1.0822	0.9287	0.8109	0.7174	0.6413	0.5780	0.5245	0.4788	0.4394	0.4049	0.3747	0.3479	0.3241	0.3028	0.2836
85	1.8971	1.4739	1.2123	1.0292	0.8923	0.7853	0.6991	0.6281	0.5686	0.5180	0.4745	0.4366	0.4035	0.3743	0.3483	0.3251	0.3043
90	2.3026	1.6946	1.3618	1.1411	0.9808	0.8580	0.7605	0.6809	0.6147	0;5587	0.5108	0.4694	0.4332	0.4013	0.3731	0.3480	0.3254
95		1.9782	1.5377	1.2670	1.0780	0.9365	0.8258	0.7366	0.6630	0.6012	0.5486	0.5032	0.4638	0.4292	0.3986	0.3714	0.3470
100		2.3755	1.7513	1.4112	1.1856	1.0217	0.8958	0.7956	0.7138	0.6455	0.5878	0.5383	0.4953	0.4578	0.4247	0.3953	0.3691
105		3.0445	2.0232	1.5796	1.3063	1.1147	0.9710	0.8583	0.7673	0.6920	0.6286	0.5746	0.5279	0.4872	0.4515	0.4199	0.3917
110			2.3979	1.7824	1.4435	1.2174	1.0524	0.9252	0.8238	0.7406	0.6712	0.6122	0.5616	0.5176	0.4790	0.4450	0.4148
115			3.0040	2.0369	1.6025	1.3318	1.1409	0.9970	0.8837	0.7918	0.7156	0.6514	0.5964	0.5489	0.5074	0.4708	0.4384
120				2.3792	1.7918	1.4610	1.2381	1.0742	0.9474	0.8457	0.7621	0.6921	0.6325	0.5812	0.5365	0.4973	0.4626
125				2.9037	2.0254	1.6094	1.3457	1.1580	1.0154	0.9027	0.8109	0.7346	0.6700	0.6146	0.5666	0.5245	0.4874
130					2.3308	1.7838	1.4663	1.2493	1.0885	0.9632	0.8622	0.7789	0.7089	0.6491	0.5975	0.5525	0.5129
135					2.7726	1.9951	1.6035	1.3499	1.1672	1.0275	0.9163	0.8253	0.7494	0.6849	0.6295	0.5813	0.5390
140						2.2634	1.7626	1.4618	1.2528	1.0962	0.9734	0.8740	0.7916	0.7220	0.6625	0.6109	0.5658
145						2.6311	1.9518	1.5877	1.3463	1.1701	1.0341	0.9252	0.8356	0.7606	0.6966	0.6414	0.5934
150						3.2189	2.1855	1.7319	1.4495	1.2498	1.0986	0.9791	0.8817	0.8007	0.7320	0.6729	0.6217
155							2.4908	1.9003	1.5645	1.3364	1.1676	1.0361	0.9301	0.8424	0.7686	0.7055	0.6508
160							2.9327	2.1030	1.6946	1.4313	1.2417	1.0965	0.9808	0.8860	0.8066	0.7391	0.6809
165								2.3576	1.8441	1.5361	1.3218	1.1609	1.0343	0.9316	0.8461	0.7739	0.7118
170								2.6999	2.0200	1.6532	1.4088	1.2296	1.0908	0.9793	0.8873	0.8099	0.7438
175								3.2244	2.2336	1.7858	1.5041	1.3035	1.1507	1.0294	0.9302	0;8473	0.7768
180									2.5055	1.9388	1.6094	1.3832	1.2144	1.0822	0.9751	0.8861	0.8109
185									2.8802	2.1195	1.7272	1.4698	1.2825	1.1379	1.0220	0.9265	0.8463
190									3.4864	2.3401	1.8608	1.5647	1.3555	1.1970	1.0713	0.9687	0.8829
195										2.6237	2.0149	1.6695	1.4343	1.2597	1.1231	1.0126	0.9209
200										3.0210	2.1972	1.7866	1.5198	1.3266	1.1778	1.0586	0.9605

Cold curves

I/Ib OL (%)	1.85	1.90	1.95	2.00	2.20	2.40	2.60	2.80	3.00	3.20	3.40	3.60	3.80	4.00	4.20	4.40	4.60
50	0.1579	0.1491	0.1410	0.1335	0.1090	0.0908	0.0768	0.0659	0.0572	0.0501	0.0442	0.0393	0.0352	0.0317	0.0288	0.0262	0.0239
55	0.1752	0.1653	0.1562	0.1479	0.1206	0.1004	0.0849	0.0727	0.0631	0.0552	0.0487	0.0434	0.0388	0.0350	0.0317	0.0288	0.0263
60	0.1927	0.1818	0.1717	0.1625	0.1324	0.1100	0.0929	0.0796	0.069	0.0604	0.0533	0.0474	0.0424	0.0382	0.0346	0.0315	0.0288
65	0.2106	0.1985	0.1875	0.1773	0.1442	0.1197	0.1011	0.0865	0.075	0.0656	0.0579	0.0515	0.0461	0.0415	0.0375	0.0342	0.0312
70	0.2288	0.2156	0.2035	0.1924	0.1562	0.1296	0.1093	0.0935	0.081	0.0708	0.0625	0.0555	0.0497	0.0447	0.0405	0.0368	0.0336
75	0.2474	0.2329	0.2197	0.2076	0.1684	0.1395	0.1176	0.1006	0.087	0.0761	0.0671	0.0596	0.0533	0.0480	0.0434	0.0395	0.0361
80	0.2662	0.2505	0.2362	0.2231	0.1807	0.1495	0.1260	0.1076	0.0931	0.0813	0.0717	0.0637	0.0570	0.0513	0.0464	0.0422	0.0385
85	0.2855	0.2685	0.2530	0.2389	0.1931	0.1597	0.1344	0.1148	0.0992	0.0867	0.0764	0.0678	0.0607	0.0546	0.0494	0.0449	0.0410
90	0.3051	0.2868	0.2701	0.2549	0.2057	0.1699	0.1429	0.1219	0.1054	0.092	0.0811	0.0720	0.0644	0.0579	0.0524	0.0476	0.0435
95	0.3251	0.3054	0.2875	0.2712	0.2185	0.1802	0.1514	0.1292	0.1116	0.0974	0.0858	0.0761	0.0681	0.0612	0.0554	0.0503	0.0459
100	0.3456	0.3244	0.3051	0.2877	0.2314	0.1907	0.1601	0.1365	0.1178	0.1028	0.0905	0.0803	0.0718	0.0645	0.0584	0.0530	0.0484
105	0.3664	0.3437	0.3231	0.3045	0.2445	0.2012	0.1688	0.1438	0.1241	0.1082	0.0952	0.0845	0.0755	0.0679	0.0614	0.0558	0.0509
110	0.3877	0.3634	0.3415	0.3216	0.2578	0.2119	0.1776	0.1512	0.1304	0.1136	0.1000	0.0887	0.0792	0.0712	0.0644	0.0585	0.0534
115	0.4095	0.3835	0.3602	0.3390	0.2713	0.2227	0.1865	0.1586	0.1367	0.1191	0.1048	0.0929	0.0830	0.0746	0.0674	0.0612	0.0559
120	0.4317	0.4041	0.3792	0.3567	0.2849	0.2336	0.1954	0.1661	0.1431	0.1246	0.1096	0.0972	0.0868	0.0780	0.0705	0.0640	0.0584
125	0.4545	0.4250	0.3986	0.3747	0.2988	0.2446	0.2045	0.1737	0.1495	0.1302	0.1144	0.1014	0.0905	0.0813	0.0735	0.0667	0.0609
130	0.4778	0.4465	0.4184	0.3930	0.3128	0.2558	0.2136	0.1813	0.156	0.1358	0.1193	0.1057	0.0943	0.0847	0.0766	0.0695	0.0634
135	0.5016	0.4683	0.4386	0.4117	0.3270	0.2671	0.2228	0.1890	0.1625	0.1414	0.1242	0.1100	0.0982	0.0881	0.0796	0.0723	0.0659
140	0.5260	0.4907	0.4591	0.4308	0.3414	0.2785	0.2321	0.1967	0.1691	0.147	0.1291	0.1143	0.1020	0.0916	0.0827	0.0751	0.0685
145	0.5511	0.5136	0.4802	0.4502	0.3561	0.2900	0.2414	0.2045	0.1757	0.1527	0.1340	0.1187	0.1058	0.0950	0.0858	0.0778	0.0710
150	0.5767	0.5370	0.5017	0.4700	0.3709	0.3017	0.2509	0.2124	0.1823	0.1584	0.1390	0.1230	0.1097	0.0984	0.0889	0.0806	0.0735
155	0.6031	0.5610	0.5236	0.4902	0.3860	0.3135	0.2604	0.2203	0.189	0.1641	0.1440	0.1274	0.1136	0.1019	0.0920	0.0834	0.0761
160	0.6302	0.5856	0.5461	0.5108	0.4013	0.3254	0.2701	0.2283	0.1957	0.1699	0.1490	0.1318	0.1174	0.1054	0.0951	0.0863	0.0786
165	0.6580	0.6108	0.5690	0.5319	0.4169	0.3375	0.2798	0.2363	0.2025	0.1757	0.1540	0.1362	0.1213	0.1088	0.0982	0.0891	0.0812
170	0.6866	0.6366	0.5925	0.5534	0.4327	0.3498	0.2897	0.2444	0.2094	0.1815	0.1591	0.1406	0.1253	0.1123	0.1013	0.0919	0.0838
175	0.7161	0.6631	0.6166	0.5754	0.4487	0.3621	0.2996	0.2526	0.2162	0.1874	0.1641	0.1451	0.1292	0.1158	0.1045	0.0947	0.0863
180	0.7464	0.6904	0.6413	0.5978	0.4651	0.3747	0.3096	0.2608	0.2231	0.1933	0.1693	0.1495	0.1331	0.1193	0.1076	0.0976	0.0889
185	0.7777	0.7184	0.6665	0.6208	0.4816	0.3874	0.3197	0.2691	0.2301	0.1993	0.1744	0.1540	0.1371	0.1229	0.1108	0.1004	0.0915
190	0.8100	0.7472	0.6925	0.6444	0.4985	0.4003	0.3300	0.2775	0.2371	0.2052	0.1796	0.1585	0.1411	0.1264	0.1140	0.1033	0.0941
195	0.8434	0.7769	0.7191	0.6685	0.5157	0.4133	0.3403	0.2860	0.2442	0.2113	0.1847	0.1631	0.1451	0.1300	0.1171	0.1062	0.0967
200	0.8780	0.8075	0.7465	0.6931	0.5331	0.4265	0.3508	0.2945	0.2513	0.2173	0.1900	0.1676	0.1491	0.1335	0.1203	0.1090	0.0993

Cold curves

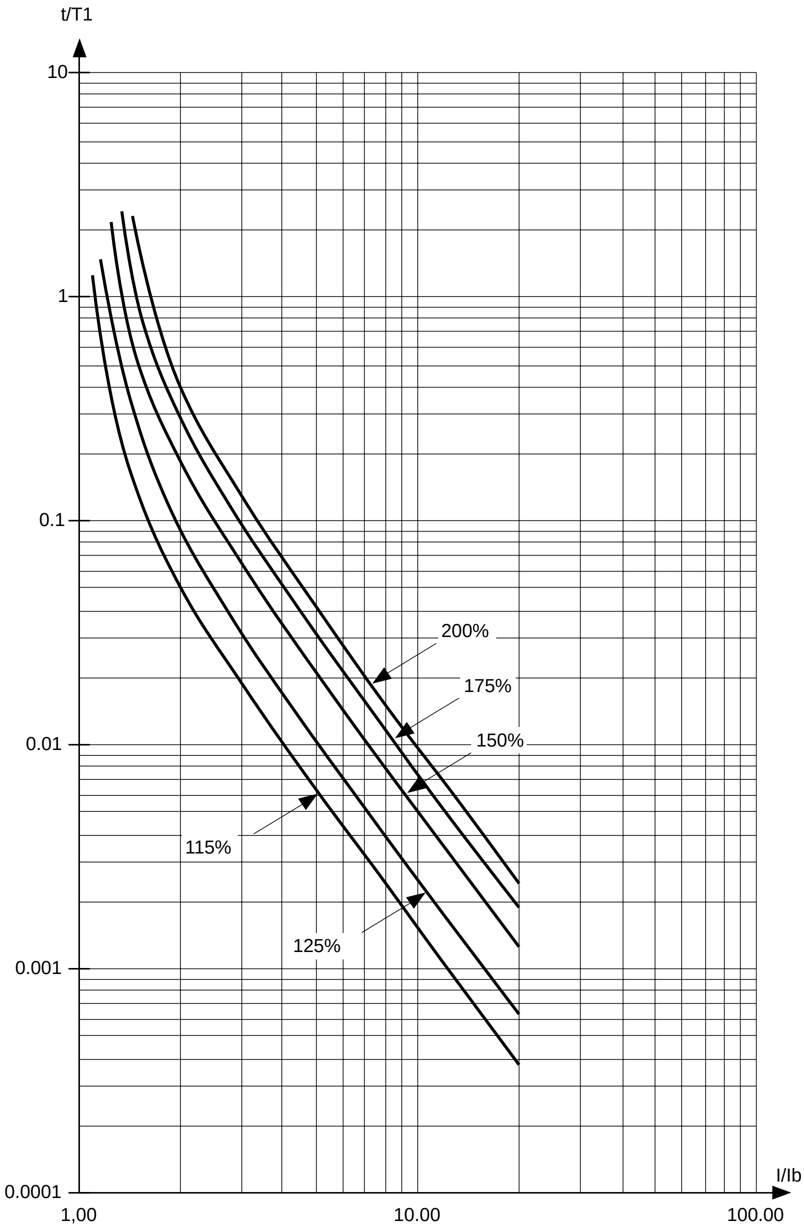
I/Ib OL (%)	4.80	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	12.50	15.00	17.50	20.00
50	0.0219	0.0202	0.0167	0.0140	0.0119	0.0103	0.0089	0.0078	0.0069	0.0062	0.0056	0.0050	0.0032	0.0022	0.0016	0.0013
55	0.0242	0.0222	0.0183	0.0154	0.0131	0.0113	0.0098	0.0086	0.0076	0.0068	0.0061	0.0055	0.0035	0.0024	0.0018	0.0014
60	0.0264	0.0243	0.0200	0.0168	0.0143	0.0123	0.0107	0.0094	0.0083	0.0074	0.0067	0.0060	0.0038	0.0027	0.0020	0.0015
65	0.0286	0.0263	0.0217	0.0182	0.0155	0.0134	0.0116	0.0102	0.0090	0.0081	0.0072	0.0065	0.0042	0.0029	0.0021	0.0016
70	0.0309	0.0284	0.0234	0.0196	0.0167	0.0144	0.0125	0.0110	0.0097	0.0087	0.0078	0.0070	0.0045	0.0031	0.0023	0.0018
75	0.0331	0.0305	0.0251	0.0211	0.0179	0.0154	0.0134	0.0118	0.0104	0.0093	0.0083	0.0075	0.0048	0.0033	0.0025	0.0019
80	0.0353	0.0325	0.0268	0.0225	0.0191	0.0165	0.0143	0.0126	0.0111	0.0099	0.0089	0.0080	0.0051	0.0036	0.0026	0.0020
85	0.0376	0.0346	0.0285	0.0239	0.0203	0.0175	0.0152	0.0134	0.0118	0.0105	0.0095	0.0085	0.0055	0.0038	0.0028	0.0021
90	0.0398	0.0367	0.0302	0.0253	0.0215	0.0185	0.0161	0.0142	0.0125	0.0112	0.0100	0.0090	0.0058	0.0040	0.0029	0.0023
95	0.0421	0.0387	0.0319	0.0267	0.0227	0.0196	0.0170	0.0150	0.0132	0.0118	0.0106	0.0095	0.0061	0.0042	0.0031	0.0024
100	0.0444	0.0408	0.0336	0.0282	0.0240	0.0206	0.0179	0.0157	0.0139	0.0124	0.0111	0.0101	0.0064	0.0045	0.0033	0.0025
105	0.0466	0.0429	0.0353	0.0296	0.0252	0.0217	0.0188	0.0165	0.0146	0.0130	0.0117	0.0106	0.0067	0.0047	0.0034	0.0026
110	0.0489	0.0450	0.0370	0.0310	0.0264	0.0227	0.0197	0.0173	0.0153	0.0137	0.0123	0.0111	0.0071	0.0049	0.0036	0.0028
115	0.0512	0.0471	0.0388	0.0325	0.0276	0.0237	0.0207	0.0181	0.0160	0.0143	0.0128	0.0116	0.0074	0.0051	0.0038	0.0029
120	0.0535	0.0492	0.0405	0.0339	0.0288	0.0248	0.0216	0.0189	0.0167	0.0149	0.0134	0.0121	0.0077	0.0053	0.0039	0.0030
125	0.0558	0.0513	0.0422	0.0353	0.0300	0.0258	0.0225	0.0197	0.0175	0.0156	0.0139	0.0126	0.0080	0.0056	0.0041	0.0031
130	0.0581	0.0534	0.0439	0.0368	0.0313	0.0269	0.0234	0.0205	0.0182	0.0162	0.0145	0.0131	0.0084	0.0058	0.0043	0.0033
135	0.0604	0.0555	0.0457	0.0382	0.0325	0.0279	0.0243	0.0213	0.0189	0.0168	0.0151	0.0136	0.0087	0.0060	0.0044	0.0034
140	0.0627	0.0576	0.0474	0.0397	0.0337	0.0290	0.0252	0.0221	0.0196	0.0174	0.0156	0.0141	0.0090	0.0062	0.0046	0.0035
145	0.0650	0.0598	0.0491	0.0411	0.0349	0.0300	0.0261	0.0229	0.0203	0.0181	0.0162	0.0146	0.0093	0.0065	0.0047	0.0036
150	0.0673	0.0619	0.0509	0.0426	0.0361	0.0311	0.0270	0.0237	0.0210	0.0187	0.0168	0.0151	0.0096	0.0067	0.0049	0.0038
155	0.0696	0.0640	0.0526	0.0440	0.0374	0.0321	0.0279	0.0245	0.0217	0.0193	0.0173	0.0156	0.0100	0.0069	0.0051	0.0039
160	0.0720	0.0661	0.0543	0.0455	0.0386	0.0332	0.0289	0.0253	0.0224	0.0200	0.0179	0.0161	0.0103	0.0071	0.0052	0.0040
165	0.0743	0.0683	0.0561	0.0469	0.0398	0.0343	0.0298	0.0261	0.0231	0.0206	0.0185	0.0166	0.0106	0.0074	0.0054	0.0041
170	0.0766	0.0704	0.0578	0.0484	0.0411	0.0353	0.0307	0.0269	0.0238	0.0212	0.0190	0.0171	0.0109	0.0076	0.0056	0.0043
175	0.0790	0.0726	0.0596	0.0498	0.0423	0.0364	0.0316	0.0277	0.0245	0.0218	0.0196	0.0177	0.0113	0.0078	0.0057	0.0044
180	0.0813	0.0747	0.0613	0.0513	0.0435	0.0374	0.0325	0.0285	0.0252	0.0225	0.0201	0.0182	0.0116	0.0080	0.0059	0.0045
185	0.0837	0.0769	0.0631	0.0528	0.0448	0.0385	0.0334	0.0293	0.0259	0.0231	0.0207	0.0187	0.0119	0.0083	0.0061	0.0046
190	0.0861	0.0790	0.0649	0.0542	0.0460	0.0395	0.0344	0.0301	0.0266	0.0237	0.0213	0.0192	0.0122	0.0085	0.0062	0.0048
195	0.0884	0.0812	0.0666	0.0557	0.0473	0.0406	0.0353	0.0309	0.0274	0.0244	0.0218	0.0197	0.0126	0.0087	0.0064	0.0049
200	0.0908	0.0834	0.0684	0.0572	0.0485	0.0417	0.0362	0.0317	0.0281	0.0250	0.0224	0.0202	0.0129	0.0089	0.0066	0.0050

Hot curves:
t/T1 = f(OL, I/Ib)

The following charts provide the numerical values of the hot curves.

Example of chart use
For an operation set point OL of 115% with a time constant T1 of 15 mn, what is the operation time when hot at 2.6 Ib?

Using the hot curve chart:
■ read at the intersection of row OL = 115 and column I/Ib = 2.6 the value t/T1 = 0.0264,
■ calculate the operation time t = 0.0264 x T1
i.e. t = 0.0264 x 15 x 60 = 23.7s



Hot curves

I/Ib OL (%)	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80
105		0.6690	0.2719	0.1685	0.1206	0.0931	0.0752	0.0627	0.0535	0.0464	0.0408	0.0363	0.0326	0.0295	0.0268	0.0245	0.0226
110		3.7136	0.6466	0.3712	0.2578	0.1957	0.1566	0.1296	0.1100	0.0951	0.0834	0.0740	0.0662	0.0598	0.0544	0.0497	0.0457
115			1.2528	0.6257	0.4169	0.3102	0.2451	0.2013	0.1699	0.1462	0.1278	0.1131	0.1011	0.0911	0.0827	0.0755	0.0693
120			3.0445	0.9680	0.6061	0.4394	0.3423	0.2786	0.2336	0.2002	0.1744	0.1539	0.1372	0.1234	0.1118	0.1020	0.0935
125				1.4925	0.8398	0.5878	0.4499	0.3623	0.3017	0.2572	0.2231	0.1963	0.1747	0.1568	0.1419	0.1292	0.1183
130				2.6626	1.1451	0.7621	0.5705	0.4537	0.3747	0.3176	0.2744	0.2407	0.2136	0.1914	0.1728	0.1572	0.1438
135					1.5870	0.9734	0.7077	0.5543	0.4535	0.3819	0.3285	0.2871	0.2541	0.2271	0.2048	0.1860	0.1699
140					2.3979	1.2417	0.8668	0.6662	0.5390	0.4507	0.3857	0.3358	0.2963	0.2643	0.2378	0.2156	0.1967
145						1.6094	1.0561	0.7921	0.6325	0.5245	0.4463	0.3869	0.3403	0.3028	0.2719	0.2461	0.2243
150						2.1972	1.2897	0.9362	0.7357	0.6042	0.5108	0.4408	0.3864	0.3429	0.3073	0.2776	0.2526
155						3.8067	1.5950	1.1047	0.8508	0.6909	0.5798	0.4978	0.4347	0.3846	0.3439	0.3102	0.2817
160							2.0369	1.3074	0.9808	0.7857	0.6539	0.5583	0.4855	0.4282	0.3819	0.3438	0.3118
165							2.8478	1.5620	1.1304	0.8905	0.7340	0.6226	0.5390	0.4738	0.4215	0.3786	0.3427
170								1.9042	1.3063	1.0076	0.8210	0.6914	0.5955	0.5215	0.4626	0.4146	0.3747
175								2.4288	1.5198	1.1403	0.9163	0.7652	0.6554	0.5717	0.5055	0.4520	0.4077
180								3.5988	1.7918	1.2933	1.0217	0.8449	0.7191	0.6244	0.5504	0.4908	0.4418
185									2.1665	1.4739	1.1394	0.9316	0.7872	0.6802	0.5974	0.5312	0.4772
190									2.7726	1.6946	1.2730	1.0264	0.8602	0.7392	0.6466	0.5733	0.5138
195									4.5643	1.9782	1.4271	1.1312	0.9390	0.8019	0.6985	0.6173	0.5518
200										2.3755	1.6094	1.2483	1.0245	0.8688	0.7531	0.6633	0.5914

I/Ib OL (%)	1.85	1.90	1.95	2.00	2.20	2.40	2.60	2.80	3.00	3.20	3.40	3.60	3.80	4.00	4.20	4.40	4.60
105	0.0209	0.0193	0.0180	0.0168	0.0131	0.0106	0.0087	0.0073	0.0063	0.0054	0.0047	0.0042	0.0037	0.0033	0.0030	0.0027	0.0025
110	0.0422	0.0391	0.0363	0.0339	0.0264	0.0212	0.0175	0.0147	0.0126	0.0109	0.0095	0.0084	0.0075	0.0067	0.0060	0.0055	0.0050
115	0.0639	0.0592	0.0550	0.0513	0.0398	0.0320	0.0264	0.0222	0.0189	0.0164	0.0143	0.0126	0.0112	0.0101	0.0091	0.0082	0.0075
120	0.0862	0.0797	0.0740	0.0690	0.0535	0.0429	0.0353	0.0297	0.0253	0.0219	0.0191	0.0169	0.0150	0.0134	0.0121	0.0110	0.0100
125	0.1089	0.1007	0.0934	0.0870	0.0673	0.0540	0.0444	0.0372	0.0317	0.0274	0.0240	0.0211	0.0188	0.0168	0.0151	0.0137	0.0125
130	0.1322	0.1221	0.1132	0.1054	0.0813	0.0651	0.0535	0.0449	0.0382	0.0330	0.0288	0.0254	0.0226	0.0202	0.0182	0.0165	0.0150
135	0.1560	0.1440	0.1334	0.1241	0.0956	0.0764	0.0627	0.0525	0.0447	0.0386	0.0337	0.0297	0.0264	0.0236	0.0213	0.0192	0.0175
140	0.1805	0.1664	0.1540	0.1431	0.1100	0.0878	0.0720	0.0603	0.0513	0.0443	0.0386	0.0340	0.0302	0.0270	0.0243	0.0220	0.0200
145	0.2055	0.1892	0.1750	0.1625	0.1246	0.0993	0.0813	0.0681	0.0579	0.0499	0.0435	0.0384	0.0341	0.0305	0.0274	0.0248	0.0226
150	0.2312	0.2127	0.1965	0.1823	0.1395	0.1110	0.0908	0.0759	0.0645	0.0556	0.0485	0.0427	0.0379	0.0339	0.0305	0.0276	0.0251
155	0.2575	0.2366	0.2185	0.2025	0.1546	0.1228	0.1004	0.0838	0.0712	0.0614	0.0535	0.0471	0.0418	0.0374	0.0336	0.0304	0.0277
160	0.2846	0.2612	0.2409	0.2231	0.1699	0.1347	0.1100	0.0918	0.0780	0.0671	0.0585	0.0515	0.0457	0.0408	0.0367	0.0332	0.0302
165	0.3124	0.2864	0.2639	0.2442	0.1855	0.1468	0.1197	0.0999	0.0847	0.0729	0.0635	0.0559	0.0496	0.0443	0.0398	0.0360	0.0328
170	0.3410	0.3122	0.2874	0.2657	0.2012	0.1591	0.1296	0.1080	0.0916	0.0788	0.0686	0.0603	0.0535	0.0478	0.0430	0.0389	0.0353
175	0.3705	0.3388	0.3115	0.2877	0.2173	0.1715	0.1395	0.1161	0.0984	0.0847	0.0737	0.0648	0.0574	0.0513	0.0461	0.0417	0.0379
180	0.4008	0.3660	0.3361	0.3102	0.2336	0.1840	0.1495	0.1244	0.1054	0.0906	0.0788	0.0692	0.0614	0.0548	0.0493	0.0446	0.0405
185	0.4321	0.3940	0.3614	0.3331	0.2502	0.1967	0.1597	0.1327	0.1123	0.0965	0.0839	0.0737	0.0653	0.0583	0.0524	0.0474	0.0431
190	0.4644	0.4229	0.3873	0.3567	0.2671	0.2096	0.1699	0.1411	0.1193	0.1025	0.0891	0.0782	0.0693	0.0619	0.0556	0.0503	0.0457
195	0.4978	0.4525	0.4140	0.3808	0.2842	0.2226	0.1802	0.1495	0.1264	0.1085	0.0943	0.0828	0.0733	0.0654	0.0588	0.0531	0.0483
200	0.5324	0.4831	0.4413	0.4055	0.3017	0.2358	0.1907	0.1581	0.1335	0.1145	0.0995	0.0873	0.0773	0.0690	0.0620	0.0560	0.0509

Hot curves

I/Ib OL (%)	4.80	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	12.50	15.00	17.50	20.00
105	0.0023	0.0021	0.0017	0.0014	0.0012	0.0010	0.0009	0.0008	0.0007	0.0006	0.0006	0.0005	0.0003	0.0002	0.0002	0.0001
110	0.0045	0.0042	0.0034	0.0029	0.0024	0.0021	0.0018	0.0016	0.0014	0.0013	0.0011	0.0010	0.0006	0.0004	0.0003	0.0003
115	0.0068	0.0063	0.0051	0.0043	0.0036	0.0031	0.0027	0.0024	0.0021	0.0019	0.0017	0.0015	0.0010	0.0007	0.0005	0.0004
120	0.0091	0.0084	0.0069	0.0057	0.0049	0.0042	0.0036	0.0032	0.0028	0.0025	0.0022	0.0020	0.0013	0.0009	0.0007	0.0005
125	0.0114	0.0105	0.0086	0.0072	0.0061	0.0052	0.0045	0.0040	0.0035	0.0031	0.0028	0.0025	0.0016	0.0011	0.0008	0.0006
130	0.0137	0.0126	0.0103	0.0086	0.0073	0.0063	0.0054	0.0048	0.0042	0.0038	0.0034	0.0030	0.0019	0.0013	0.0010	0.0008
135	0.0160	0.0147	0.0120	0.0101	0.0085	0.0073	0.0064	0.0056	0.0049	0.0044	0.0039	0.0035	0.0023	0.0016	0.0011	0.0009
140	0.0183	0.0168	0.0138	0.0115	0.0097	0.0084	0.0073	0.0064	0.0056	0.0050	0.0045	0.0040	0.0026	0.0018	0.0013	0.0010
145	0.0206	0.0189	0.0155	0.0129	0.0110	0.0094	0.0082	0.0072	0.0063	0.0056	0.0051	0.0046	0.0029	0.0020	0.0015	0.0011
150	0.0229	0.0211	0.0172	0.0144	0.0122	0.0105	0.0091	0.0080	0.0070	0.0063	0.0056	0.0051	0.0032	0.0022	0.0016	0.0013
155	0.0253	0.0232	0.0190	0.0158	0.0134	0.0115	0.0100	0.0088	0.0077	0.0069	0.0062	0.0056	0.0035	0.0025	0.0018	0.0014
160	0.0276	0.0253	0.0207	0.0173	0.0147	0.0126	0.0109	0.0096	0.0085	0.0075	0.0067	0.0061	0.0039	0.0027	0.0020	0.0015
165	0.0299	0.0275	0.0225	0.0187	0.0159	0.0136	0.0118	0.0104	0.0092	0.0082	0.0073	0.0066	0.0042	0.0029	0.0021	0.0016
170	0.0323	0.0296	0.0242	0.0202	0.0171	0.0147	0.0128	0.0112	0.0099	0.0088	0.0079	0.0071	0.0045	0.0031	0.0023	0.0018
175	0.0346	0.0317	0.0260	0.0217	0.0183	0.0157	0.0137	0.0120	0.0106	0.0094	0.0084	0.0076	0.0048	0.0034	0.0025	0.0019
180	0.0370	0.0339	0.0277	0.0231	0.0196	0.0168	0.0146	0.0128	0.0113	0.0101	0.0090	0.0081	0.0052	0.0036	0.0026	0.0020
185	0.0393	0.0361	0.0295	0.0246	0.0208	0.0179	0.0155	0.0136	0.0120	0.0107	0.0096	0.0086	0.0055	0.0038	0.0028	0.0021
190	0.0417	0.0382	0.0313	0.0261	0.0221	0.0189	0.0164	0.0144	0.0127	0.0113	0.0101	0.0091	0.0058	0.0040	0.0030	0.0023
195	0.0441	0.0404	0.0330	0.0275	0.0233	0.0200	0.0173	0.0152	0.0134	0.0119	0.0107	0.0096	0.0061	0.0043	0.0031	0.0024
200	0.0464	0.0426	0.0348	0.0290	0.0245	0.0211	0.0183	0.0160	0.0141	0.0126	0.0113	0.0102	0.0065	0.0045	0.0033	0.0025

Commissioning, settings

Check:
- ■ the connections,
- ■ the positions of the microswitches SW associated with the current inputs,
- ■ the general parameters in the **status** menu.

Set the following:
- ■ OL1 and OL2 set points as %.
The protection may be disabled by being set to 999%: all the outputs are set to zero, but heat rise is calculated and may be read on the pocket terminal or via the communication link (Jbus/Modbus),
- ■ time constants T1 and T2,
- ■ negative sequence factor adjust.

T1 and T2 setting
For rotating machines, T1 < T2, since there is no ventilation when the motor is stopped.
For transformers, capacitors or cables, T1 = T2.

Adjust setting
For motor, the adjust factor may have the following values: 0 - 2,25 - 4,5 - 9.

For asynchronous motors the setting is determined as follows:
- ■ calculate k

$$k = 2 \times \frac{Cd}{Cn} \times \frac{1}{g \cdot \left(\frac{Id}{Ib}\right)^2} - 1$$

Cn, Cd = rated and starting torque,
Ib, Id = rated and starting current
g = pole slipping
- ■ choose the adjust value that is the closest to k.

For transformers, capacitors or cables, adjust = 0

Characteristics

hot state detection set point OL1	
setting	50 to 200%
resolution	1%
inhibition	999%
tripping set point OL2	
setting	50 to 200%
resolution	1%
heat rise time constant T1	
setting	5 mn to 120 mn
cooling time constant T2	
setting	5 mn to 600 mn
accounting for harmonics	
numbers	1 to 21
accounting for negative sequence factor adjust	
setting	none (0), low (2.25), average (4.5), high (9)
heat rise measurement heating	
measurement range	0% to 999%
characteristic times	
accuracy (4)	2%
outputs available for control logic	
hot status set point reached	F431/1
tripping set point reached	F431/2

remote reading, remote setting* (1)		
function code F43	43h	
identification number	1	
parameters	hot state detection set point OL1	unit: % (2)
(order of parameters)	tripping set point OL2	unit: % (2)
	neg. sequence component factor adjust	unit: index (3)
	heat rise time constant T1	unit: mn
	cooling time constant T2	unit: mn

(1) the data formats are defined in the manuals which describe each communication protocol.
(2) rated heat rise percentage of the equipment to be protected when it is operating with its rated load.
(3) meaning of negative sequence index:
0: adjust setting = 0
1: adjust setting = 2.25
2: adjust setting = 4.5
3: adjust setting = 9
(4) in reference conditions (IEC 60255-8).

Sensors

Thermal overload protection is related to the currents connected to the following connectors::

current	sensor	connector
	1A or 5A CT	2B
	CSP	2L1, 2L2, 2L3

* function available as of version 9802 SFT2800.

Negative sequence / unbalance

ANSI code	46	
function n°	F45X	$1 \leqslant X \leqslant 2$

Operation

This functions is designed to protect equipment against unbalances:

- it picks up when the negative sequence component of phase currents is greater than the set point,
- it is time delayed. The time delay may be definite or IDMT time (see curve).

Negative sequence current Ii is calculated for the 3 phase currents:

$$Ii = \frac{1}{3} \times \left(\vec{I1} + a^2 \vec{I2} + a\vec{I3} \right)$$

with $a = e^{j\frac{2\pi}{3}}$

When Sepam is connected to 2 phase current sensors only, the negative sequence current is:

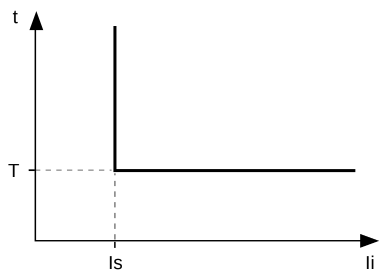
$$Ii = \frac{1}{\sqrt{3}} \times \left(I1 - a^2 I3 \right)$$

with $a = e^{j\frac{2\pi}{3}}$

The function may be used to display the negative sequence percentage on the pocket terminal.
It corresponds to the ratio Ii/Ib expressed as a percentage
(Ib: equipment basis current set in the **status** menu).

Definite time delay

For Ii > Is, the time delay is definite (independent of Ii) and equal to T.



Definite time protection principle.

IDMT time delay

For Ii > Is, the time delay depends on the value of Ii/Ib.
T corresponds to the time delay for Ii/Ib = 5.

IDMT protection principle.

The tripping curve is defined according to the following equations:

- for Is/Ib ≤ Ii/Ib ≤ 0.5

$$t = \frac{3.19}{(Ii/Ib)^{1.5}} .T$$

- for 0.5 ≤ Ii/Ib ≤ 5

$$t = \frac{4.64}{(Ii/Ib)^{0.96}} .T$$

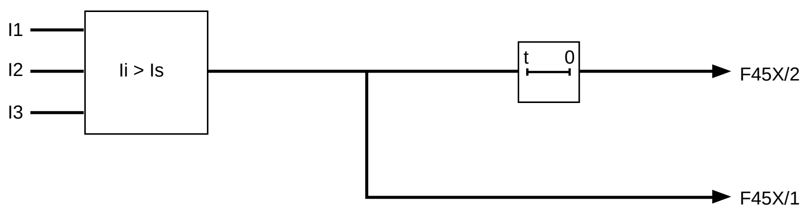
- for Ii/Ib > 5

t = T

The function takes into account negative sequence current variations during the time delay.

The negative sequence measurement expressed as a percentage of the basis current may be accessed via the pocket terminal.
It is available even if the protection is disabled.

Block diagram



Characteristics

curve		
setting		definite, IDMT
Is set point		
setting	definite time	10% Ib ⩽ Is ⩽ 500% Ib
	IDMT	10% Ib ⩽ Is ⩽ 50% Ib
resolution		1%
accuracy (1)		±5%
inhibition		999 %Ib
T time delay		
setting	definite time	100 ms ⩽ T ⩽ 655 s
	IDMT	100 ms ⩽ T ⩽ 1 s
resolution		10 ms or 1 digit
accuracy (1)	definite time	±2% or ±25 ms
	IDMT	±5 ou ±35 ms :
drop out/pick-up ratio		(93.5 ±5)%
current unbalance % measurement (Ii)		
measurement range		1%Ib to 999%Ib
accuracy (1)		±5% at In
resolution		1%
characteristic times		
instantaneous tripping time		< 85 ms
time delayed tripping time		according to time delay
memory time		< 65 ms
fault recognition time		90 ms < t < 120 ms
return time		< 45 ms
outputs available for program logic		
instantaneous	F45X/1	1 ⩽ X ⩽ 2
time delayed	F45X/2	1 ⩽ X ⩽ 2
remote reading, remote setting* (1)		
function code F45	45h	
identification number	X (2)	
parameters	curve	unit: 0..1 (3)
(order of parameters)	Is set point	unit: % (4)
	T time delay	unit: 10 x ms

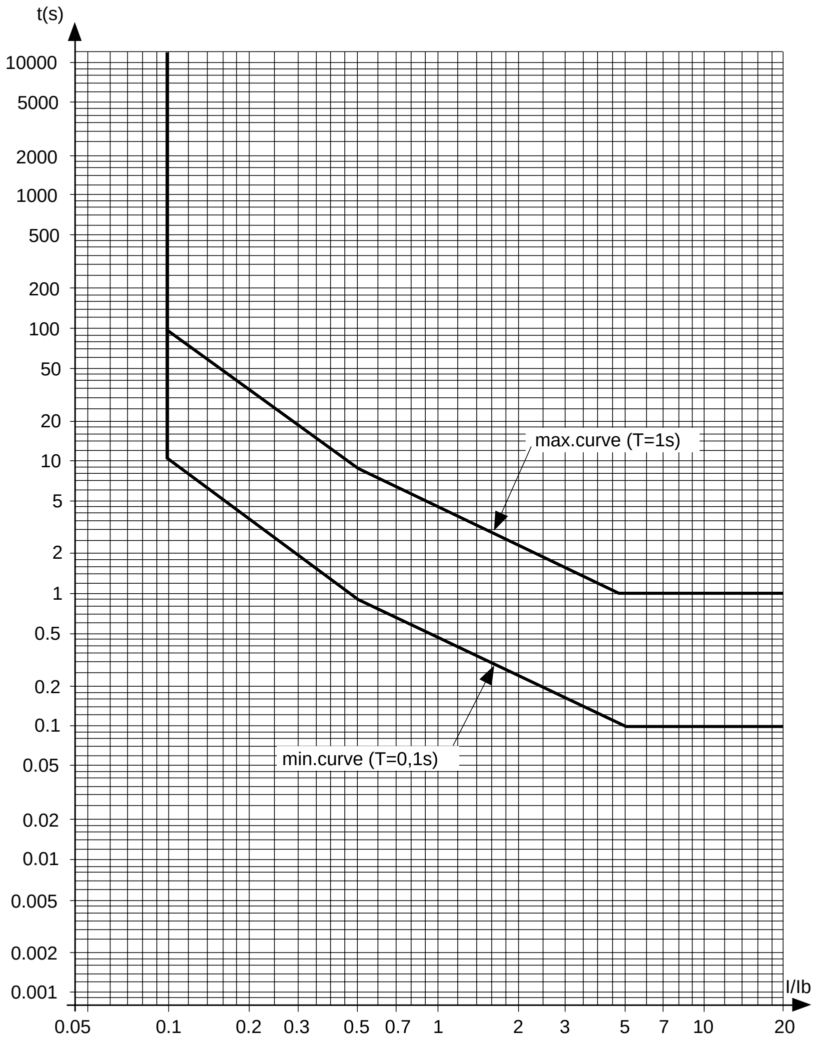
(1) the data formats are defined in the manuals which describe each communication protocol.
(2) the number of protection functions depends on the type of Sepam.
(3) meaning of curve index:
0: definite time,
1: IDMT.
(4) percentage of basis current of load Ib.
(5) under reference conditions (IEC 60255.6)

Sensors

Negative sequence unbalance protection is related to the currents connected to the following connectors:

current	sensor	connector
	1A or 5A CT	2B
	CSP	2L1, 2L2, 2L3

IDMT tripping curve



Commissioning, settings

Check:
■ the connections,
■ the positions of the microswitches SW associated with the current inputs,
■ the general parameters in the **status** menu.

Set the following:
■ type of time delay:
□ definite time,
□ IDMT;
■ Is set point:
Is is set as a percent of the basis current Ib.
The 999% setting may be used to inhibit the protection: all the outputs are set to 0.
■ T time delay:
□ definite time: T is the operation time delay,
□ IDMT: T is the operation time delay at 5Ib.

The negative sequence unbalance time delay setting must be greater than the earth fault protection setting so as to avoid unwanted tripping before the earth fault protection in the presence of earth fault current.

Typical settings
■ Generator:
□ definite time,
□ Is = 0.15 Ib.

■ Motor controlled by contactor / fuse:
□ IDMT,
□ 0.3Ib < Is < 0.4 Ib,
□ T > 5 s.

How does the user find out the tripping time for different negative sequence current values for a given curve?
Using the chart, the user finds the value of K that corresponds to the desired negative sequence current. The tripping time is equal to KT.

Example
Given a tripping curve with the setting T = 0.5s
What will the tripping time be at 0.6Ib?
Using the chart, find the value of K that corresponds to 60% of Ib. It is
K = 7.55. The tripping time is: 0.5 x 7.55 = 3.755 s

Ii (% Ib)	K
10	99.95
15	54.50
20	35.44
25	25.38
30	19.32
33.33	16.51
35	15.34
40	12.56
45	10.53
50	9.00
55	8.21
57.7	7.84
60	7.55
65	7.00
70	6.52
75	6.11
80	5.74
85	5.42
90	5.13
95	4.87
100	4.64
110	4.24
120	3.90
130	3.61
140	3.37
150	3.15
160	2.96
170	2.80
180	2.65
190	2.52
200	2.40

Ii (% Ib)	K
210	2.29
220	2.14
230	2.10
240	2.01
250	1.94
260	1.86
270	1.80
280	1.74
290	1.68
300	1.627
310	1.577
320	1.53
330	1.485
340	1.444
350	1.404
360	1.367
370	1.332
380	1.298
390	1.267
400	1.236
410	1.18
420	1.167
430	1.154
440	1.13
450	1.105
460	1.082
470	1.06
480	1.04
490	1.02
⩾ 500	1

* function available as of version 9802 SFT2800.

Starts per hour

ANSI code	66
function n°	F421

Operation

This function is three-phase.
It picks up when the number of starts reaches the following limits:

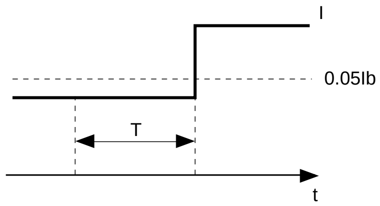
■ maximum number of starts allowed per hour (Nstart),
■ maximum allowed number of consecutive hot starts (Hstart),
■ maximum allowed number of consecutive cold starts (Cstart).

Set the following:

■ number of starts still allowed before the maximum, if the protection has not picked up,
■ waiting time before a start is allowed, if the protection has picked up.

The information is saved in the event of an auxiliary power failure.

Starting is detected when the absorbed current becomes greater than 5% of Ib current after having been lower during the time delay T.



Detection of starting

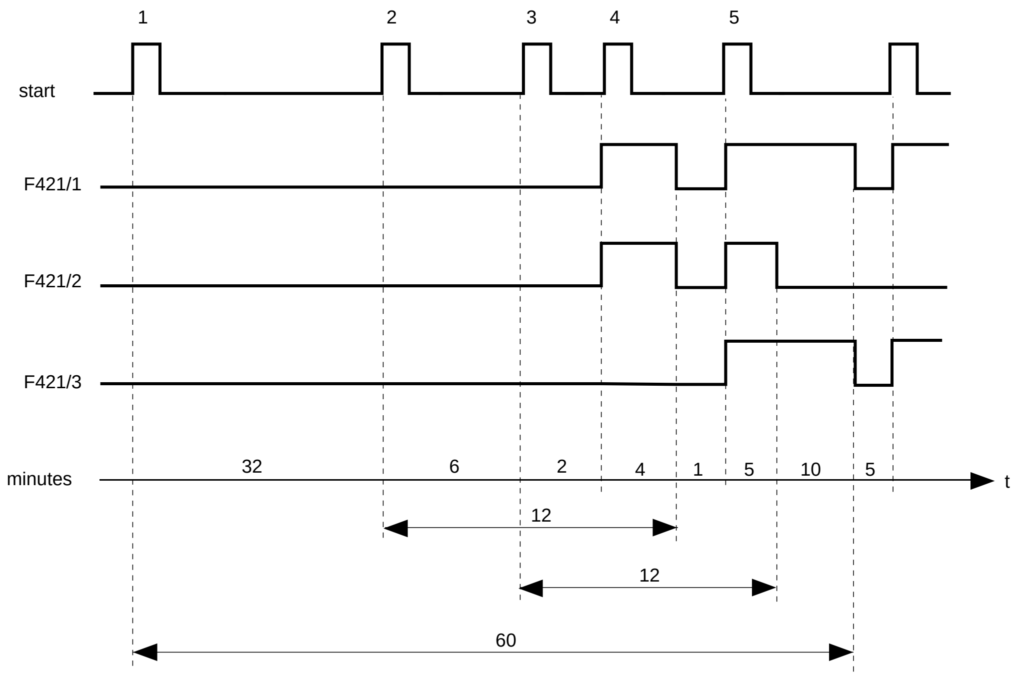
The number of starts per hour is the number of starts counted during the last 60 minutes.

The number of consecutive starts is the number of starts counted during the last 60/Nstart minutes, Nstart being the number of starts allowed per hour.

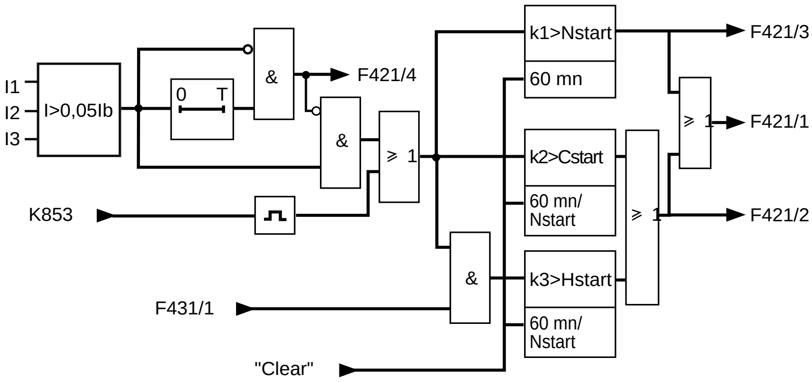
Motor hot status corresponds to overrunning of the first set point of the thermal overload function.

It is posible to increment the number of starts by a logic data input.

Example
Nstart = 5 and Hstart = 3
Consecutive starts are counted over an interval of 60/Nstart, i.e. 12 minutes.



Block diagram



Characteristics

Nstart total number of starts		
setting	1 to 60	
resolution	1	
Hsart and Cstart number of consecutive hot and cold starts		
setting	1 to Nt	
resolution	1	
T time delay between starts		
setting	500 ms ⩽ T ⩽ 655 s	
resolution	10 ms or 1 digit	
accuracy [(1)]	±2% or ±25 ms	
waiting time measurement		
measurement range	1 mn to 60 mn	
resolution	1 mn	
accuracy [(1)]	±2 mn	
N number of remaining starts measurement		
measurement range	1 to 60	
resolution	1	
outputs available for program logic		
total or consecutive starts	F421/1	
consecutive	F421/2	
total	F421/3	
lock-out between starts in progress	F421/4	
remote reading, remote setting* [(1)]		
function code F42	42h	
identification number	1	
parameters (order of parameters)	N start: total number of starts	unit: 1..60
	H start: number of consecutive hot starts	unit: 1..60
	C start: number of consecutive cold starts	unit: 1..60
	T time between starts	unit: 10 x ms

[(1)] under reference conditions (IEC 60255-6)
[(2)] the data formats are defined in the manuals which describe each communication protocol.

* function available as of version 9802 SFT2800.

Commissioning, setting

Check:
■ the connections,
■ the positions of the microswitches SW associated with the current inputs,
■ the general parameters in the **status** menu.

Set the following:
■ N start: starts per hour, N start may be set to 999 to disable the protection; all the outputs are set to zero,
■ H start: number of consecutive hot starts,
■ C start: number of consecutive cold starts,
■ T: time delay between starts, which defines a minimum shutdown time before another start will be allowed and counted.

The T time delay between starts has several possible uses:
□ to space out consecutive starts by a minimum time,
□ to avoid counting a start during transient current cancellation, e.g. changeover to synchronous operation after asynchronous starting.

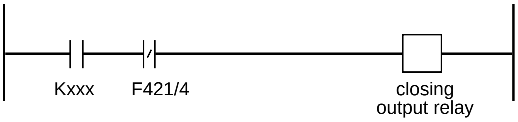
Sensors

The **starts per hour** protection is related to the currents connected to the following connectors:

current	sensor	connector
	1A or 5A CT	2B
	CSP	2L1, 2L2, 2L3

Precaution

It is **necessary** to use the **lock-out between starts in progress** (F421/4) data item in program logic in order for all the starts to be counted.



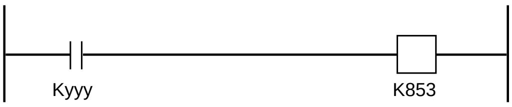
Kxxx identifies the closing condition.
Diagram of use of lock-out between starts data

Special use

During reacceleration, the motor undergoes stress similar to starting stress without the current having previously dropped to a value of less than 5% of Ib.

This logic data may be used to increment the start counters.

(1) under reference conditions (IEC 60255-6)



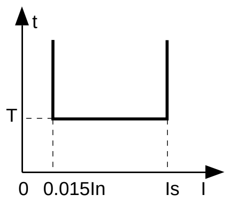
Kyyy identifies reacceleration.
Diagram of use of user-set incrementation

Phase undercurrent

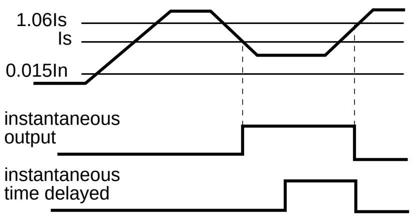
ANSI code	37
function n°	F221

Operation

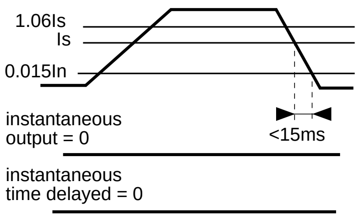
This protection is single-phase:
■ it picks up when phase 1 current is less than the set point Is,
■ it is inactive when the current is less than 1.5% of In,
■ it is insensitive to current drops (breaking) due to circuit breaker tripping,
■ it includes a definite time delay T.



Operating principle.



Case of current sag.



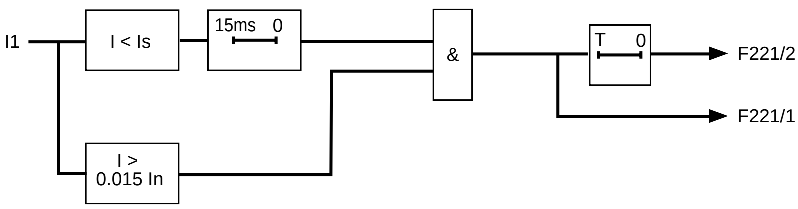
Case of circuit breaker opening.

Commissioning, settings

Check:
■ the connections,
■ the positions of the microswitches SW associated with the current inputs,
■ the general parameters in the **status** menu.

Set the following:
■ Is current: Is is set as a percentage of service current (Ib).
Setting Is to 999% Ib disables the protection: all the outputs are set to zero.
■ T time delay

Block diagram



Characteristics

Is set point		
setting	5%Ib ⩽ Is ⩽ 100%Ib by steps of 1%	
accuracy (1)	±5%	
inhibition	999%	
drop out/pick-up ratio	(106 ±5)% for Is > 0.1 In	
T time delay		
setting	50 ms ⩽ T ⩽ 655 s	
accuracy (1)	±2% or ±25 ms	
resolution	10 ms or 1 digit	
characteristic times		
instantaneous tripping time	< 50 ms	
time delayed tripping time	T	
memory time	< 25 ms	
fault recognition time	10 ms < t < 40 ms	
reset time	< 45 ms	
outputs available for control logic		
instantaneous	F221/1	
time delayed	F221/2	
remote reading, remote setting* (2)		
function number	22h	
identification number	1	
parameters	Is set point	unit: % (3)
(order of parameters)	T time delay	unit : 10 x ms

(1) in reference conditions (IEC 60255-6).
(2) the data formats are defined in the manuals which describe each communication protocol.
(3) percentage of load basis current

Sensors

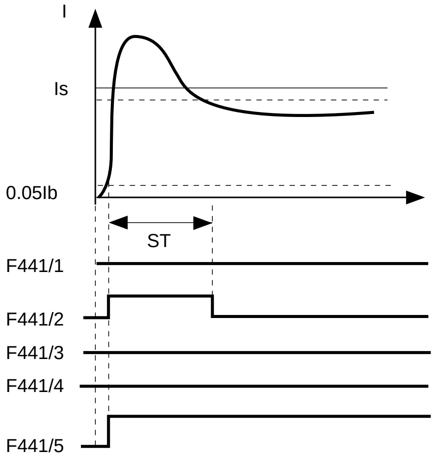
This protection is related to the CTs connected to the following connector:

current	sensor	connector
	1A or 5A CT	2B
	CSP	2L1, 2L2, 2L3

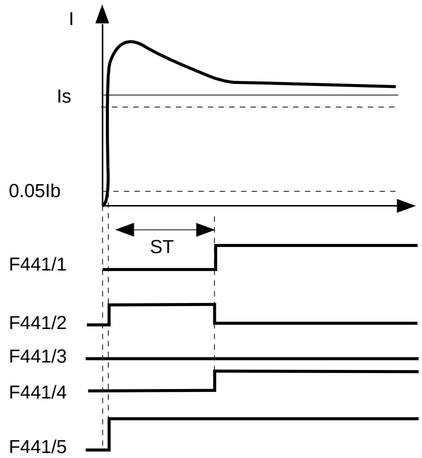
* function available as of version 9802 SFT2800.

Excessive starting time and locked rotor

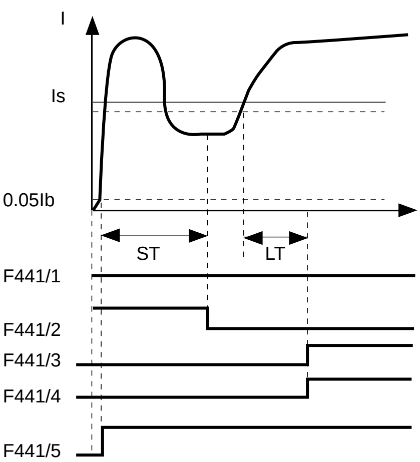
ANSI code	**51LR**
function n°	F441



Case of normal starting



Case of excessive starting time



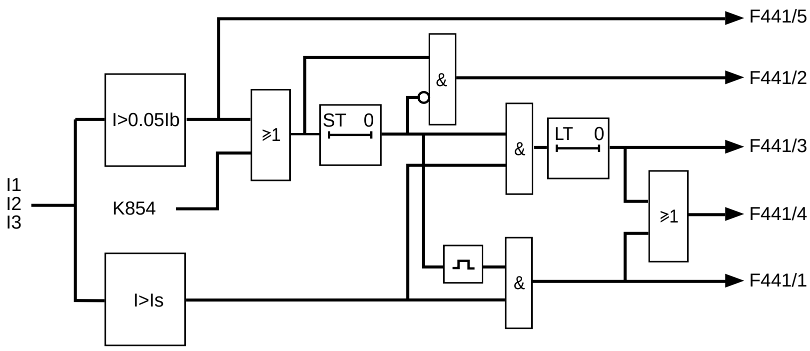
Case of a locked rotor

Operation

This function is three-phase.
It comprises two parts:
■ excessive starting time: during starting, this protection picks up when one of the 3 phase currents is greater than the set point Is for a longer time period than the time delay ST (normal starting time),
■ locked rotor: at the normal operating rate (post starting), this protection picks up when one of the 3 phase currents is greater than the set point Is for a longer time period than the time delay LT of the definite time type.

Starting is detected when the absorbed current is 5% greater than the Ib current. The time delay ST which corresponds to the normal starting time may be reinitialized by a logic data input for a particular use.

Block diagram

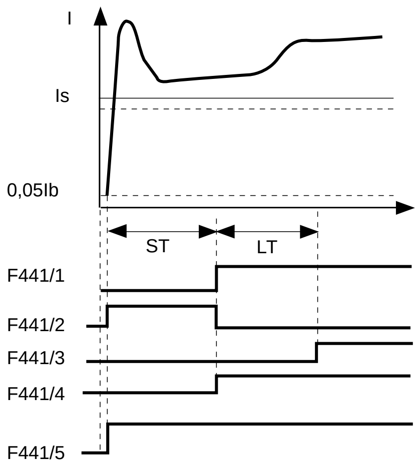


Commissioning, settings

Check:
■ the connections,
■ the positions of the microswitches SW associated with the current inputs,
■ the general parameters in the **status** menu.

Set the following:
■ Is set point: Is is set as a percentage of the operating currrent (Ib). The value of Is must be between the operating current (Ib) value and the starting current value.

999 % Ib may be set to disable the protection: all the outputs are set to zero:
■ ST time delay: ST corresponds to the normal starting time;
■ LT time delay: LT is designed for reacceleration which is not detected as being a restart.



Case of excessive starting time followed by a locked rotor

Sensors

Excessive starting time and locked rotor protection is related to the currents connected to the following connectors:

current	sensor	connector
	1 A or 5 A CT	2B
	CSP	2L1, 2L2, 2L3

Characteristics

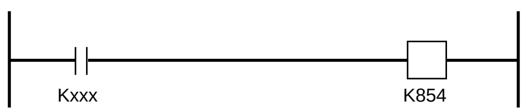
Is set point		
setting		50% Ib ⩽ Is ⩽ 500% Ib
resolution		1%
accuracy (1)		±5%
inhibition		999 %Ib
percentage of pick-up		(93.5 ±5)%
ST and LT time delays		
setting	ST	500 ms ⩽ T ⩽ 655 s
	LT	50 ms ⩽ T ⩽ 655 s
resolution		10 ms or 1 digit
accuracy (1)		±2% or ±25 ms
characteristics times		
excessive starting time tripping time	< 40 ms	
locked rotor tripping time	LT	
memory time	< 25 ms	
fault recognition time	< 30 ms	
reset time	< 45 ms	
outputs available for control logic		
excessive starting time	F441/1	
ST time delay in progress	F441/2	
locked rotor	F441/3	
F441/1 or F441/3	F441/4	
I greater than 5% Ib	F441/5	
remote reading, remote setting* (1)		
function code	F44	44h
identification number	1	
parameters	Is	unit: % Ib (2)
(order of parameters)	ST time delay	unit: 10 x ms
	LT time delay	unit: 10 x ms

(1) the data formats are defined in the manuals which describe each communication protocol.
(2) percentage of basis current of load Ib.
(3) under reference conditions (IEC 60255-6)

Special use

Reacceleration
During reacceleration, the motor absorbs current that is similar to starting current (> Is) without the current having previously dropped to a value of 5% less than Ib.
A logic data input may be used to:
■ reset the **excessive starting time** protection,
■ set the **locked rotor** protection LT time delay to a low value.

Diagram of use



Kxxx identifies reacceleration

* function available as of version 9802 SFT2800.

Phase-to-phase undervoltage

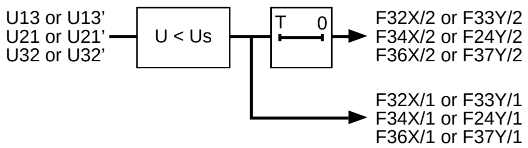
ANSI code	27
function n°	F32X[1] for U13 phase-to-phase undervoltage 1 ⩽ X ⩽ 2 F34X for U21 phase-to-phase undervoltage F36X for U32 phase-to-phase undervoltage F33Y for U13' phase-to-phase undervoltage 1 ⩽ Y ⩽ 2 F24Y for U21' phase-to-phase undervoltage F37Y for U32' phase-to-phase undervoltage

[1] function not available on S25.

Operation

This protection is single-phase:
■ it picks up when the system voltage is less than the set point Us,
■ the protection includes a definite time delay,
■ the set point and time delay are independent for each single-phase function,
■ if there is only one sensor, the F34X and F24Y protections operate with system undervoltage (system voltage setting):
□ based on a single phase voltage signal, if the phase VT ratio number parameter is V,
□ based on a single system voltage signal, if the phase VT ratio number parameter is 1U.

Block diagram



Commissioning, setting

Check:
■ the connections,
■ the positions of the microswitches SW associated with the voltage inputs,
■ the general parameters in the **status** menu.

status		V	1U	3U
function n°	undervoltage			
F32, F33	U13, U13'	[1]	[1]	■
F34, F24	U21, U21'	■	■	■
F36, F37	U32, U32'	[1]	[1]	■

[1] it is impossible to set the protection, the protection is disabled and the corresponding outputs are set to zero.

Set the following:
■ Us set point:
Us is set in rms, volts or kilovolts. The 999 kV setting disables the protection: all the outputs are set to zero.
■ T time delay

Sensors

This protection is related to the voltages of the VTs connected to the following connector:

U13, U21, U32 voltages

Sepam	connector
S36*	4A [1]
S26*	3A

[1] 3A connector for S36*TR and S36TS models.

U13', U21', U32' voltages

Sepam	connector
S36*TR	4A
S36TS	4A

If there is only one sensor (phase-to-neutral or phase-to-phase voltage), the voltage signal is connected to terminals 4 and 5 of the connector, whatever the phase.

* S35, S25 for earlier versions.

Characteristics

Us set point	
setting	5% Un to 100%Un
accuracy [1]	±1.5%Un to 0.5Un, ±5%Un to 0.05Un
resolution	1 Volt or 1 digit
drop out/pick-up ratio	(103 ±25)% for Us > 0.1 Un
T time delay	
setting	50 ms to 655 s
accuracy [1]	±2% or 35 ms
resolution	10 ms or 1 digit
characteristic times	
instantaneous output response time	< 60 ms
time delayed tripping time	T
memory time	< 25 ms
fault recognition time	< 40 ms
reset time	< 45 ms

outputs available for program logic				
instantaneous	F32X/1 F34X/1 F36X/1	1 ⩽ X ⩽ 2	F33Y/1 F24Y/1 F37Y/1	1 ⩽ Y ⩽ 2
time delayed	F32X/2 F34X/2 F36X/2	1 ⩽ X ⩽ 2	F33Y/2 F24Y/2 F37Y/2	1 ⩽ Y ⩽ 2

remote reading, remote setting* [1]		
function code F32, F33	32h and 33h	
identification number	X, Y [2]	
parameters	Us set point	unit: V
(order of parameters)	T time delay	unit: 10 x ms
function code F34, F24	34h and 24h	
identification number	X, Y [2]	
parameters	Us set point	unit: V
(order of parameters)	T time delay	unit: 10 x ms
function code F36, F37	36h and 37h	
identification number	X, Y [2]	
parameters	Us set point	unit: V
(order of parameters)	T time delay	unit: 10 x ms

(1) the data formats are defined in the manuals which describe each communication protocol.
(2) the number of protection functions depends on the type of Sepam.
(3) in reference conditions (IEC 60255-6).

* function available as of version 9802 SFT2800.

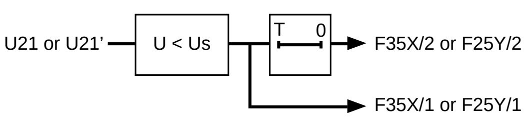
Remanent undervoltage

ANSI code	27R	
function n°	F35X for remanent undervoltage (U or V)	1 ⩽ X ⩽ 2
	F25Y for remanent undervoltage (U’ or V’)	1 ⩽ Y ⩽ 2

Operation

This protection is single-phase:
■ it picks up when phase-to-phase voltage U21 is less than the set point Us,
■ it includes a definite time delay,
■ if there is only one sensor, the protection operates as phase-to-phase undervoltage protection (adjustable phase-to-phase voltage):
□ via a single phase-to-neutral voltage signal if the phase VT number set up is V,
□ via a single phase-to-phase voltage signal if the phase VT number set up is 1U.

Block diagram



Commissioning, setting

Check:
■ the connections,
■ the positions of the microswitches SW associated with the voltage inputs,
■ the general parameters in the **status** menu.

Set the following:
■ Us set point: Us is set in rms, volts or kilovolts. The 999 kV setting disables the protection: all the outputs are set to zero.
■ T time delay

Sensors

This protection is related to the voltages of the VTs connected to the U21 input of the following connectors:

U21 voltage

Sepam	connector
S36*	4A [1]
S26*	3A

[1] 3A connector for S36*TR and S36TS models.

U21’ voltage

Sepam	connector
S36*TR	4A
S36TS	4A

* S35, S25 for earlier versions.
** function available as of version 9802 SFT2800.

Characteristics

Us set point		
setting	5%Un to 100%Un	
accuracy	±5%	
drop out/pick-up ratio	(104 ±3)% for Us > 0.1 Un	
resolution	1 Volt or 1 digit	
T time delay		
setting	50 ms to 655 s	
accuracy [1]	±2% or 35 ms	
resolution	10 ms or 1 digit	
characteristic times		
instantaneous output reponse time	< 60 ms	
time delayed tripping time	T	
memory time	< 25 ms	
fault recognition time	< 40 ms	
reset time	< 45 ms	
outputs available for program logic		
instantaneous	F35X/1 1 ⩽ X ⩽ 2	F25Y/1 1 ⩽ Y ⩽ 2
time delayed	F35X/2	F25Y/2
remote reading, remote setting [2]**		
function code F35, F25	35h and 25h	
identification number	X, Y [3]	
parameters	Us set point	unit: V
(order of parameters)	T time delay	unit: 10 x ms

[1] in reference conditions (IEC 60255-6).
[2] the data formats are defined in the manuals which describe each communication protocol.
[3] the number of protection functions depends on the type of Sepam.

Positive sequence undervoltage and phase rotation direction check

ANSI code	27D - 47	
function n°	F38X	1 ⩽ X ⩽ 2

Operation

Positive sequence undervoltage
This protection picks up when the positive sequence component Vd of the three-phase system voltages is less than the set point Vsd with:

$$\vec{Vd} = (1/3)\,[\vec{V1} + a\vec{V2} + a^2\vec{V3}]$$

$$\vec{Vd} = (1/3)\,[\vec{U21} - a^2\,\vec{U32}]$$

with $V = \frac{U}{\sqrt{3}}$ and $a = e^{j\frac{2\pi}{3}}$

- it includes a definite time delay T,
- it allows drops in motor electrical torque to be detected.

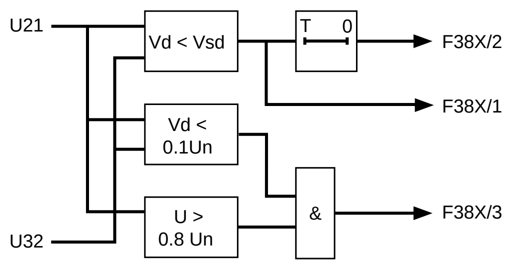
Phase rotation direction
This protection also allows the phase rotation direction to be detected.

The protection considers that the phase rotation direction is inverse when the positive sequence voltage is less than 10% of Un and when the system voltage is greater than 80% of Un.

Positive sequence voltage measurement
This protection also indicates the positive sequence voltage value on the pocket terminal.

The voltage is expressed in volts or kilovolts.
When the phase rotation direction is inverse the following is displayed:
Vd = Inverse

Block diagram



Sensors

This protection is related to the voltages of the VTs connected to the following connector:

Sepam	connector
S36*	4A (1)
S26*	3A

(1) 3A connector for S36*TR and S36TS models.

Commissioning, setting

Check:
- the connections,
- the positions of the microswitches SW associated with the voltage inputs,
- the general parameters in the **status** menu. The number of voltages set up in the phase VT heading of the **status** menu should be 3U. Otherwise it is impossible to set the protection.

Set the following:
- Vsd voltage:

Vsd is set in rms, volts or kilovolts. The 999 kV setting disables the protection: all the outputs are set to zero.
- T time delay

Characteristics

Vsd set point		
setting	30%Vn to 100%Vn	
accuracy (1)	±2%	
drop out/pick-up ratio	(103 ±25)%	
resolution	1 V or 1 digit	
T time delay		
setting	50 ms to 655 s	
accuracy (1)	±2% or +50 ms	
resolution	10 ms or 1 digit	
characteristic times		
instantaneous output response time	< 80 ms	
time delayed tripping time	T	
memory time	< 65 ms	
fault recognition time	< 65 ms	
reset time	< 85 ms	
Vd measurement		
measurement range	0 to 150% Vn (2)	
accuracy	±5% at Vn	
resolution	10 V or 1 digit	
outputs available for program logic		
instantaneous	F38X/1 1 ⩽ X ⩽ 2	
time delayed	F38X/2	
inverse rotation direction detection	F38X/3	
remote reading, remote setting (3)**		
function code F38	38h	
identification number	X (4)	
parameters	Vsd set point	unit: V
(order of parameters)	T time delay	unit: 10 x ms

$Vn = Un / \sqrt{3}$
(1) in reference conditions (IEC 60255-6).
(2) Vd = inverse displayed if the system is rotating backwards.
(3) the formats of remotely read data are defined in the manuals that describe each communication protocol (JBUS, FIP,...)
(4) the number of protection functions depends on the type of Sepam.

* or S35, S25 for earlier versions.
** function available as of version 9802 SFT2800.

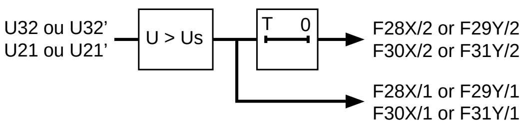
Phase-to-phase overvoltage

ANSI code	59
function n°	F28X for U32 overvoltage F30X for U21 overvoltage 1 ⩽ X ⩽ 2 F29Y for U32' overvoltage F31Y for U21' overvoltage 1 ⩽ Y ⩽ 2

Operation

This protection is single-phase:
■ it picks up when the phase-to-phase voltage is greater than the set point Us.
■ the protection includes a definite time delay,
■ the set point and time delay are independent for each single-phase function,
■ if there is only one sensor, the F30X and F31Y protections operate with system overvoltage (phase-to-phase voltage setting):
□ based on a single phase-to-neutral voltage signal, if the phase VT ratio number parameter is V,
□ based on a single phase-to-phase voltage signal, if the phase VT ratio number parameter is 1U.

Block diagram



Commissioning, setting

Check:
■ the connections,
■ the positions of the microswitches SW associated with the voltage inputs,
■ the general parameters in the **status** menu

status		V	1U	3U
function n°	overvoltage			
F28, F29	U32, U32'	(1)	(1)	■
F30, F31	U21, U21'	■	■	■

(1) it is impossible to set the protection, the protection is disabled and the corresponding outputs are set to zero.

Set the following:
■ Us set point: Us is set in rms, volts or kilovolts. The 999 kV setting disables the protection: all the outputs are set to zero.
■ T time delay.

Sensors

This protection is related to the voltages of the VTs connected to the following connector:

U32, U21 voltages

Sepam	connector
S36*	4A (1)
S26*	3A

(1) 3A connector for S36*TR and S36TS models.

U32', U21' voltages

Sepam	connector
S36*TR	4A
S36TS	4A

If there is only one sensor (phase-to-neutral or phase-to-phase voltage), the voltage signal is connected to terminals 4 and 5 of the connector, whatever the phase.

Characteristics

Us set point				
setting	5%Un to 150%Un			
accuracy (1)	±1%			
resolution	1 V or 1 digit			
drop out/pick-up ratio	97% ±1%			
T time delay				
setting	50 ms to 655 s			
accuracy (1)	±2%, or 35 ms			
resolution	10 ms or 1 digit			
characteristic times				
instantaneous output response time	< 60 ms			
time delayed tripping time	T			
memory time	< 25 ms			
fault recognition time	< 40 ms			
reset time	< 45 ms			
outputs available for program logic				
instantaneous	F28X/1 F30X/1	1 ⩽ X ⩽ 2	F29Y/1 F31Y/1	1 ⩽ Y ⩽ 2
time delayed	F28X/2 F30X/2		F29Y/2 F31Y/2	
remote reading, remote setting (2)**				
function code F28, F29	28h et 29h			
identification number	X, Y (3)			
parameters	Us set point		unit: V	
(order of parameters)	T time delay		unit: 10 x ms	
function code F30, F31	30h and 31h			
identification number	X, Y (3)			
parameters	Us set point		unit: V	
(order of parameters)	T time delay		unit: 10 x ms	

(1) in reference conditions (IEC 60255-6).
(2) the data formats are defined in the manuals which describe each communication protocol.
(3) the number of protection functions depends on the type of Sepam 2000.

* S35, S25 for earlier versions.
** function available as of version 9802 SFT2800.

Neutral voltage displacement

ANSI code	59N
function n°	F39X for neutral voltage displacement Vo $1 \leqslant X \leqslant 2$ F41Y for neutral voltage displacement Vo' $1 \leqslant Y \leqslant 2$

Operation

This protection picks up when the neutral voltage Vo is greater than a set point Vso,
with $\overrightarrow{\mathbf{Vo}} = \overrightarrow{\mathbf{V1}} + \overrightarrow{\mathbf{V2}} + \overrightarrow{\mathbf{V3}}$,

■ it includes a definite time delay T,
■ neutral voltage is either calculated from the 3 phase voltages or measured by an external VT.

Commissioning, setting

Check:
■ the connections,
■ the positions of the microswitches SW associated with the voltage inputs,
■ the general parameters in the **status** menu.

Set the following:
■ Vso set point: Vso is set in rms, volts or kilovolts. The 999 kV setting disables the protection: all the outputs are set to zero.
■ T time delay.

Sensors

This protection is related to the voltages of the VTs connected to the following connectors:

Vo voltage

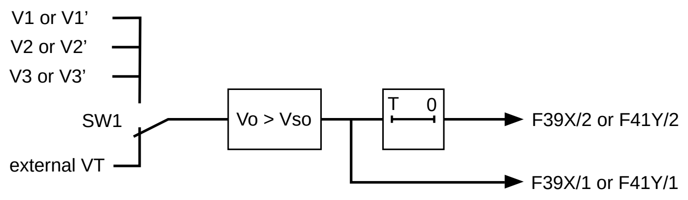
Sepam	connector
S36*	4A [1]
S26*	3A

[1] 3A connector for S36*TR and S36TS models.

Vo' voltage

Sepam	connector
S36*TR	4A
S36TS	4A

Block diagram



Characteristics

Vso set point		
setting	2% Un to 80% Un if Vnso [2] = sum 3V 2% Un to 80% Un if Vnso [2] = Uns / $\sqrt{3}$ 5% Un to 80% Un if Vnso [2] = Uns / 3	
accuracy [1]	±1% or 0.25% Un	
resolution	1 V or 1 digit	
drop out/pick-up ratio	(97 ±1)%	
T time delay		
setting	50 ms to 655 s	
accuracy [1]	±2%, or 25 ms at 2 Vso	
resolution	10 ms or 1 digit	
characteristic times		
instantaneous output response time	< 85 ms	
time delayed tripping time	T	
memory time	< 65 ms	
fault recognition time	< 65 ms	
reset time	< 85 ms	
outputs available for program logic		
instantaneous	F39X/1 $1 \leqslant X \leqslant 2$	F41Y/1 $1 \leqslant Y \leqslant 2$
time delayed	F39X/2	F41Y/2
remote reading, remote setting*[3]		
function code F39, F41	39h and 41h	
identification number	X, Y [4]	
parameters	Vso set point	unit: V
(order of parameters)	T time delay	unit: 10 x ms

[1] in reference conditions (IEC 60255-6).
[2] Vnso is one of the general parameters in the **status** menu.
[3] the formats of remotely read data are defined in the manuals that describe each communication protocol.
[4] the number of protection function modules depends on the type of Sepam.

* or S35, S25 for earlier versions.
** function available as of version 9802 SFT2800.

Negative sequence overvoltage

ANSI code	47	
function n°	F40X	1 ⩽ X ⩽ 2

Operation

This function picks up when the negative sequence of voltages (Vi) is greater than the setting (Vsi).

It includes a definite time T time delay.
The negative sequence voltage Vi is determined from the three phase voltages:

$$\vec{Vi} = (1/3)\,[\vec{V1} + a^2\vec{V_2} + a\vec{V_3}]$$

$$\vec{Vi} = (1/3)\,[\vec{U_{21}} - a\,\vec{U_{32}}]$$

with $a = e^{j2\pi/3}$

This function is used to display the negative sequence voltage on the pocket terminal.
The voltage is expressed in primary volts or kilovolts.

Commissioning, setting

Check:
■ the connections,
■ the positions of the microswitches SW associated with the voltage inputs,
■ general parameters in the **status** menu.

Access to the protection settings is impossible if the Number setting accessible via the **status** menu is set to V or 1U. The protection is inhibited in this case: all the outputs are set to zero.

Set the following:
■ Vsi set point: Vsi is set in rms, volts or kilovolts. The 999 kV setting may be used to inhibit the protection: all the outputs are set to 0.
■ T time delay.

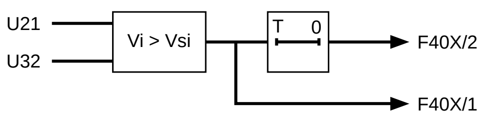
Sensors

This protection is related to the voltages of the VTs connected to the following connector:

Sepam	connector
S36*	4A [(1)]
S26*	3A

(1) 3A connector for S36*TR and S36TS models.

Block diagram



Characteristics

Vsi set point		
setting	2%Vn to 80%Vn	
accuracy (1)	±2% for Vi ⩾ 10% Un ±5% for Vi < 10% Un	
drop out/pick-up ratio	(97.5 ±2.5)% with Vsi > 10% Un	
resolution	1 V ou 1 digit	
T time delay		
setting	50 ms to 655 s	
accuracy (1)	±2% or 25 ms with 2 Vsi	
resolution	10 ms or 1 digit	
characteristic times		
instantaneous output response time	< 85 ms	
time delayed tripping time	T	
memory time	< 65 ms	
fault recognition time	< 60 ms	
reset time	< 80 ms	
Vi measurement		
measurement range	0 to 150% Un	
accuracy	±2% for Vi > 10% Un ±5% for Vi < 10% Un	
resolution	1 V or 1 digit	
outputs available for program logic		
instantaneous	F40X/1 1 ⩽ X ⩽ 2	
time delayed	F40X/2	
remote reading, remote setting (2)**		
function code F40	40h	
identification number	X (3)	
parameters	Vs set point	unit: V
(order of parameters)	T time delay	unit: 10 x ms

Vn = Un / $\sqrt{3}$
(1) in reference conditions (IEC 60255-6).
(2) the data formats are defined in the manuals which describe each communication protocol.
(3) the number of protection functions depends on the type of Sepam 2000.

* S35, S25 for earlier versions.
** function available as of version 9802 SFT 2800.

Rate of change of frequency protection

ANSI code	81R	
function n°	F58X	$1 \leqslant X \leqslant 2$

Operation

This protection picks up if the rate of change of frequency (dF/dt) of the voltage DC component is greater than the set point. It includes a definite time delay T.

The protection operates if:

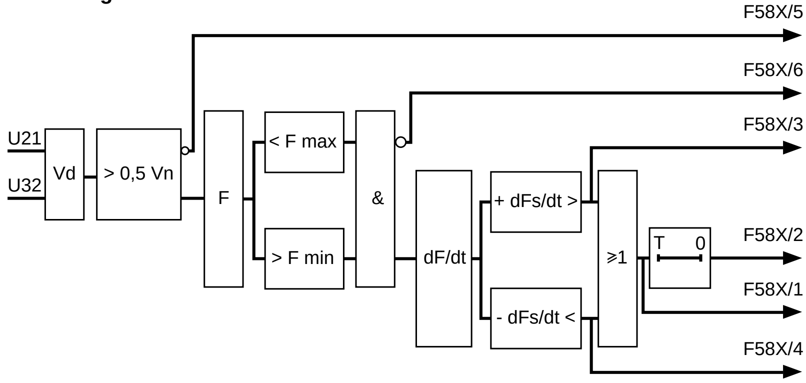
- the positive sequence voltage (Vd) is greater than 50% of the rated phase-to-neutral voltage (Vn),
- the system frequency measured is between 42.2 Hz and 56.2 Hz for 50 Hz systems and between 51.3 Hz and 67.8 Hz for 60 Hz systems,
- the value of the rate of change of frequency monitored is greater than the preset limit.

The positive sequence voltage is obtained as follows:

$$3\vec{Vd} = \vec{V1} + a\vec{V2} + a^2\vec{V3} \quad \text{or}$$

$$3\vec{Vd} = \vec{U21} - a^2\vec{U32} \quad \text{with } a = e^{2\pi j/3}$$

Block diagram



Fmin = 42.4 Hz or 51.3 Hz according to the system rated frequency.
Fmax = 56.2 Hz or 67.8 Hz according to the system rated frequency.

Sensors

Sepam	connector
S36	4A (1)
S26	3A

(1) 3A connector for S36TR and S36TS models.

Characteristics

dFs/dt set point		
setting	0.1 to 10 Hz/s	
accuracy (1)	- 0.05 Hz/s, + 5% or - 0.05 Hz/s, + 0.1 Hz/s	
drop-out/pick-up ratio	(93% ±5)%	
resolution	0.01 Hz/s	
T time delay		
setting	100 ms to 655 s	
accuracy (1)	±2% or ±40 ms	
resolution	10 ms or 1 digit	
outputs available for program logic		
instantaneous	F58X/1	$1 \leqslant X \leqslant 2$
time delayed	F58X/2	
dF/dt ⩾ + dFs/dt	F58X/3	
dF/dt ⩽ - dFs/dt	F58X/4	
voltage inhibition	F58X/5	
frequency inhibition	F58X/6	
remote reading, remote setting (2)		
function code F58	58h	
identification number	X	
parameters	dFs/dt set point	unit: 0.01 Hz/s
(order of parameters)	T time delay	unit: 10 x ms

(1) in reference conditions (IEC 60255-6).
(2) the data formats are defined in the manuals which describe each communication protocol.
(3) the number of protection function modules depends on the type of Sepam 2000.

Rate of change of frequency protection (cont'd)

Commissioning

Check:
■ the connections,
■ the positions of the microswitches SW associated with the voltage inputs,
■ the general parameters in the **status** menu.

Set the following:
■ dFs/dt set point:
dFs/dt is set in Hertz per second.

The 999 Hz/s setting disables the protection: all the outputs are set to zero.
■ T time delay.

It is impossible to access the protection settings if the Number setting in **phase VT** heading of the **status** menu is set to V or 1U. If that is the case, the protection is disabled: all the outputs are set to zero.

Application, setting

The rate of change of frequency protection is a complement to the underfrequency and overfrequency protections used to detect loss of mains protection or load shedding.

The protection settings must be consistent with the other frequency protections.

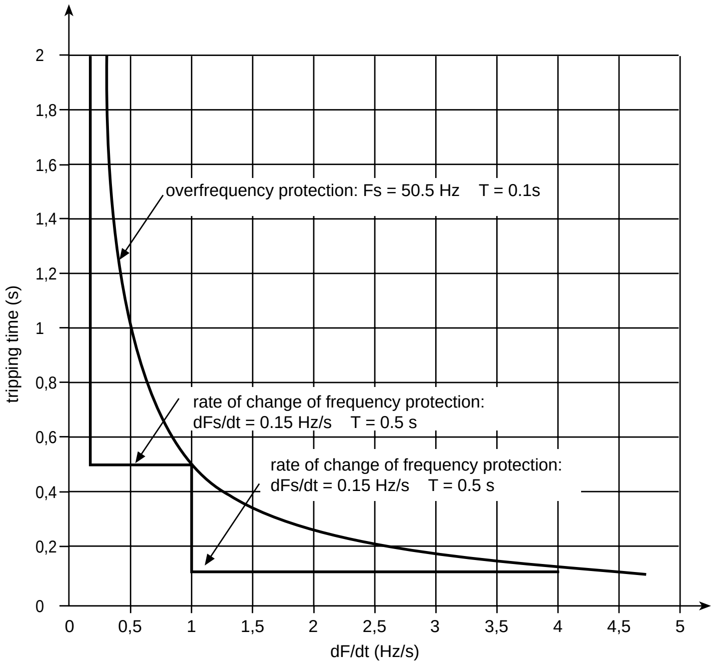
Loss of mains application
This function is used on the incomer of an installation which includes a generator that can be run in parallel with the mains.

Its role is to detect the loss of the mains, resulting in isolated operation of the generator. If the power through the mains prior to isolated generator operation is not zero, the generator frequency varies. The rate of change of frequency protection detects this conditions more rapidly than a conventional frequency protection would.

Other disturbances such as short-circuits, load changes and switching can cause frequency changes. The low set point may be temporarily reached during such conditions so a time delay is necessary.

In order to maintain the frequency derivative protection's advantage of speed compared to conventional frequency protections, a second, higher set point with a short time delay may be added.

Overfrequency and underfrequency protections in loss of mains applications are conventionally set to the fundamental frequency + 0.5 Hz or – 0.5 Hz. Based on the assumption of a constant rate of change of frequency, the tripping times of the rate of change of frequency protection and the underfrequency and overfrequency protections may be shown on the same graph:



Comparison of an overfrequency protection and two rate of change of frequency protections set points. The rate of change of frequency protection detects isolated generator operation faster than a frequency protection does.

In fact, the rate of change of frequency is not constant. Often the rate of change of frequency is the highest at the beginning of the disturbance and then decreases, which extends the frequency protection tripping time but does not affect the tripping time of the rate of change of frequency protection.

■ Low set point

□ If rules have been established by the utility, they should be followed.
□ If no rules are given by the utility:
- If the maximum rate of change of frequency on the mains in normal conditions is known, dFs/dt should be set above it.
- If no information on the mains is available, the low set point may be established based on generator data. A good approximation of the rate of change of frequency following a loss of mains accompanied by a load change ΔP is:

$$\frac{df}{dt} = -\frac{\Delta P * Fn}{2 * Sn * H}$$

with Sn: Rated load
Fn: Rated frequency
H: inertia constant MW*s/MVA

Typical inertia constant value:
0.5 ⩽ H ⩽ 1.5 for diesel and low rated generators (⩽ 2 MVA)
2 ⩽ H ⩽ 5 for gas turbine and medium rated generators (⩽ 40 MVA)

$$H = \frac{1}{2} \frac{J \times \Omega^2}{Sn}$$

with J = inertia moment
Ω = machine speed

Examples

rated load	2 MVA	20 MVA
inertia constant	0.5 s	2 s
load variation	0.1 MVA	1 MVA
df/dt	- 2.5 Hz/s	- 0.6 Hz/s

■ Low set point time delay

For good protection stability in the event of short-circuits or transient disturbances, the recommended time delay is 300 ms or more.
□ If an automatic recloser is in service upstream from the installation, detection of isolated generator operation and coupling circuit breaker opening should take place during the recloser isolation time.

■ High set point
The second set point may be chosen so that the rate of change of frequency tripping curve remains below the underfrequency and overfrequency protection curves.

If the frequency protections are set to Fn+/-0.5 Hz and if the low set point time delay of the rate of change of frequency protection is T, the high set point could be set to 0.5/T.

■ High set point time delay
No particular recommendations.

■ Recommendations on setting when no information is available

settings		rated generator 2 - 10 MVA	rated generator > 10 MVA
F581	dFs	0.5 Hz/s	0.2 Hz/s
	T	500 ms	500 ms
F582	dFs	2.5 Hz/s	1 Hz/s
	T	150 ms	150 ms

■ Precautions for use:
At the time the generator is being coupled to the mains, power oscillations may appear until the generator becomes fully synchronized.
The rate of change of frequency protection is sensitive to this phenomenon.

It is advisable to inhibit the protection for a few seconds after the closing of the circuit breaker.

Load shedding application
The rate of change of frequency protection may also be used for load shedding combined with underfrequency protections.

In such cases, it equips the installation's busbar protection.

Two methods are available:
■ acceleration of load shedding:
The rate of change of frequency protection commands load shedding. It acts faster than an underfrequency protection does and the value measured (df/dt) is directly proportional to the load to be shed.
■ inhibition of load shedding:
The rate of change of frequency protection inhibits load shedding in the case of a fast change in frequency. This method is used when it is considered that a strong change in frequency is not due to an overload but to a production facility insufficiency. Load shedding in those conditions is unnecessary.

When that is the case, the underfrequency protections must be time-delayed in order to be sure that the rate of change of frequency protection inhibition order will be conveyed before the tripping of the underfrequency protection (underfrequency protection tripping time setting T = 0.2 s).

In both of these applications, only negative rates of change of frequency protection are used.

Underfrequency

ANSI code	81	
function n°	F56X	$1 \leqslant X \leqslant 4$

Operation

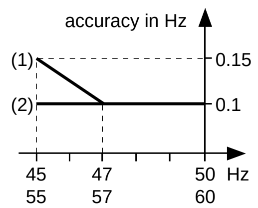
The protection may be supplied in different ways:
■ by U21 and U32, if the phase VT ratio number parameter is set to 3U. It picks up if the positive sequence voltage frequency is less than the set point Fs and if U21 voltage is greater than 20% (± 5%) of Un,
■ by a single voltage, phase-to-neutral or phase-to-phase, if the phase VT ratio number parameter is set to V or 1U.
It picks up if the frequency is less than the set point Fs and if the voltage is greater than 35% (± 5%) of Vn or Un respectively.

It includes a definite time delay T.

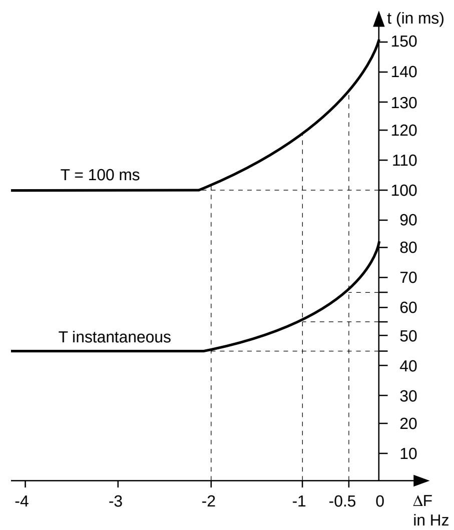
Commissioning, setting

Check:
■ the connections,
■ the positions of the microswitches SW associated with the voltage inputs,
■ lthe general parameters in the **status** menu.

Set the following:
■ Fs set point: Fs is set in Hertz. The 999 Hz setting disables the protection: all the outputs are set to zero.
■ T time delay.



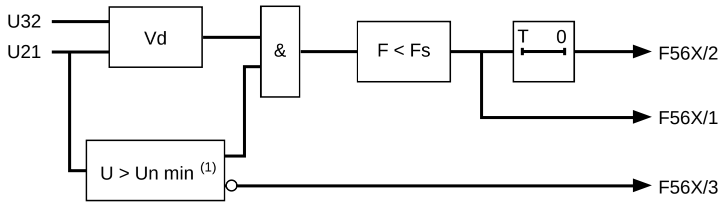
(1) curve for a measurement taken from a single phase-to-neutral or phase-to-phase voltage (U21).
(2) curve for a measurement taken on U21 and U32.



Time delay accuracy curve

* S35, S25 for earlier versions.
** function available as of version 9802 SFT2800.

Block diagram



(1) U min = 20% Un if phase VT number set up is equal to 3U,
35% Un if phase VT number set up is equal to 1U,
35% Un if phase VT number set up is equal to V.

Sensors

This protection is related to the voltages of the VTs connected to the following connector:

Sepam	connector
S36*	4A (1)
S26*	3A

(1) 3A connector for S36*TR and S36TS models.

If there is only one sensor (phase-to-neutral or phase-to-phase voltage), the voltage signal is connected to terminals 4 and 5 of the connector, whatever the phase.

Characteristics

Fs set point		
setting	45 to 50 Hz or 55 to 60 Hz	
resolution	0.1 Hz	
accuracy (1) U21 and U32 measurement U21 measurement	 0.1 Hz across the dynamic range measurement see curve	
drop out - pick-up difference	0.2 Hz ± 0.1 Hz	
T time delay		
setting	100 ms to 655 s	
resolution	10 ms or 1 digit	
accuracy (1)	± 2%, or 40 ms (see curve)	
characteristic times (1)		
instantaneous tripping time	see curve	
time delayed tripping time	T	
memory time	< 65 ms	
fault recognition time	< 65 ms	
reset time	< 85 ms	
outputs available for program logic		
instantaneous	F56X/1 $1 \leqslant X \leqslant 4$	
time delayed	F56X/2	
U21 < U min	F56X/3	
remote reading, remote setting (2)		
function code F56	56h	
identification number	X (3)	
parameters	Fs set point	unit: 0,1 x Hz
(order of parameters)	T time delay	unit : 10 x ms

(1) in reference conditions (IEC 60255-6) and df/dt < 3 Hz/s.
(2) the data formats are defined in the manuals which describe each communication protocol.
(3) the number of protection function modules depends on the type of Sepam.

Overfrequency

ANSI code	81	
function n°	F57X	1 ≤ X ≤ 2

Operation

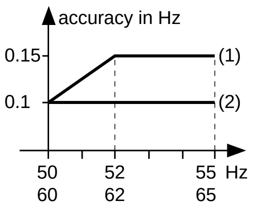
The protection may be supplied in different ways:
■ by U21 and U32, if the phase VT ratio number parameter is set to 3U. It picks up if the positive sequence voltage frequency is greater than the set point Fs and if U21 voltage is greater than 20% (± 5%) of Un,
■ by a single voltage, phase-to-neutral or phase-to-phase, if the phase VT ratio number parameter is set to V or 1U. It picks up if the frequency is greater than the set point Fs
and if the voltage is greater than 35% (± 5%) of Vn or Un respectively.

It includes a definite time delay T.

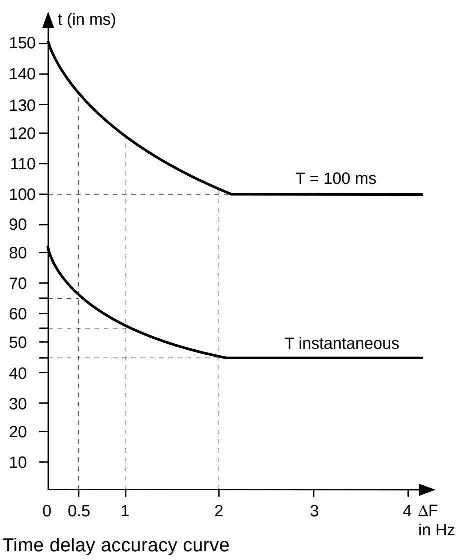
Commissioning, setting

Check:
■ the connections,
■ the positions of the microswitches SW associated with the voltage inputs,
■ the general parameters in the **status** menu.

Set the following:
■ Fs set point: Fs is set in Hertz.
The 999 Hz setting disables the protection: all the outputs are set to zero.
■ T time delay.



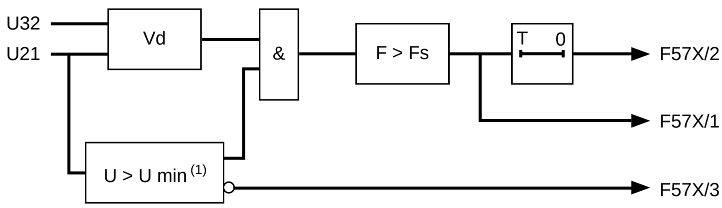
(1) curve for a measurement taken from a single phase-to-neutral or phase-to-phase voltage (U21).
(2) curve for a measurement taken on U21 and U32.



Time delay accuracy curve

* or S35, S25 for earlier versions.
** function available as of version 9802 SFT 2800.

Block diagram



(1) U min = 20% Un if phase VT number set up is equal to 3U,
35% Un if phase VT number set up is equal to 1U,
35% Un if phase VT number set up is equal to V.

Sensors

This protection is related to the voltages of the VTs connected to the following connector:

Sepam	connector
S36*	4A (1)
S26*	3A

(1) 3A connector for S36*TR and S36TS models.

If there is only one sensor (phase-to-neutral or phase-to-phase voltage), the voltage signal is connected to terminals 4 and 5 of the connector, whatever the phase.

Characteristics

Fs set point		
setting	50 to 55 Hz or 60 to 65 Hz	
resolution	0.1 Hz	
accuracy (1) U21 and U32 measurement U21 measurement	 0.1 Hz across the dynamic range measurement see curve	
pick-up-drop out difference	0.2 Hz ± 0.1 Hz	
T time delay		
setting	100 ms to 655 s	
accuracy (1)	± 2%, or 40 ms (see curve)	
resolution	10 ms or 1 digit	
characteristic times (1)		
instantaneous tripping time	see curve	
time delayed tripping time	T	
memory time	< 65 ms	
fault recognition time	< 65 ms	
reset time	< 85 ms	
outputs available for program logic		
instantaneous	F57X/1	
time delayed	F57X/2	
U21 < U min	F57X/3	
remote reading, remote setting (2)**		
function code F57	57h	
identification number	X (3)	
parameters	Fs set point	unit: 0.1 x Hz
(order of parameters)	T time delay	unit: 10 x ms

(1) in reference conditions (IEC 60255-6) and df/dt < 3 Hz/s.
(2) the data formats are defined in the manuals which describe each communication protocol.
(3) the number of protection function modules depends on the type of Sepam 2000.

Real overpower

ANSI code	32P
function n°	F531

Operation

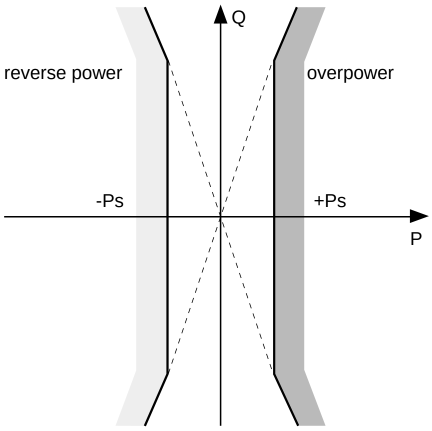
This protection is designed for balanced and unbalanced 3-wire, 3-phase systems (non distributed neutral).

■ It picks up when the real power flowing in one direction or the other, depending on the use (supplied or absorbed) is above the set point,
■ It includes a definite time delay.

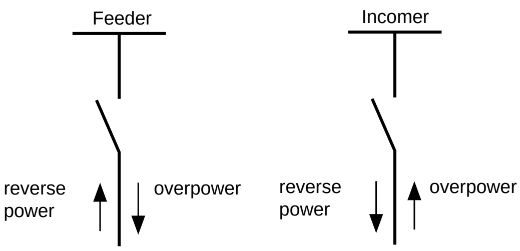
The function only operates when the following condition is met: P $\geq$ 3.1% Q which provides a high level of sensitivity and stability in the event of a short-circuit.

It is based on the "two wattmeter" method.

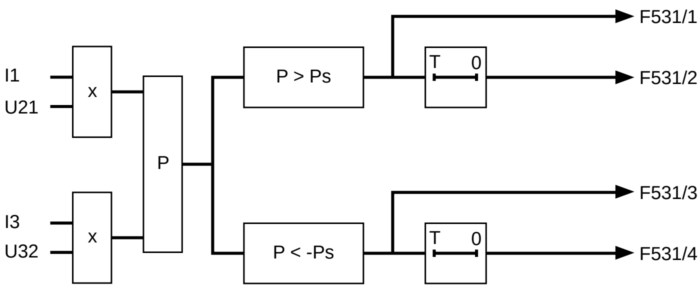
■ The direction of power is in accordance with parameter selection **feeder** or **incomer** in the status menu.



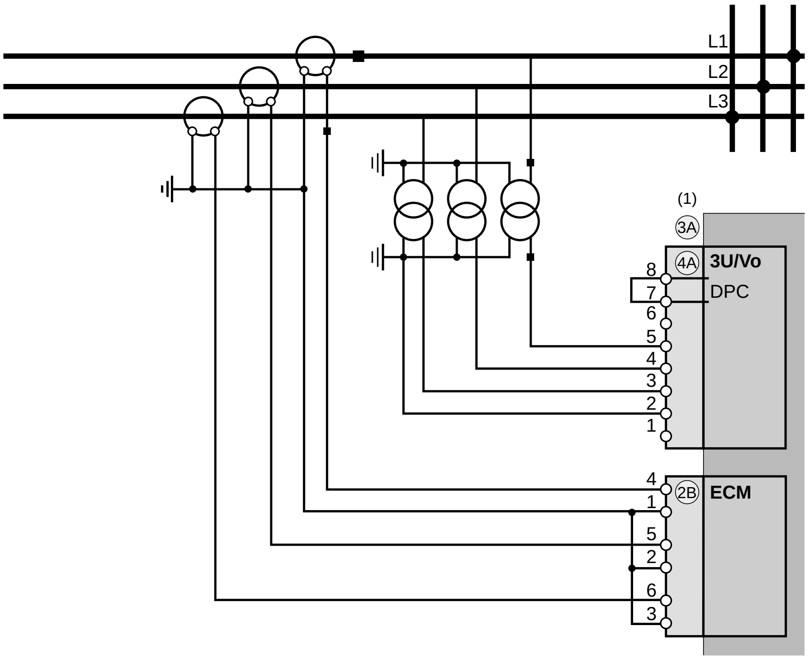
Operating zone

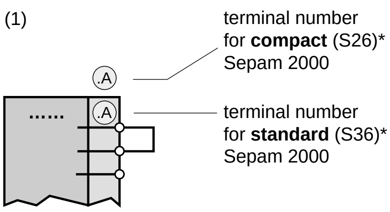


Block diagram



Direction data are in accordance with the following wiring diagram:





Note: Refer to the installation document for other arrangements.

* or S35, S25 for earlier versions.

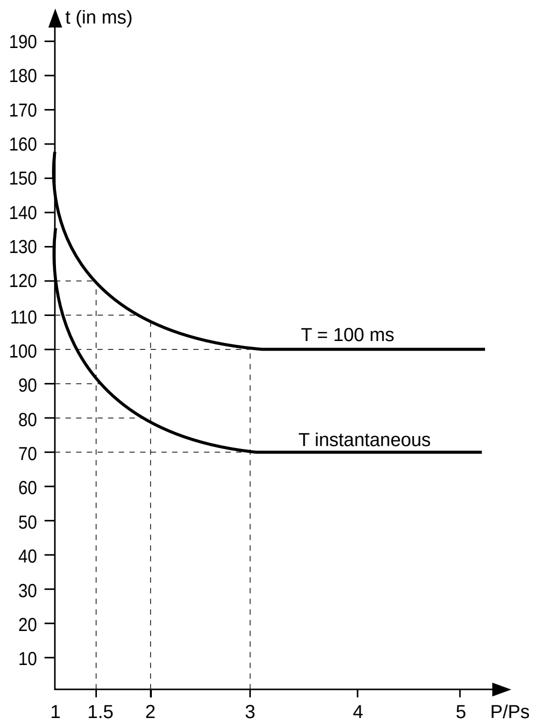
Commissioning, setting

Check:
■ the connections,
■ the positions of the microswitches SW associated with the current and voltage inputs,
■ the general parameters in the **status** menu.
The Number parameter in the phase VT heading should be se to 1U or 3U.

Set the following:
■ Ps set point:
Ps is set in W, kW, MW or GW.
The 999 GW setting disables the protection:
all the outputs are set to zero.
■ T time delay.

It corresponds to the operation time for 3Ps.

As shown in the curve below, the operation time is not always constant P < 3Ps, which improves the stability of the function in the vicinity of the set point.



Operation time t = f(P/Ps).

Sensors

Real overpower protection is related to the currents and voltages connected to the following connectors:

voltage	Sepam	connector
	1A or 5A CT	2B
	CSP	2L1, 2L2, 2L3
voltage	**Sepam**	**connector**
	S36*	4A [1]
	S26*	3A

[1] 3A connector for S36*TR and S36TS models.

Characteristics

Ps set point		
setting	1% Sn to 120%Sn expressed in W	
accuracy [1]	±0.3% Sn between 1% Sn and 5% Sn ±5% Sn between 5% Sn and 40% Sn ±3% Sn between 40% Sn and 120% Sn	
resolution	1 W or 1 digit	
drop out/pick-up ratio	(93.5 ±5)%	
min. return variance	0.004Sn	
T time delay		
setting	100 ms to 655 s	
accuracy [1]	±5%, or 25 ms (see curve)	
resolution	10 ms or 1 digit	
characteristic times		
instantaneous output response time	see curve	
memory time	< 115 ms	
fault recognition time	< 115 ms	
reset time	< 130 ms	
outputs available for program logic		
instantaneous	F531/1 for real overpower F531/3 for reverse real power	
time delayed	F531/2 for real overpower F531/4 for reverse real power	
remote reading, remote setting [2]**		
function code F53	53h	
identification number	1	
parameters	Ps set point	unit: W
(order of parameters)	T time delay	unit: 10 x ms

[1] in reference conditions (IEC 60255-6) with Pf. > 0.3.
[2] the data formats are defined in the manuals which describe each communication protocol.

* S35, S25 for earlier versions.
** function available as of version 9802 SFT2800.

Reactive overpower (cont'd)

ANSI code	32Q
function n°	F541

Operation

This protection is designed for balanced and unbalanced 3-wire, 3-phase systems (non distributed neutral).

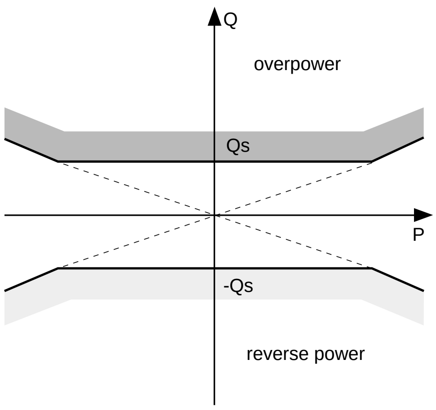
■ It picks up when the real power flowing in one direction or the other, depending on the use (supplied or absorbed) is greater than the set point,

■ It includes a definitie time delay.

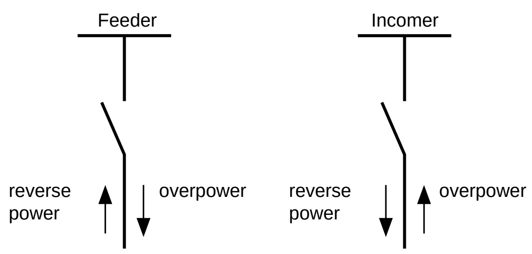
The function only operates when the following condition is met: Q $\geq$ 3.1% P which provides a high level of sensitivity and stability.

It is based on the "two wattmeter" method.

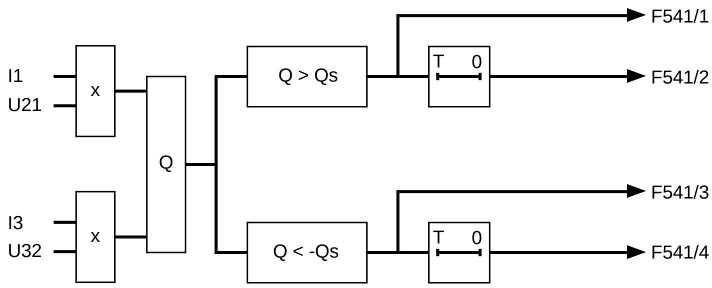
■ The direction of power is in accordance with parameter selection **feeder** or **incomer** in the status.



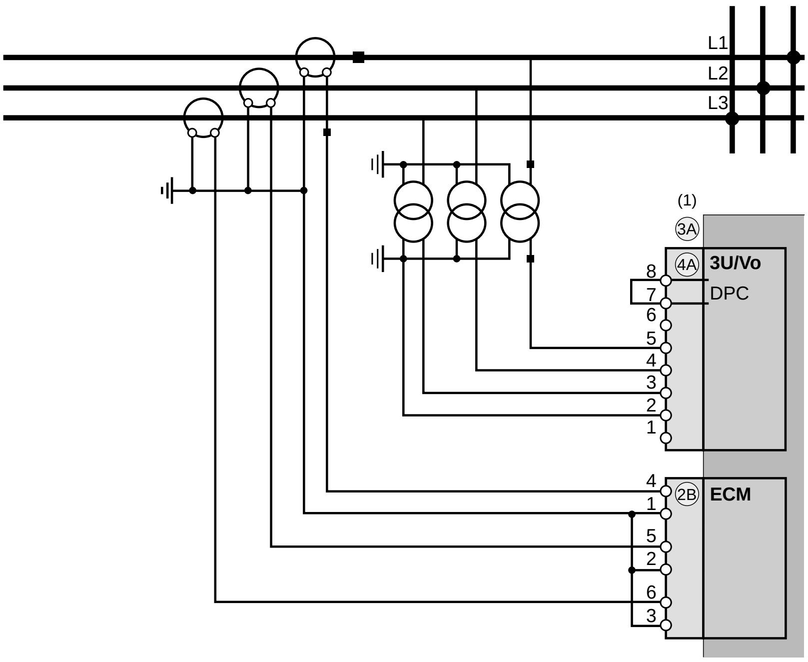
Operating zone



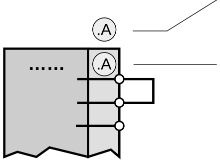
Block diagram



Direction data are in accordance with the following wiring diagram:



(1)



terminal number for **compact** (S26)* Sepam 2000

terminal number for **standard** (S36)* Sepam 2000

Note: refer to the installation document for other arrangements.

* S35, S25 for earlier versions.

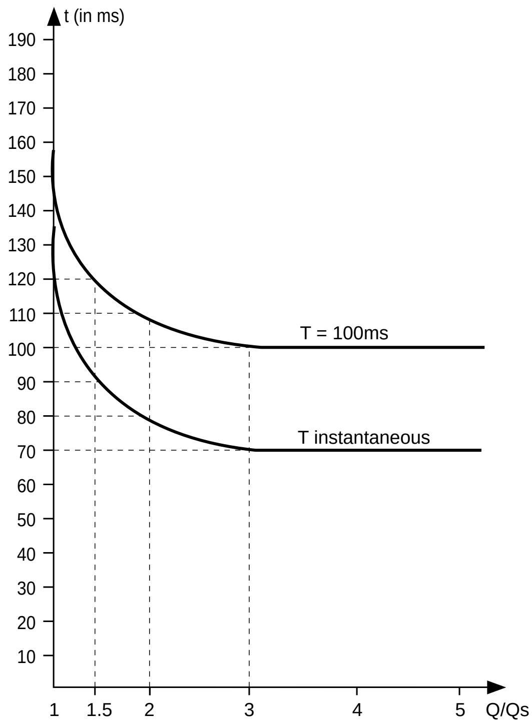
Commissioning, setting

Check:
■ the connections,
■ the positions of the microswitches SW of the analog acquisition boards,
■ the general parameters in the **status** menu.
The Number parameter in the phase VT heading should be se to 1U or 3U.

Set the following:
■ Qs set point:
Qs is set in VAR, kVAR, MVAr or GVAr.
The 999 GVAr setting disables the protection: all the outputs are set to zero.
■ T time delay.

It corresponds to the operation time for 3Qs.

As shown in the curve below, the operation time is not always constant Q < 3Qs, which improves the stability of the function in the vicinity of the set point.



Operation time t = f(Q/Qs).

Sensors

Reactive overpower protection is related to the currents and voltages connected to the following connectors:

voltage	Sepam	connector
	1A or 5A CT	2B
	CSP	2L1, 2L2, 2L3
voltage	**Sepam**	**connector**
	S36*	4A [1]
	S26*	3A

[1] 3A connector for S36*TR and S36TS models.

Characteristics

Qs set point		
setting	5% to 120% Sn expressed in VAr	
accuracy [1]	±5% Sn between 5% Sn and 40% Sn ±3% Sn between 40% Sn and 120% Sn	
drop out/pick-up ratio	(93.5 ±5)%	
T time delay (at 3xQs)		
setting	100 ms to 655 s	
accuracy [1]	±5%, or 25 ms (see curve)	
characteristic times		
instantaneous output response time	see curve	
memory time	< 115 ms	
fault recognition time	< 115 ms	
reset time	< 130 ms	
outputs available for program logic		
instantaneous	F541/1 for reactive overpower F541/3 for for reverse reactive power	
time delayed	F541/2 for for reactive overpower F541/4 for for reverse reactive power	
remote reading, remote setting [2]**		
function code F54	54h	
identification number	1	
parameters	Qs set point	unit: VAr
(order of parameters)	T time delay	unit: 10 x ms

[1] in reference conditions (IEC 60255-6) with Pf. < 0.8.
[2] the data formats are defined in the manuals which describe each communication protocol.

* S35, S25 for earlier versions.
** function available as of version 9802 SFT2800.

ANSI Code	37P
function n°	F551

Operation

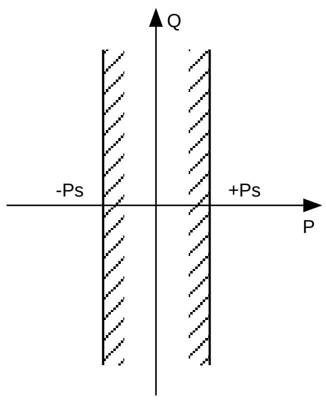
This protection is designed for balanced and unbalanced 3-wire, 3-phase systems (non distributed neutral).

■ It picks up when the real power flowing in one direction or the other, depending on the use (supplied or absorbed), is below the set point,

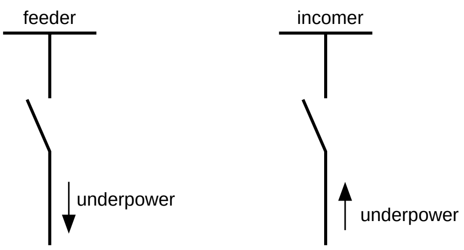
■ It includes a definite time delay.

It is based on the “two wattmeter” method.

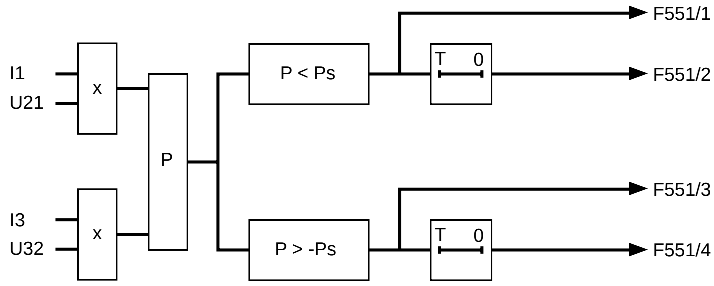
■ The direction of power is in accordance with parameter selection **incomer** or **feeder** in the status menu.



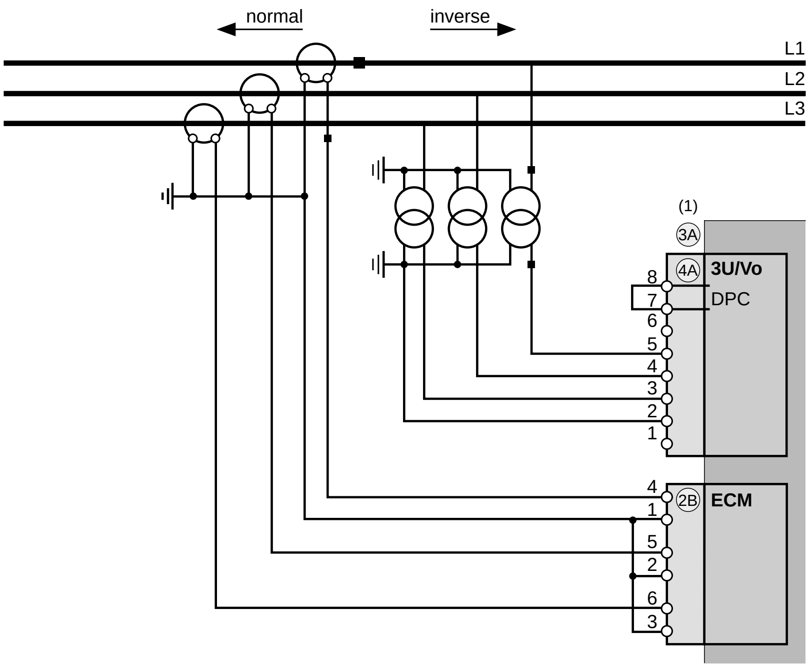
Operating zone.

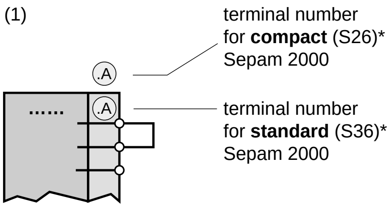


Block diagram



Direction data are in accordance with the following wiring diagram:





Note: refer to the installation document for other arrangements.

* S35, S25 for earlier versions.

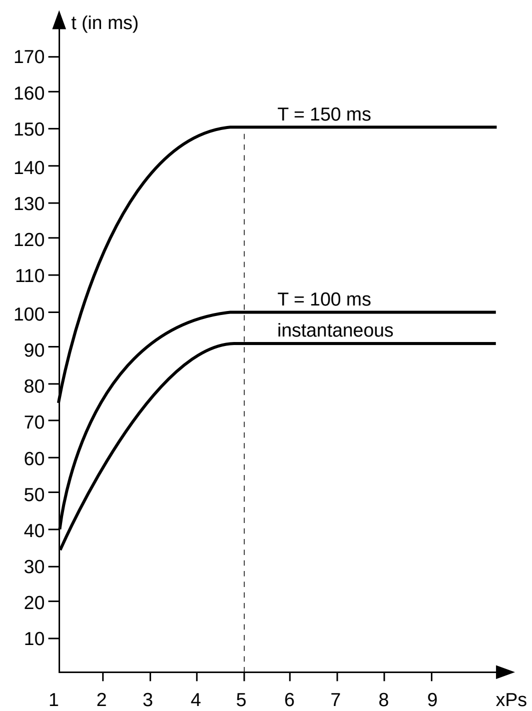
Commissioning, setting

Check:
■ the connections,
■ the positions of the microswitches SW associated with the current and voltage inputs,
■ the general parameters in the **status** menu.
The Number parameter in the phase VT heading should be se to 1U or 3U.

Set the following:
■ Ps set point:
Ps is set in W, kW, MW or GW.
The 999 GW setting disables the protection:
all the outputs are set to zero.
■ T time delay.

It corresponds to the operation time for 5Ps.

As shown in the curve below, the operation time is not always constant for P < 5Ps, which improves the stability of the function in the vicinity of the set point.



Operation time curves when the real power goes from xPs to 0.

Sensors

Real underpower protection is related to the currents and voltages connected to the following connectors:

voltage	Sepam	connector
	1A or 5A CT	2B
	CSP	2L1, 2L2, 2L3
voltage	**Sepam**	**connector**
	S36*	4A [1]
	S26*	3A

[1] 3A connector for S36*TR and S36TS models.

Characteristics

Ps set points		
setting	5% Sn to 100% Sn expressed in W	
accuracy [1]	±5% Sn between 5% Sn and 40% Sn ±3% Sn between 40% Sn and 120% Sn	
resolution	1 W or 1 digit	
drop out/pick-up ratio	(106 ±5)%	
min. return variance	0.004Sn	
T time delay		
setting	100 ms to 655 s	
accuracy [1]	±5%, or 25 ms (see curve)	
resolution	10 ms or 1 digit	
characteristic times		
instantaneous output response time	see curve	
memory time	< 115 ms	
fault recognition time	< 115 ms	
reset time	< 130 ms	
outputs available for program logic		
instantaneous	F551/1	P< + Ps
time delayed	F551/2	P< + Ps
instantaneous	F551/3	P> - Ps
time delayed	F551/4	P> - Ps
remote reading, remote setting [2]**		
function code F55	55h	
identification number	1	
parameters	Ps set point	unit: W
(order of parameters)	T time delay	unit: 10 x ms

[1] in reference conditions (IEC 60255-6) with Pf. > 0.3.
[2] the data formats are defined in the manuals which describe each communication protocol.

* S35, S25 for earlier versions.
** function available as of version 9802 SFT2800.

Synchro-check

ANSI code	25
function n°	F171 synchro-check on first voltage acquisition board
	F181 synchro-check on second voltage acquisition board

Operation

The synchro-check function is single-phase.
It is designed to allow a circuit breaker to close without the risk of dangerous coupling of two voltages Usync 1 and Usync 2.

The voltages that are compared may be 2 phase-to-phase voltages Uxy or two phase-to-neutral voltages Vx.

The relay picks up if the voltages compared are equal, i.e., if the phase, frequency and amplitude differences are within the set limits.

In addition, it comprises 4 operating modes which allow coupling in different cases of voltage absence:

■ mode 1 if voltage Usync 2 is present and voltage Usync1 is absent,
■ mode 2 if voltage Usync 1 is present and voltage Usync 2 is absent,
■ mode 3 if one of the two voltages is present and the other one is absent,
■ mode 4 if one of the two voltages or both voltages are absent.

The presence of each of the 2 voltages is detected by comparing the voltage with the high setting (Us high).

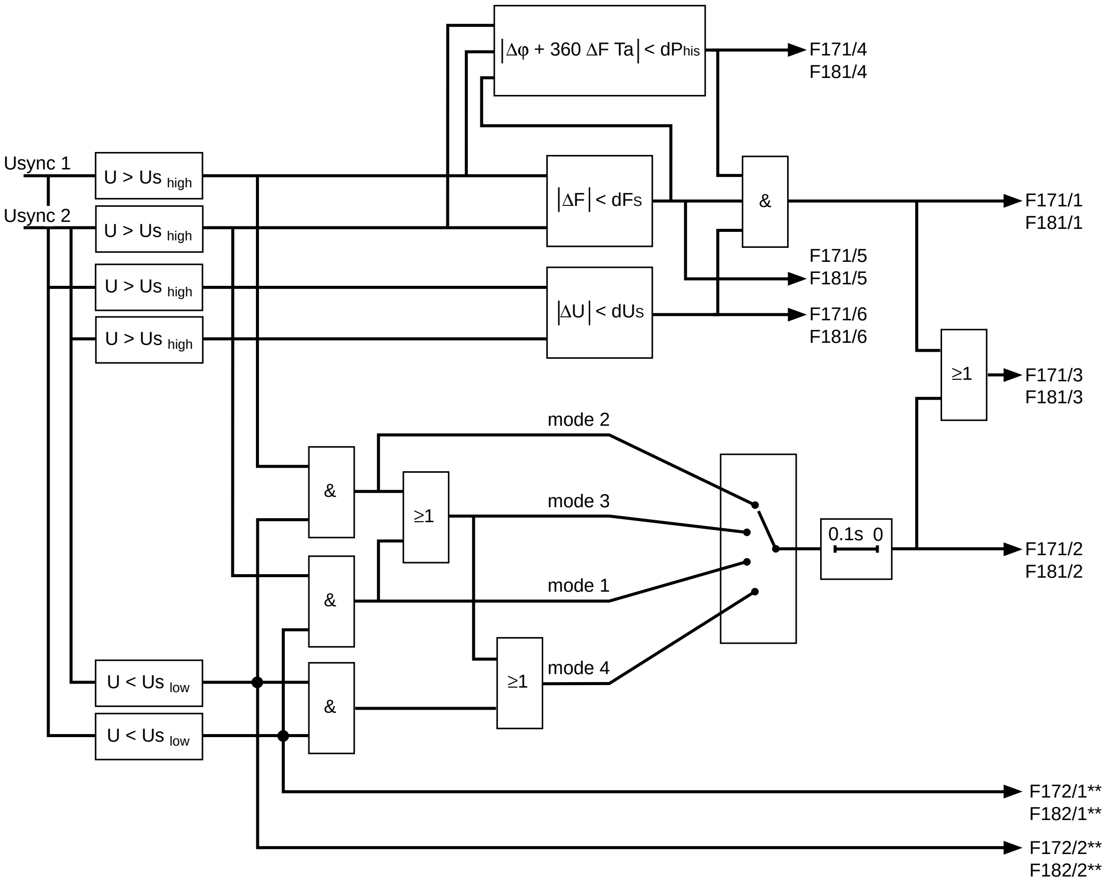
The absence of each of the 2 voltages is detected by comparison with the low setting (Us low).

Anticipation*
It is possible to anticipate function action by a time Ta taking into account the frequency difference and circuit breaker closing time in order for synchronism to be reached at the time of coupling.

Measurements
The following measurements may be accessed via the pocket terminal:

■ phase difference between voltages Usync 1 and Usync 2,
■ amplitude of voltage Usync 1,
■ amplitude of voltage Usync 2.

Block diagram



* available as version 9802 SFT2800.
** available as version 9940 SFT2800.

Characteristics

dUs set point			
range	3 to 30% of Un		
resolution	1 digit		
accuracy [1]	±2.5% or 0.003 Un		
dFs set point			
range	0.05 to 0.5 Hz		
resolution	0.01 Hz		
accuracy [1]	±10 mHz		
dPhi set point			
range	5 to 80 degrees		
resolution	1 degree		
accuracy [1]	±2 degrees		
Us high set point			
range	0.8 Un to 1.1 Un		
resolution	1 Volt or 1 digit		
accuracy [1]	±1%		
drop out/pick-up ratio	(93 ±5)%		
Us low set point			
range	0.1 Un to 0.7 Un		
resolution	1 Volt or 1 digit		
accuracy [1]	±1% or ±0.003 Un		
drop out/pick-up ratio	(106 ±5)%		
operating mode with voltage absent			
Usync 1 absent and Usync 2 present		mode 1	
Usync 2 absent and Usync 1 present		mode 2	
(Usync 1 absent, and Usync 2 present) or (Usync 2 absent, and Usync 1 present)		mode 3	
(Usync 1 absent, Usync 2 absent) or (Usync 2 absent, Usync 1 present) or (Usync 1 absent, Usync 2 present)		mode 4	
anticipation Ta			
range	$0 \leqslant T \leqslant 500$ ms		
resolution	10 ms or 1 digit		
characteristic times [1]	**dUs**	**dFs**	**dPhi**
operation time	< 120 ms	< 190 ms	< 120 ms
reset time	< 120 ms	< 190 ms	< 40 ms
measurement of phase difference			
measurement range	0 to 359 degrees		
resolution	1 degree		
accuracy [1]	±2 degrees		
measurement of voltages Usync 1 and Usync 2			
range	0 and 1.5 Un		
resolution	1 Volt or 1 digit		
accuracy [1]	±1.5% at Un		
outputs available for program logic			
synchro-check	F171/1, F181/1		
power off checking	F171/2, F181/2		
enable coupling	F171/3, F181/3		
phase difference check	F171/4, F181/4		
frequency difference check	F171/5, F181/5		
voltage difference check	F171/6, F181/6		
Usync 1 < Us low [2]	F172/1, F182/1		
Usync 2 < Us low [2]	F172/2, F182/2		

[1] in reference conditions (IEC 60255-6).
[2] available as of version 9940 SFT2800.

Commissioning, setting

Check:
■ the connections,
■ the positions of the microswitches SW associated with voltage inputs,
■ general parameters in the **status** menu.

Set the following:
■ voltage difference dUs: dUs is set as an rms value in volts or kilovolts.
The 999 kV setting may be used to inhibit the protection: all the outputs are set to zero,
■ frequency difference dFs: dFs is set in Hertz,
■ phase difference dPhi: dPhi is set in degrees,
■ voltage present Us high setting: Us high is set in volts or kilovolts (phase-to-phase voltage),
■ voltage absent Us low setting: Us low is set in volts or kilovolts (phase-to-phase voltage),
■ operating mode with voltage absent:
mode 1, mode 2, mode 3, mode 4.
■ anticipation Ta: Ta is the anticipation time which corresponds to the circuit breaker closing time.
Ta is set in ms.

remote reading, remote setting** (1)		
function code F17, F18	17h and 18h	
identification number	1	
parameters	dUs set point	unit: V
(order of parameters)	dFs set point	unit: 0.01 x Hz
	angle	unit: degree
	Us high set point	unit: V
	Us low set point	unit: V
	mode	0 : mode 1 2 : mode 2 4 : mode 3 6 : mode 4
	anticipation Ta	unit: x10 ms

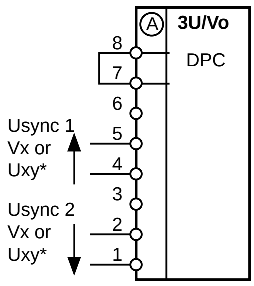
(1) the data formats are defined in the manuals that describe each communication protocol.

Sensors

The F171 synchro-check protection is related to the voltages of the VTs connected to the following connector:

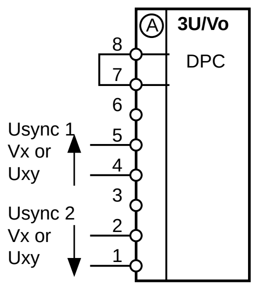
Sepam	connector
S36*	4A (1)
S26*	3A

(1) 3A connector for the S36*TR and S36TS models.
(2) The Usync 1 and Usync 2 voltages connected should be phase-to-phase voltages U21 if the Sepam includes other functions related to voltages (voltage and power measurements, voltage protections, directional protections).



The F181 synchro-check protection is related to the voltages of the VTs connected to the following connector:

Sepam	connector
S36*TR	4A
S36TS	4A

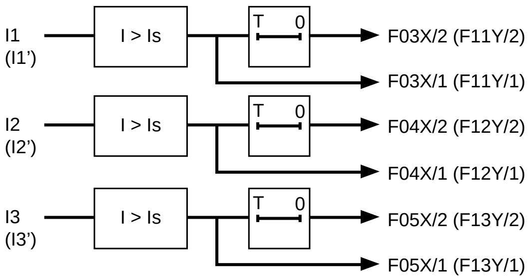


* S35, S25 for earlier versions.
** function available as of version 9802 SFT2800.

Percentage-based single-phase overcurrent

ANSI code	50-51
function n°	F03X for phase overcurrent I1 F04X for phase overcurrent I2 F05X for phase overcurrent I3 1 ⩽ X ⩽ 2 F11Y for phase overcurrent I1' F12Y for phase overcurrent I2' F13Y for phase overcurrent I3' 1 ⩽ Y ⩽ 2

Block diagram



Operation

This function includes 3 independent single-phase overcurrent protections.

Each single-phase overcurrent protection picks up when the related current reaches the operation set point, expressed as a percentage of 1 A or 5 A according to the parameter setting of the current inputs.

It is time-delayed with a definite time delay (DT). The set point and time delay are independent for each single-phase function.

Current measurement
In order to facilitate commissioning of the function, the values of the 3 single-phase currents may be measured as a percentage of 1 A or 5 A using the pocket terminal.

Commissioning, setting

Check:
■ the connections,
■ the positions of the microswitches SW2 associated with the current inputs,
■ the general parameters in the **status** menu (rated frequency).

Set the following:
■ Is set point: Is is set as a relative value, % of 1 A or 5 A.
The 999% setting may be used to inhibit the protection: all the outputs are set to 0.
■ T time delay: T is the operation time delay.

Sensors

The percentage-based single-phase overcurrent protection is related to the currents connected to the following connectors:

current	sensor	connector
I1, I2, I3	1 A or 5 A CT	2B
I1', I2', I3'	1 A or 5 A CT	3B

Characteristics

Is set point		
setting	3% to 200% of 1 A or 5 A (according to parameter setting)	
resolution	1%	
accuracy (1)	+5%	
inhibition	999%	
drop out/pick-up ratio	(93.5 ±5)%	
T time delay		
setting	50 ms to 655 ms	
resolution	10 ms or 1 digit	
accuracy (1)	±2% or 35 ms	
measurement of single-phase current as % of In		
measurement range	1% to 999% of 1 A or 5 A (according to parameter setting)	
accuracy (1)	±5 %	
resolution	1%	
characteristic times		
instantaneous tripping time	< 85 ms	
time-delayed tripping time	T	
memory time	< 65 ms	
fault recognition time	< 65 ms	
reset time	< 85 ms	
outputs available for program logic		
instantaneous	F03X/1, F04X 1, F05X/1 F11Y/1 F12Y/1 F13Y/1	1 ⩽ X ⩽ 2 1 ⩽ Y ⩽ 2
time-delayed	F03X/2, F04X/2, F05X/2 F11Y/2, F12Y/2, F13Y/2	1 ⩽ X ⩽ 2 1 ⩽ Y ⩽ 2
remote reading, remote setting* (2)		
function code F03X, F04X, F05X F11Y, F12Y, F13Y	 03 h, 04 h, 05 h 11 h, 12 h, 13 h	
identification number parameters (order of parameters)	X, Y (3) Is set point T time delay	 unit: % unit: 10 x ms

(1) in reference conditions (IEC 60255-6).
(2) the data formats are defined in the manuals that describe each communication protocol.
(3) the number of function modules relays depends on the type of Sepam.

* function available as of version 9802 SFT2800.

Breaker failure protection

ANSI code	50BF + 62
function n°	F981

Operation

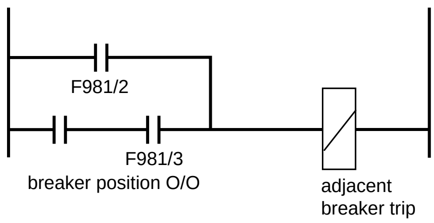
This function is designed to protect against the failure of a circuit breaker to open.
It is suited to circuit breakers with 3-pole control or 1-pole control used in systems in which 3-phase or single-phase reclosing is practised ‡ in which 3-phase or single-phase reclosing is used

The “Breaker failure protection” function picks up when triggered by a tripping order from a protection:
■ internal to Sepam 2000 (phase overcurrent, directional overcurrent, ...) via logic data K858,
■ external to Sepam 2000 via the logic inputs chosen by setting:
□ I 3ph for 3-pole action,
□ I ph 1 for action on phase 1,
□ I ph 2 for action on phase 2,
□ I ph 3 for action on phase 3.

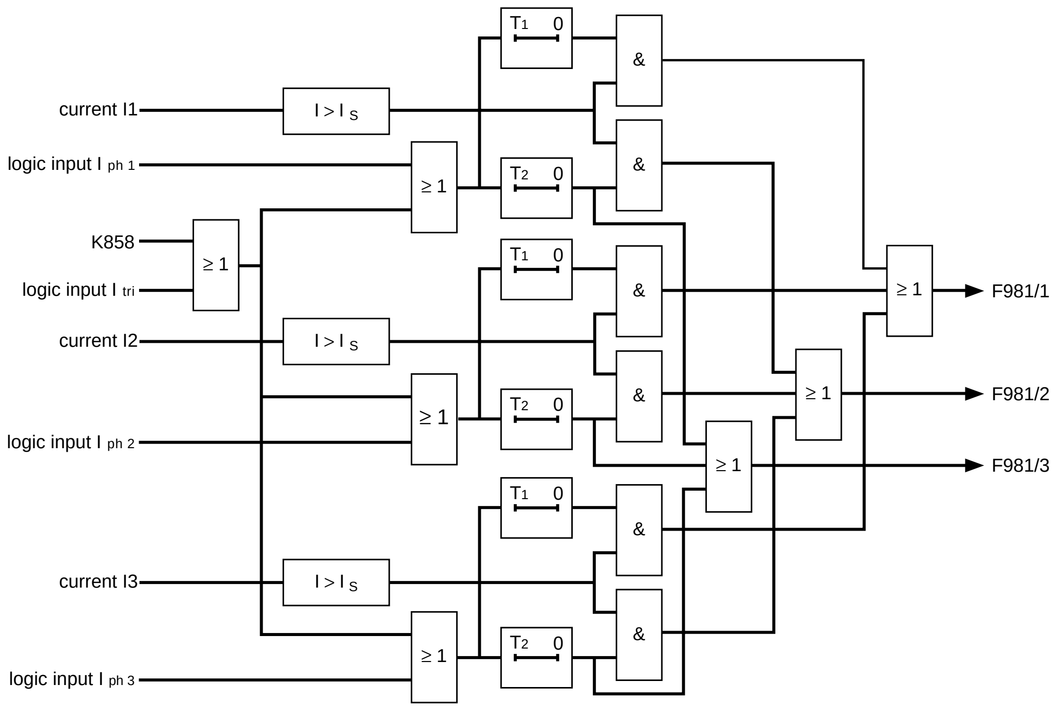
The function comprises 3 outputs:
■ F981/1 picks up if the presence of current is detected in the phases, after a 1-pole or 3-pole tripping order is received from a Sepam 2000 internal protection or an external protection, taking into account the circuit breaker tripping time (time delay T1).

This output is designed to initiate a 3-pole retripping order.
■ F981/2 picks up if the presence of current is detected in the phases, after a 1-pole or 3-pole tripping order is received from tripping of the adjacent circuit breakers or an external protection, taking into account the circuit breaker tripping time and retripping time (time delay T2). This output is designed to initiate the adjacent circuit breakers tripping.
■ F981/3 picks up if time delay T2 has elapsed after a 1-pole or 3-pole tripping order is received from a Sepam 2000 internal protection or an external protection.

This output associated with the circuit breaker position report is designed to trigger an adjacent circuit breaker tripping order.



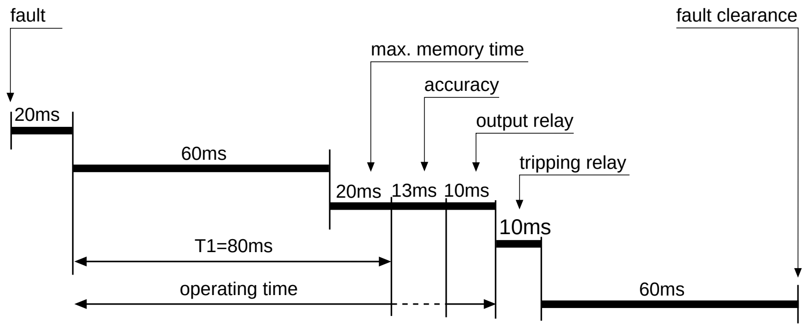
Block diagram



Performance

The performance of this function is linked to current detection memory time and time delay accuracy.

Example :
The function's fault clearance time is 200 ms, given the following assumptions:
■ operation time of line protection = 20 ms,
■ operation time of circuit breaker = 60 ms,
■ operation time of auxiliary tripping relay = 10 ms,



Commissioning, setting

Check:
■ the connections,
■ the positions of the microswitches SW associated with current inputs,
■ general parameters in **status** menu.

Set the following:
■ Is set point: Is set as an rms value, in amps or kiloamps. The 999 kA setting may be used to inhibit the protection: all the outputs are set to zero.
■ time delays T1 and T2:
□ T1 is the time after which an attempt to retrip may be made if the function does not detect zero current (if the breaker has not operated).
T1 should be greater than circuit breaker operating time + memory time.
□ T2 is the time after which the adjacent circuit breaker tripping order may be given if the function does not detect zero current (if the breaker has not operated for retripping). T2 should be equal to 2 x T1.
■ choice of logic input I 3ph used for 3-pole tripping by protection external to Sepam 2000.
■ choice of logic input I ph 1 used for 1-pole phase 1 tripping by protection external to Sepam 2000.
■ choice of logic input I ph 2 used for 1-pole phase 2 tripping by protection external to Sepam.
■ choice of logic input I ph 3 used for 1-pole phase 3 tripping by protection external to Sepam 2000.

Sensors

Protection against circuit breaker faults is related to the currents connected to the following connectors:

sensor	connector
TC 1A or 5A	2B
CSP	2L1, 2L2, 2L3

Characteristics

Is set point		
range	0.2 In to 2 In expressed in Amps	
resolution	1 A or 1 digit	
accuracy [1]	±5%	
inhibition	999 kA	
drop out/pick-up ratio	(87.5 ±10)%	
T1 and T2 time delays		
range	50 ms to 65.5 s	
resolution	10 ms or 1 digit	
accuracy [1]	0 + 13 ms	
I ph 1, I ph 2, I ph 3, I 3ph		
logic inputs [2]	I1 to 12 on ESB board I11 to I18 on ESTOR 1 board I21 to I28 on ESTOR 2 board I31 to I38 on ESTOR 3 board	
characteristic times		
operation time	T1 < t < T1 + 13 ms	T2 < t < T2 + 13 ms
memory time	< 20 ms (10 ms typically)	
outputs available for program logic		
retrip. of circuit breaker with fault	F981/1	
tripping of adjacent circuit breakers	F981/2	
time delay setting reached	F981/3	
remote reading, remote setting* [3]		
function code F98	98h	
identification number	1	
parameters	Is set point	unit: A
(order of parameters)	T1 time delay	unit: 10 x ms
	T2 time delay	unit: 10 x ms
	ph 1 logic input [2]	
	ph 2 logic input [2]	
	ph 3 logic input [2]	
	3 phase logic input [2]	

(1) in reference conditions (IEC 60255-6).
(2) chosen according to model and ESTOR option.
(3) the data formats are defined in the manuals which describe each communication protocol.
(4) base 10 index of tripping input (XY):

X
0 = ESB board
1 = ESTOR1 board
2 = ESTOR2 board
3 = ESTOR3 board

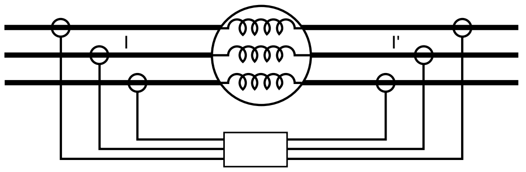
Y
1 = input 1 (ESB and ESTOR boards)
2 = input 2 (ESB and ESTOR boards)
3 = input 3 (ESTOR board)
4 = input 4 (ESTOR board)
5 = input 5 (ESTOR board)
6 = input 6 (ESTOR board)
7 = input 7 (ESTOR board)
8 = input 8 (ESTOR board)

Moto-generator differential

ANSI code	87G - 87M
function n°	F621

Operation

Motor-generator differential protection is 3-phase.
It is based on phase by phase comparison of the currents on either side of the windings of a generator or motor.



Percentage-based differential
The protection picks up when the difference between currents $\vec{I} - \vec{I'}$ for at least one phase is above the operation set point.

The set point is defined by the curve opposite (based characteristic curve). It has an adjustable minimum value and depends on the through current.

$$|It| = \frac{|\vec{I} + \vec{I'}|}{2}$$

The based characteristic curve comprises two half-curves defined by the following inequations:

half-curve 1:

$$|\vec{Id}\,x|^2 - \frac{|\vec{It}\,x|^2}{32} > Is^2$$

in which $\leq |\vec{It}\,x| \leq \sqrt{2}\,In$ and x = 1,

half-curve 2*:

$$\frac{|\vec{Id}\,x|^2}{8} - \frac{|\vec{It}\,x|^2}{32} > (0.05In)^2$$

in which $\sqrt{2}\,In < |\vec{It}\,x|$ and x = 1, 2, 3

* available as of version 9840 SFT2800.

Restraint element
The stability of the protection in the event of external faults, of the energizing of transformers supplied by a machine or of machine starting, is ensured by means of a tripping restraint when one of the following conditions is met on one of the phases:
- ■ detection of an external fault or a starting phase,
- ■ detection of CT saturation,
- ■ detection of transformer energizing.

Detection of an external fault or starting phase
At the time of starting or an external fault, the through current is much higher than 1.5 In. As long as the CTs do not saturate, the differential current is low.
This transient state is detected by the following characteristic:

$$\frac{|\vec{Id}\,x|^2}{2} - \frac{|\vec{It}\,x|^2}{32} < -(0.25In)^2 \quad \text{in which } x = 1, 2, 3$$

Since external faults may be followed by a brief high differential current, a restraint time over 10 network periods is included so as to ensure protection stability with this type of phenomenon.

Detection of CT saturation
The saturation of a CT may cause the appearance of a false differential current and inadvertently trip the protection. This type of detection simply analyzes the asymmetry of the signals and restrains tripping in the event of CT saturation.

Detection of transformer energizing*
This type of detection is carried out by ensuring that the harmonic 2 distortion of the differential current is greater than 15%.

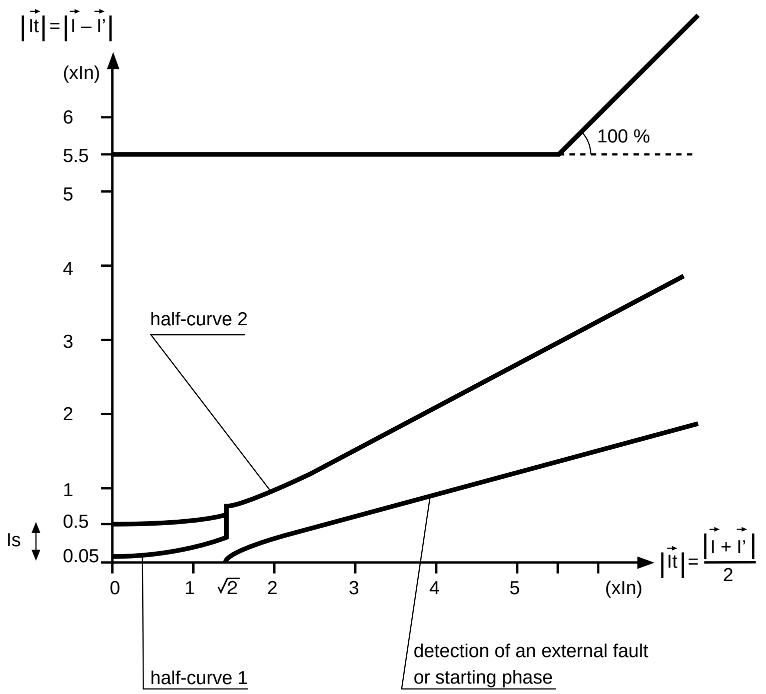
$$\frac{|\vec{Id}\,xh2|}{|\vec{Id}\,x|} > 0.15 \quad \text{in which } x = 1,$$

High set differential*
To avoid unwanted tripping at the time of starting, the protection stability can be improved by cross-blocking and detection of external faults. To avoid any protection delay in the event of high asymmetric faults, a high set differential, which is not subject to restraints, is applied.

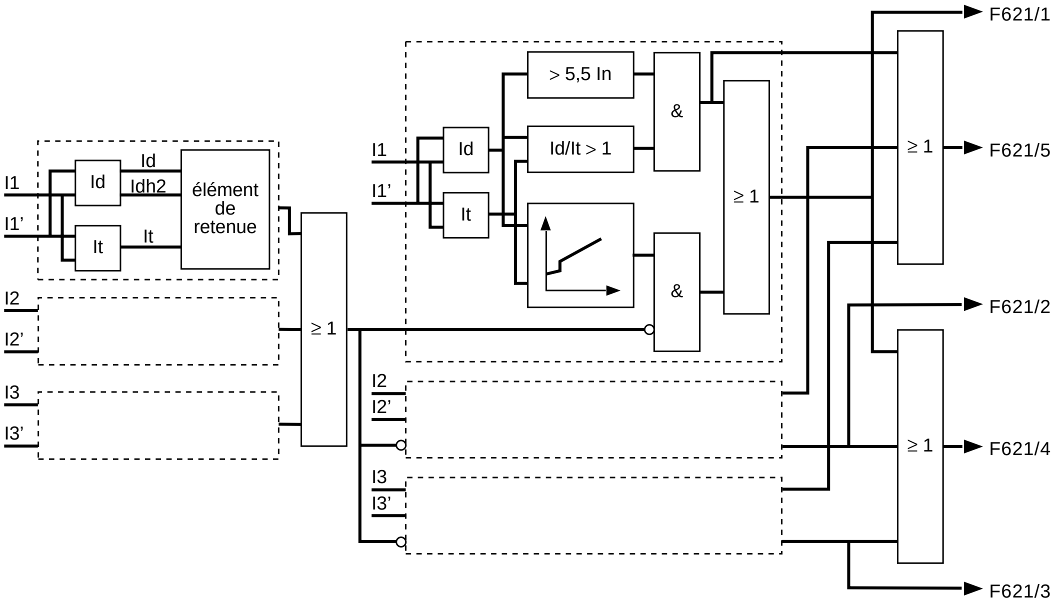
The characteristic of this set point is as follows:

$$|\vec{Id}\,x| > 5{,}5\ In \text{ and } \frac{|\vec{Id}\,x|}{|\vec{It}\,x|} > 100\ \% \quad \text{in which } x = 1, 2, 3$$

Operation curve



Block diagram



Commissioning, setting

Check:
■ the connections,
■ the positions of the microswitches SW associated with the current inputs,
■ the general parameters in the **status** menu.

Set the following:
■ **Is** current:
Is is set in rms, amps or kiloamps.
The 999 kA setting may be used to inhibit the protection: all the outputs are set to 0.

Operation time depends on the differential current value.
It is defined by the curve opposite and provides a high level of function stability.

Sensors

The current transformers (CTs) must be of the 5P20 type.

The power rating should be chosen so that the wiring resistance is greater than the rated load of the current transformer, i.e.:

$VA_{CT} > R_W . In^2$

R_W: wiring resistance
In: CT secondary rated current
VA_{CT}: current transformer rated load

The **motor-generator differential** protection is related to the currents connected to the following connectors:

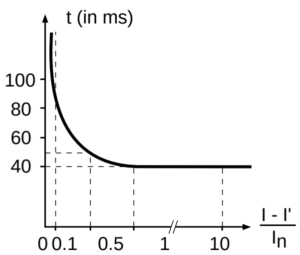
current	sensor	connectors
I1, I2, I3	1 A or 5 A CT	2B
I1', I2', I3'	1 A or 5 A CT	3B

* available as of version 9802 SFT2800.
** available as of version 9940 SFT2800.

Characteristics

Is set point		
setting	0.05In 0.5In expressed in amps	
resolution	1 A or 1 digit	
accuracy [1]	±5% Is or 0,4% In	
inhibition	999 kA	
drop out/pick-up ratio	(93.5 ±5)%	
characteristic times		
operation time	see curve	
memory time	< 25 ms	
fault recognition time	< 25 ms (for I - I' > In)	
reset time	< 35 ms	
outputs available for program logic		
fault on phase 1	F621/1	
fault on phase 2	F621/2	
fault on phase 3	F621/3	
fault on one phase	F621/4	
high set tripping**	F621/5	
remote reading, remote setting* [2]		
function code F62	62h	
identification number	1	
parameters	Is set point	unit: A

[1] in reference conditions (IEC 60255-13).
[2] the data formats are defined in the manuals which describe each communication protocol.



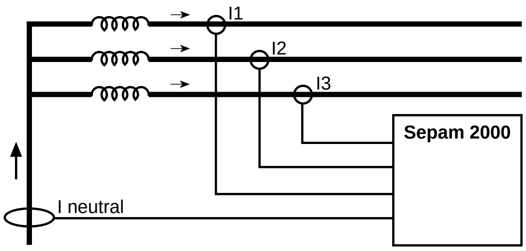
Operation time.

Restricted earth fault protection

ANSI code	64REF
function n°	F641 for restricted earth fault protection winding 1
	F651 for restricted earth fault protection winding 2
	F661 for restricted earth fault protection winding 3

Operation

Restricted earth fault protection detects phase to earth faults in earthed neutral three-phase windings.



The function is based on the comparison of residual current Io ($\vec{Io} = \vec{I1} + \vec{I2} + \vec{I3}$) and neutral current I neutral.

It is activated when the Io - Ineutral difference is greater than the operation set point.

This set point is defined based on the minimum set point Iso and also by a percentage-based tripping curve with a slope of 1.05 and restraint current Iro in normal conditions (see curve).

$Iro = |\vec{I1} + \vec{I2} + \vec{I3}|$

The protection sensitivity is determined by the phase current sensors with a minimum set point of 5% In.

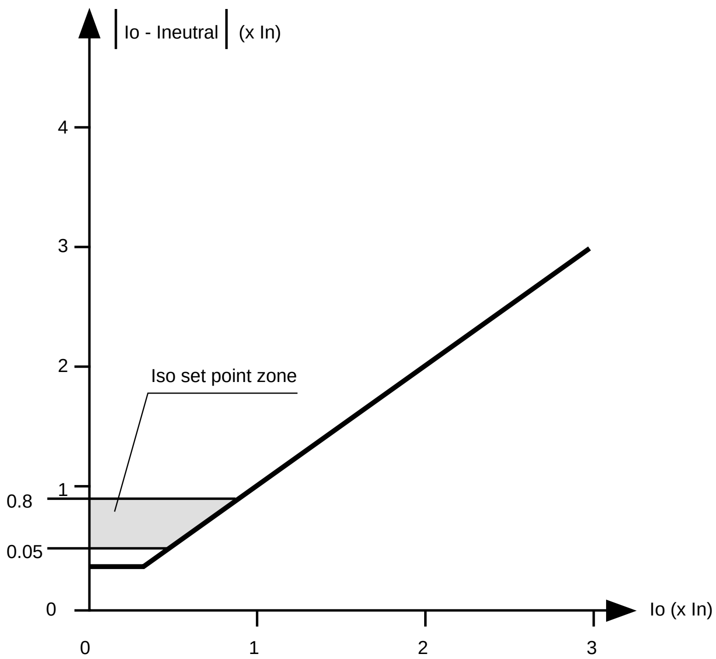
The protected zone is between the phase CTs and the neutral point.

External fault stability

When an external fault is detected, the restraint current becomes $2^*|(\vec{I1} + \vec{I2} + \vec{I3}) + \vec{Io}/3|$.

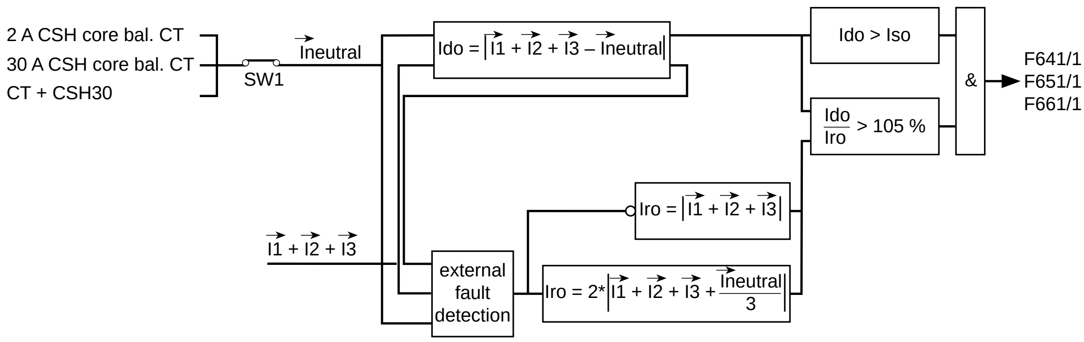
This makes it possible to make the protection insensitive to current transformer saturation without disabling it.

Curve



In: phase CT rating.

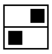
Block diagram



Commissioning, setting

Neutral current is measured:
■ by CSH sensor,
■ by a 1A or 5A current transformer associated with a CSH30.

Residual current is measured by the internal vector sum of the 3 phase currents.

Check:
■ the connections,
■ the position of microswitch SW1: 

■ the position of microswitch SW2 for the use of 1A or 5A CT or CSP sensor,
■ general parameters in the **status** menu.

Set the Iso current:
■ Iso is set as an rms value, in amps or kiloamps. The 999 kA setting may be used to inhibit the protection: all the outputs are set to zero.

Sensors

Restricted earth fault protection F641 is related to the currents connected to the following connectors:

current	sensor	connector
I1, I2, I3	1A or 5A CT	2B
	CSP	2L1, 2L2, 2L3
Ineutral	**CSH**	**2A**
Io	CT+CSH30	2A

Restricted earth fault protection F651 is related to the currents connected to the following connectors:

current	sensor	connector
I1', I2', I3'	1A or 5A CT	3B
	CSP	3L1, 3L2, 3L3
Ineutral	**CSH**	**3A**
Io'	CT+CSH30	3A

Restricted earth fault protection F651 is related to the currents connected to the following connectors:

current	sensor	connector
I1", I2", I3"	1A or 5A CT	4B
	CSP	4L1, 4L2, 4L3
Ineutral	**CSH**	**4A**
Io"	CT+CSH30	4A

In order to guarantee the accuracy and stability of the protection, the current transformers must be of the 5P20 type.

The power rating should be chosen so that the wiring resistance is less than the rated load of the current transformer, i.e.:

$VA_{CT} > R_w \, In^2$

VA_{CT}: current transformer rated load

R_w: wiring resistance

In: CT secondary rated current

In those conditions, correct operation is ensured in most applications.

To size class X CTs, the following rules must be followed:
■ restricted earth fault protection on the transformer secondary circuit:

external fault stability is ensured if the phase CT saturation current is more than 2.4 times the phase-to-earth fault current and 1.6 times the 3-phase fault current.
Internal fault sensitivity is ensured if the neutral CT saturation current is more than 2 times the phase-to-earth fault current.
■ restricted earth fault protection on the transformer primary circuit:
external fault stability is ensured if the phase CT saturation current is more than 2.4 times the protected transformer phase-to-earth fault current.
Internal fault sensitivity is ensured if the neutral CT saturation current is more than 2 times the protected transformer phase-to-earth fault current.
■ restricted earth fault protection for generators:
external fault stability is ensured if the phase CT saturation current is more than 2 times the generator rated current.
Internal fault sensitivity is ensured if the neutral CT saturation current is more than 2 times the generator phase-to-earth fault current.

Characteristics

Iso set point		
range	0.05 In to 0.8 In for In ⩾ 20 A 0.1 In to 0.8 In for In < 20A	
resolution	1 A or 1 digit	
accuracy (1)	±5% or 5% In	
drop out/pick-up ratio	(93 ±5)%	
minimum return variance	min. 0.4% In	
Io restraint-Ineutral/Io		
fixed value	1.05	
accuracy (1)	±2%	
characteristic times		
operation time	< 40 ms	
memory time	< 25 ms	
fault recognition time	< 25 ms	
reset time	< 40 ms	
outputs availaible for program logic		
instantaneous	F641/1, F651/1, F661/1	
remote reading, remote setting* (1)		
function code F64, F65, F66	64h, 65h and 66h	
identification number	1	
parameters	Iso set point	unit: 1 A

(1) in reference conditions (IEC 60255-13).
(1) the data formats are defined in the manuals that describe each communication protocol.

Temperature monitoring

ANSI code	49T - 38
function n°	F46X for RTD monitoring X is the RTD number 1 ⩽ X ⩽ 6 F47Y for additional RTD monitoring Y is the RTD number 1 ⩽ Y ⩽ 6

Operation

This protection is associated with RTDs (Pt100 platinum probe 100 Ω at 0 °C) in accordance with the IEC 60751 and DIN 43760 standards.

■ It picks up when the monitored temperature is greater than the set point Ts.
■ It has two independent set points:
□ alarm set point,
□ tripping set point.

Self-calibration of each RTD channel takes place once a minute.

■ The protection detects if an RTD is shorted or disconnected:
□ RTD shorting is detected when the measured temperature is less than -70 ± 10 °C,
□ RTD disconnection is detected when the measured temperature is greater than 302° ± 27 °C (minimum).
If an RTD fault is detected, the set point output relays are disabled: the protection outputs are set to zero.

Commissioning, settings

It is preferable for temperature to be measured in the 3-wire mode (see **Metering functions - temperature** chapter). The 2-wire mode is reserved for use on an exceptional basis in installations which already exist (see commissioning manuals).

Set the following:
■ Ts1 and Ts2 set points.
Ts1 and Ts2 are set in degrees Celsius. Setting 999°C inhibits the protection: all the outputs are set to zero.

Sensors

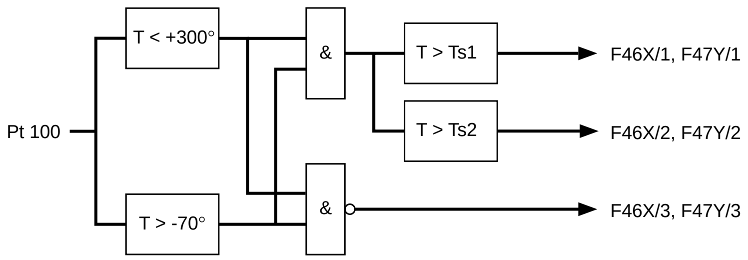
The F46X protection is related to the RTDs connected to the following connector:

Sepam	connector
S26* LS	3A
S36* SR	3A
S36* SS	3A
S36* ZR	3A
S36* LS	8A
S36* KZ	8A
S36 TS	8A
S46 ZR	3A
S46 ZM	3A

The F47Y protection is related to the RTDs connected to the following connector:

Sepam		connector
S36*	SS	8A

Block diagram



Characteristics

Ts1 and Ts2 set points			
setting		0 °C to 180 °C	
accuracy (1)		±1.5 °C	
resolution		1 °C	
pick-up-drop out difference		3 °C ± 0.5 °C	
inhibition		Ts1 = 999 °C	
characteristic times			
tripping time		< 3 seconds	
outputs available for program logic			
set point overrun	alarm tripping	F46X/1, F47Y/1 F46X/2, F47Y/2	
faulty RTD detection		F46X/3, F47Y/3	
remote reading and remote setting (2)**			
function code F46, F47		46h et 47h	
identification number		X, Y (3)	
parameters		Ts1 set point	unit: °C
(order of parameters)		Ts2 set point	unit: °C

(1) refer to the **Metering functions - temperature** chapter for information on accuracy derating according to wiring cross-section.
(2) the data formats are defined in the manuals which describe each communication protocol.
(3) the number of protection function modules depends on the type of Sepam 2000.

* S35, S25 for earlier versions.
** function available as of version 9802 SFT2800.

Appendix
Contents

IDMT protections

Operation time depends on the type of protection (phase current, earth fault current, ...).

Operation is represented by a characteristic curve:
- t = f(I) curve for the **phase overcurrent** function,
- t = f(Io) curve for the **earth fault** function.

The rest of the document is based on t = f(I); the same reasoning may be extended to other variables Io,…

The curve is defined by:
- the type (standard inverse **SIT**, very inverse **VIT** or **LTI**, extremely inverse **EIT**, ultra inverse **UIT**),
- the Is setting current which corresponds to the vertical asympote of the curve,
- the T time delay setting which corresponds to the operation time for I = 10Is.

These 3 settings are made in the following chronological order: type, Is current, T time delay.

Changing the T setting by x% changes all the operation times in the curves by x%.

Examples of problems to be solved

Problem n°1
Knowing the type of IDMT time, determine the Is and T settings.

Theoretically, Is is set to the maximum current that may be permanent: it is generally the rated current of the protected equipment (cable, transformer).

Time delay T is set to the operation point at 10Is on the curve. This setting is determined taking into account the constraints involved in discrimination with the upstream and downstream protections.

The discrimination constraint leads to the definition of point A on the operation curve (IA, tA), e.g. the point that corresponds to the maximum fault current affecting the downstream protection.

Problem n°2
Knowing the type of IDMT time, the Is current setting and a point K (Ik, tk) on the operation curve, determine the T time delay setting.

On the standard curve of the same type, read the operation time tsk that corresponds to the relative current

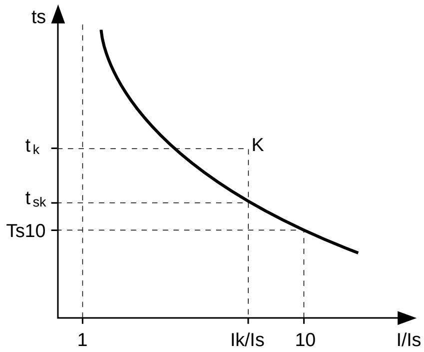
$$\frac{I_k}{Is}$$

and the operation time Ts10 that corresponds to the relative current

$$\frac{I}{Is} = 10$$

The time delay setting that should be made in order for the operation curve to pass through the point K (I_k, t_k) is:

$$T = Ts10 \times \frac{t_k}{t_{sk}}$$



Another practical method:
The chart below gives the values of

$$k = \frac{ts}{Ts10} \text{ as a function of } \frac{I}{Is}$$

In the column that corresponds to the type of time delay, read the value $k = \frac{t_{sk}}{Ts10}$ in the line that corresponds to $\frac{I_k}{Is}$

The time delay setting to be used so that the operation curve passes through the point K (I_k, t_k) is: $T = \frac{t_k}{k}$

Example
Data:
- type of time delay: standard inverse time (**SIT**)
- set point: Is
- a point K on the operation curve: K (3.2 Is; 4 s)

Question: What is the time delay T setting (operation time at 10Is)?

Chart reading: **inverse** column

line $\frac{I}{Is} = 3.2$

k = 2.00

Answer: The time delay setting is $T = \frac{4}{2} = 2\ s$

Problem n°3
Knowing the settings of Is current and T time delay for a type of time delay (standard inverse, very inverse, extremely inverse),
find the operation time for a current value of IA.
On the standard curve of the same read the operation time tsA that corresponds to the relative current

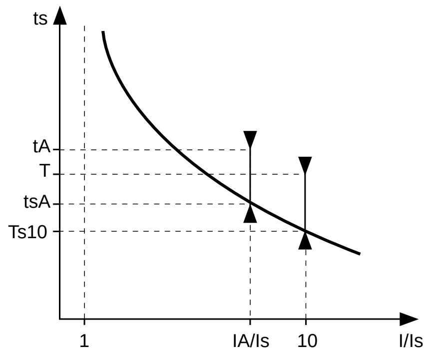
$$\frac{IA}{Is}$$

and the operation time Ts10 that corresponds to the relative current

$$\frac{I}{Is} = 10$$

The operation time tA for current IA with the Is and T settings is

$$t_A = t_{sA} \times \frac{T}{Ts10}$$



Another practical method: the chart below gives the values of $k = \frac{ts}{Ts10}$ as a function of $\frac{I}{Is}$

In the column that corresponds to the type of time delay, read the value

$k = \frac{tsA}{Ts10}$ in the line that corresponds to $\frac{IA}{Is}$

The operation time tA for current IA with the Is and T settings is tA = kT

Example

Data:

- type of time delay: very inverse time (**VIT**)
- set point: Is
- time delay T = 0.8 s

Question: What is the operation time for current IA = 6Is?

Chart reading: **very inverse** column

line $\frac{I}{Is} = 6$

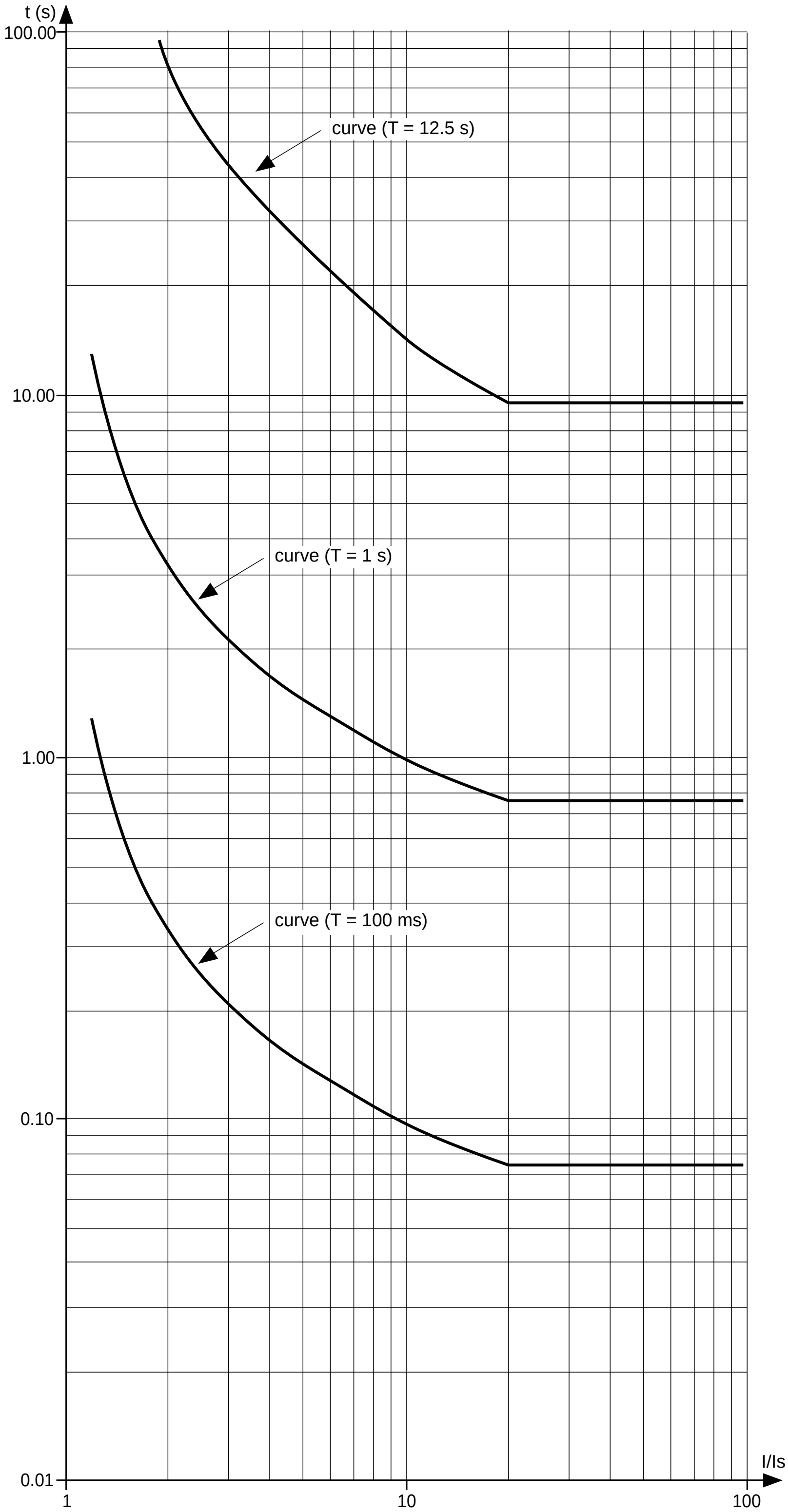
k = 1.80

Answer: The operation time for current IA is t = 1.80 x 0.8 = 1.44s

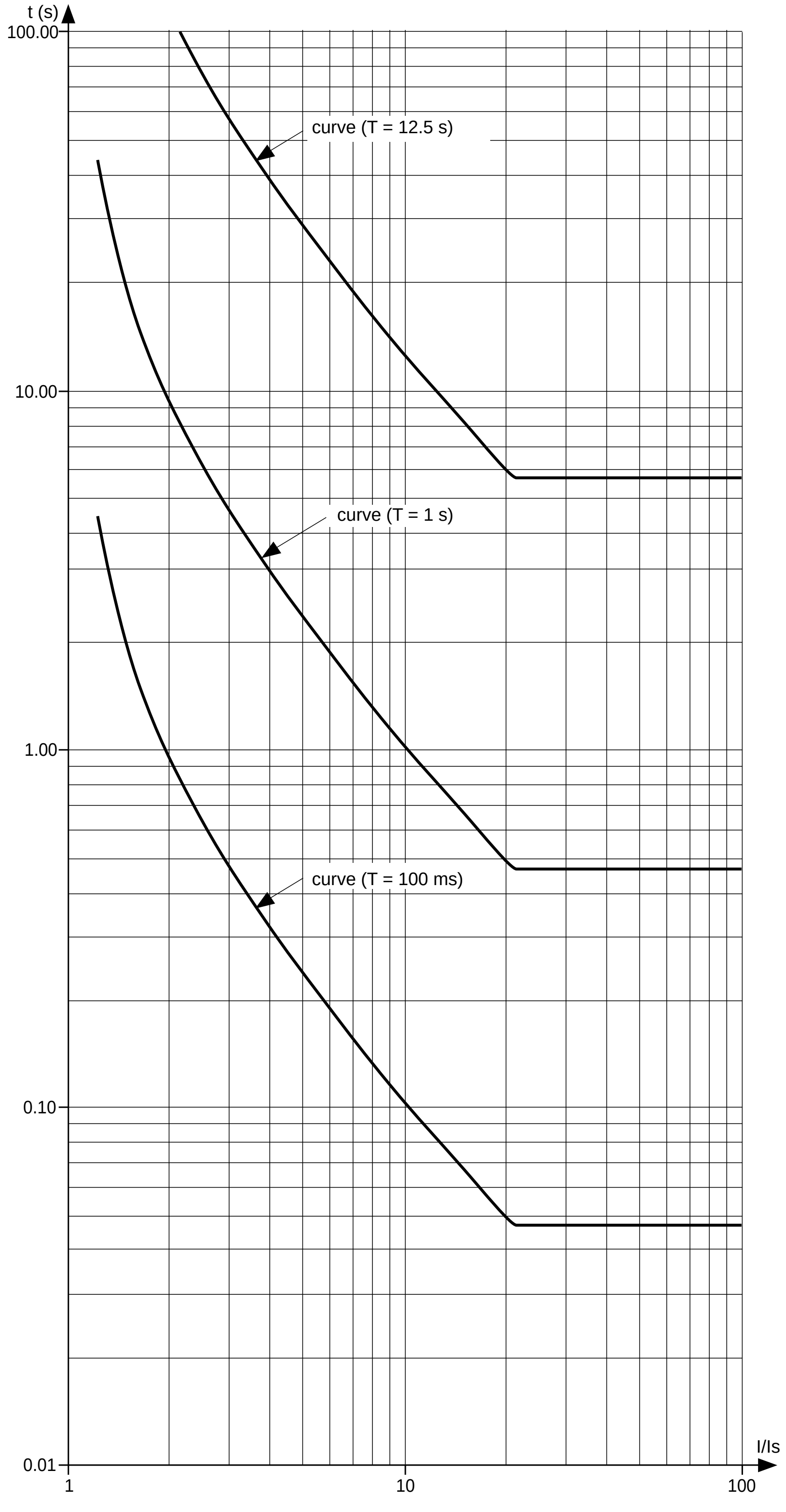
I/Is	std inv.	very inv.	ext. inv.	ultra inv.
1.2	12.90	45.00	225.00	545.51
1.3	8.96	30.00	143.48	339.84
1.4	6.98	22.50	103.13	238.80
1.5	5.79	18.00	79.20	179.42
1.6	4.99	15.00	63.46	140.74
1.7	4.42	12.86	52.38	113.80
1.8	3.99	11.25	44.20	94.12
1.9	3.65	10.00	37.93	79.22
2.0	3.38	9.00	33.00	67.64
2.1	3.15	8.18	29.03	58.43
2.2	2.97	7.50	25.78	50.98
2.3	2.81	6.92	23.08	44.85
2.4	2.67	6.43	20.80	39.76
2.5	2.55	6.00	18.86	35.46
2.6	2.44	5.63	17.19	31.82
2.7	2.35	5.29	15.74	28.69
2.8	2.27	5.00	14.47	25.99
2.9	2.19	4.74	13.36	23.65
3.0	2.12	4.50	12.38	21.59
3.1	2.06	4.29	11.50	19.79
3.2	2.00	4.09	10.71	18.19
3.3	1.95	3.91	10.01	16.77
3.4	1.90	3.75	9.38	15.51
3.5	1.86	3.60	8.80	14.37
3.6	1.82	3.46	8.28	13.35
3.7	1.78	3.33	7.80	12.43
3.8	1.74	3.21	7.37	11.60
3.9	1.71	3.10	6.97	10.85
4.0	1.68	3.00	6.60	10.16
4.1	1.65	2.90	6.26	9.53
4.2	1.62	2.81	5.95	8.96
4.3	1.59	2.73	5.66	8.44
4.4	1.57	2.65	5.39	7.95
4.5	1.54	2.57	5.14	7.51
4.6	1.52	2.50	4.91	7.10
4.7	1.50	2.43	4.69	6.72
4.8	1.48	2.37	4.49	6.37
4.9	1.46	2.31	4.30	6.04
5.0	1.44	2.25	4.13	5.74
5.1	1.42	2.20	3.96	5.46
5.2	1.41	2.14	3.80	5.19
5.3	1.39	2.09	3.65	4.95
5.4	1.37	2.05	3.52	4.72
5.5	1.36	2.00	3.38	4.50
5.6	1.34	1.96	3.26	4.30
5.7	1.33	1.91	3.14	4.11
5.8	1.32	1.88	3.03	3.94
5.9	1.30	1.84	2.93	3.77
6.0	1.29	1.80	2.83	3.61
6.1	1.28	1.76	2.73	3.47
6.2	1.27	1.73	2.64	3.33
6.3	1.26	1.70	2.56	3.19
6.4	1.25	1.67	2.48	3.07
6.5	1.24	1.64	2.40	2.95

I/Is	std inv.	very inv.	ext. inv.	ultra inv.
6.6	1.23	1.61	2.33	2.84
6.7	1.22	1.58	2.26	2.73
6.8	1.21	1.55	2.19	2.63
6.9	1.20	1.53	2.12	2.54
7.0	1.19	1.50	2.06	2.45
7.1	1.18	1.48	2.00	2.36
7.2	1.17	1.45	1.95	2.28
7.3	1.16	1.43	1.89	2.20
7.4	1.15	1.41	1.84	2.13
7.5	1.15	1.38	1.79	2.06
7.6	1.14	1.36	1.74	1.99
7.7	1.13	1.34	1.70	1.93
7.8	1.12	1.32	1.65	1.86
7.9	1.12	1.30	1.61	1.81
8.0	1.11	1.29	1.57	1.75
8.1	1.10	1.27	1.53	1.70
8.2	1.10	1.25	1.49	1.64
8.3	1.09	1.23	1.46	1.60
8.4	1.08	1.22	1.42	1.55
8.5	1.08	1.20	1.39	1.50
8.6	1.07	1.18	1.36	1.46
8.7	1.07	1.17	1.33	1.42
8.8	1.06	1.15	1.30	1.38
8.9	1.05	1.14	1.27	1.34
9.0	1.05	1.13	1.24	1.30
9.1	1.04	1.11	1.21	1.27
9.2	1.04	1.10	1.18	1.23
9.3	1.03	1.08	1.16	1.20
9.4	1.03	1.07	1.13	1.17
9.5	1.02	1.06	1.11	1.14
9.6	1.02	1.05	1.09	1.11
9.7	1.01	1.03	1.06	1.08
9.8	1.01	1.02	1.04	1.05
9.9	1.00	1.01	1.02	1.02
10.0	1.00	1.00	1.00	1.00
10.5	0.98	0.95	0.91	0.88
11.0	0.96	0.90	0.83	0.79
11.5	0.94	0.86	0.75	0.70
12.0	0.92	0.82	0.69	0.63
12.5	0.91	0.78	0.64	0.57
13.0	0.90	0.75	0.59	0.52
13.5	0.88	0.72	0.55	0.47
14.0	0.87	0.69	0.51	0.43
14.5	0.86	0.67	0.47	0.39
15.0	0.85	0.64	0.44	0.36
15.5	0.84	0.62	0.41	0.43
16.0	0.83	0.60	0.39	0.31
16.5	0.82	0.58	0.36	0.29
17.0	0.81	0.56	0.34	0.26
17.5	0.80	0.55	0.32	0.25
18.0	0.79	0.53	0.31	0.23
18.5	0.78	0.51	0.29	0.21
19.0	0.78	0.50	0.28	0.20
19.5	0.77	0.49	0.26	0.19
20.0	0.76	0.47	0.25	0.18

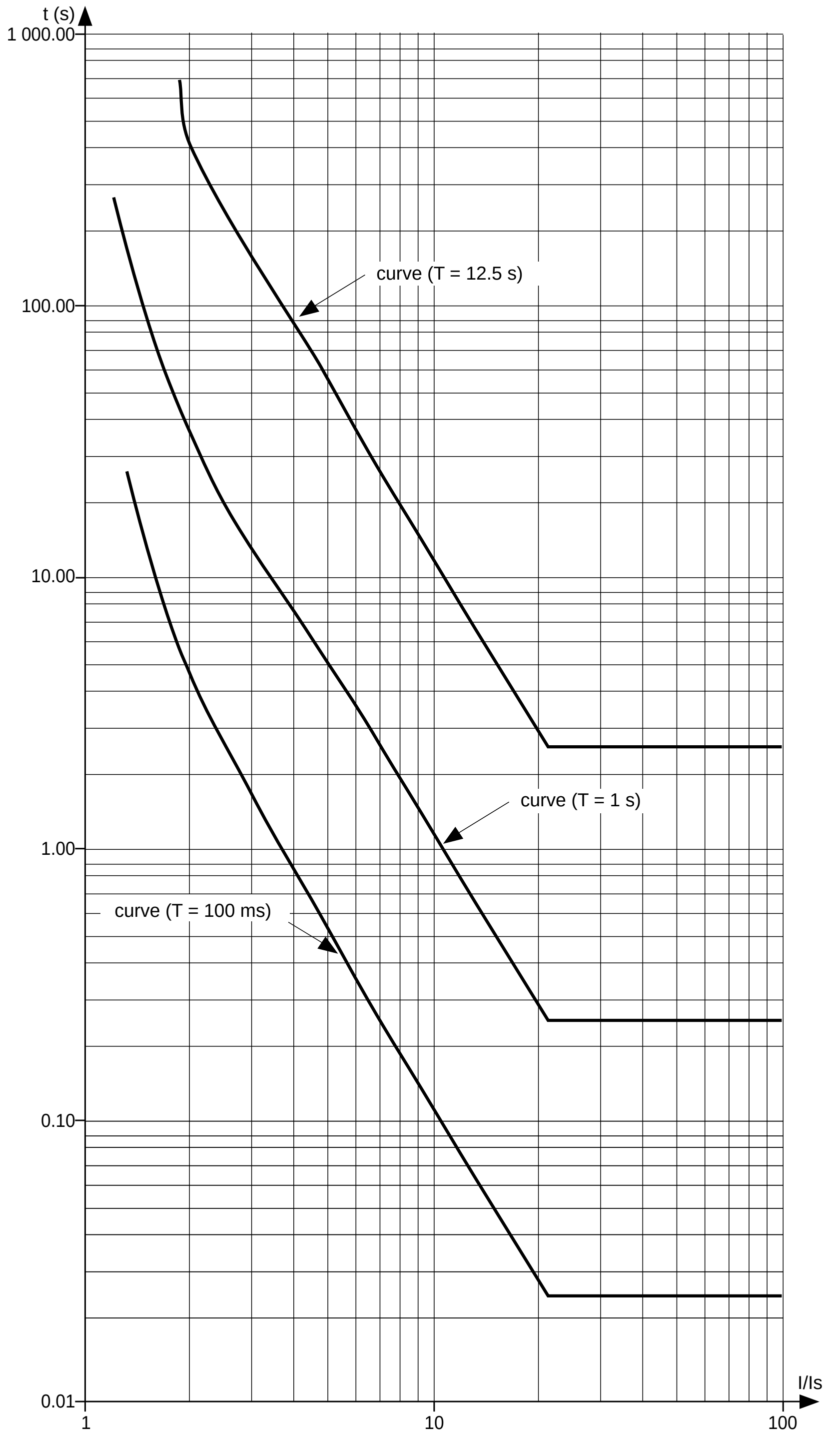
Inverse time curve SIT



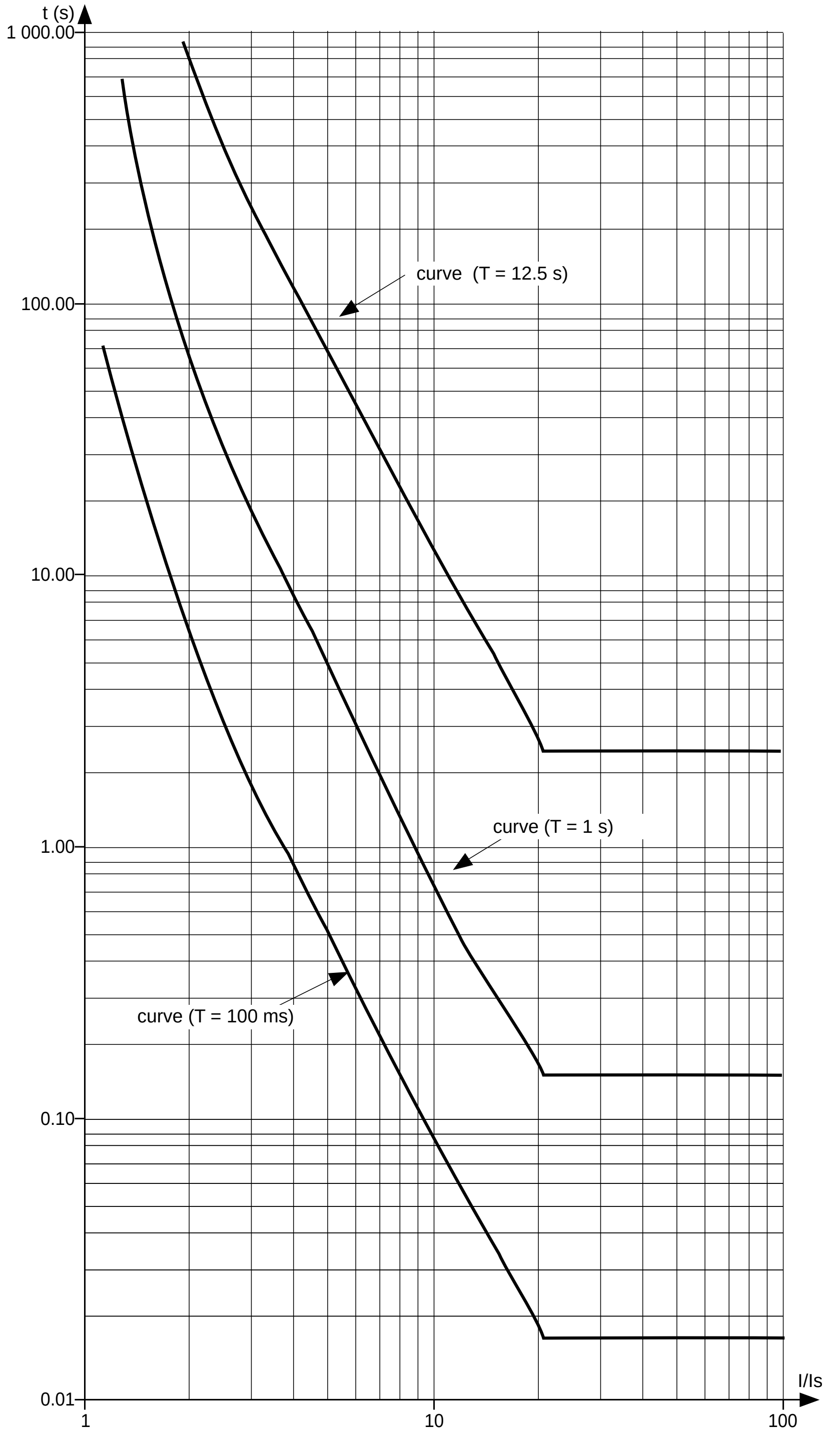
Very inverse time curve VIT or LTI



Extremely inverse time curve EIT



Ultra inverse time curve UIT



Start-up of time delays

Use of logical data K859 and K860

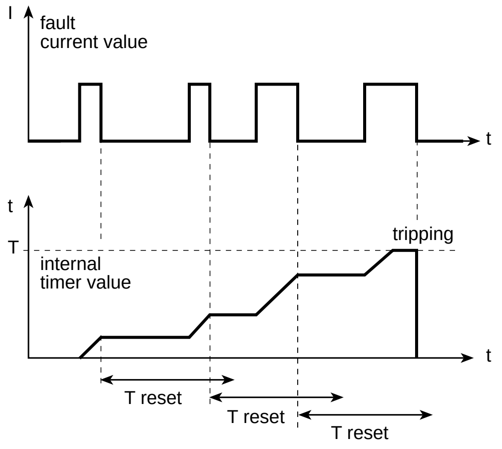
Logical data K859 and K860 may be used to detect recurring faults.

They may be used to adjust the reset time of the internal timers.

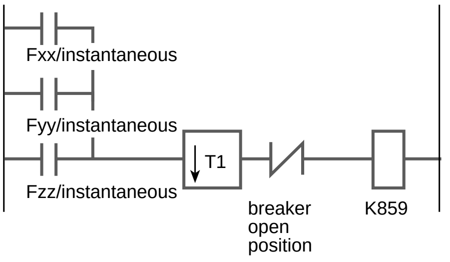
Logical data K859 = 1 may be used to prevent the start-up of the time delays of the following functions:
- phase overcurrent protection (F01X, F02Y) with $1 \leqslant X \leqslant 6$ and $1 \leqslant Y \leqslant 2$,
- voltage-restrained overcurrent protection (F19X, F20Y) with $1 \leqslant X, Y \leqslant 2$,
- earth fault protection (F06X, F07X, F08X, F09Y) with $1 \leqslant X \leqslant 4$ and $1 \leqslant Y \leqslant 2$,
- directional overcurrent protection in normal zone (F52X) with $1 \leqslant X \leqslant 2$,
- directional earth fault protection in normal zone (F50X) with $1 \leqslant X \leqslant 2$,

Logical data K860 = 1 may be used to prevent the start-up of the time delays of the following functions:
- directional earth fault protection in inverse zone (F50X) with $1 \leqslant X \leqslant 2$,
- directional overcurrent protection in inverse zone (F52X) with $1 \leqslant X \leqslant 2$.

The operation is shown in the following diagram:



As an example, the related program logic sequence (used in the case of a recloser) could be as follows:



T1 = adjustable reset time programmed by program logic.

General parameter settings

The general parameters adapt the Sepam metering and protection functions according to the electrical values that are connected.

The parameters are accessible:
■ in the "status" menu of the pocket terminal,
■ remotely using the remote reading function.

General parameters chart

heading	name	function	command	selection
frequency	Fn	mains frequency	data + and - keys	50 or 60 Hz
phase CT, phase CT'	In	CT ratings	numeric keys	adjustable 10 A and 6250 A
	rating or CSP		data + and - keys	setting between 20 A and 5000 A
	Ib	basis current of the equipment being protected	numeric keys	0.4 to 1.3In in amperes
	number	number of current sensors	data + and - keys	2 sensors (I1-I3) 3 sensors (I1-I2-I3)
Io sensor, Io' sensor Io" sensor	sensor	type of residual current measurement	data + and - keys	■ 3I sum (CT) ■ 3I sum 1 (CSP) ■ 3I sum 2 (CSP) ■ 2 A core bal. CT ■ 30 A core bal. CT ■ CT + CSH30 ■ core bal. CT + ACE 990
	Ino	CT rating with CT + CSH30	numeric keys	setting between 1 A and 6250 A
		core bal. CT sensitivity with core bal. CT + ACE 990	numeric keys	setting between 1,0 A and 6250 A
max. interval	interval	max. demand integration period	data + and - keys	adjustable: 5, 10, 15, 30, 60 mn
VT ratio, VT' ratio	number	number of VTs wired	data + and - keys	S26/36** / S46 V / V1 1U / V2 3U / V3 V1-V2-V3
	Unp	rated VT primary voltage	numeric keys	S26/S36*** adjustable between 220 V and 250 kV S46 adjustable between 220 V and 500 kV
	Uns	rated VT secondary voltage	data + and - keys	100, 110, 115, 120 V
	Vnso	type of residual voltage measurement	data + and - keys	■ sum of 3Vs ■ Uns/$\sqrt{3}$ ■ Uns / 3
direction of energy	incomer feeder	reverses the sign of power and energy measurement	data + and - keys	incomer (1) cable –-> busbars feeder (1) busbars –-> cable
transducer	range	EANA board input range	data + and - keys	0-20 mA 0-10 mA 4-20 mA -10/+10 mA
disturbance recording****	pretrig	time before triggering event	numeric keys	1 to 85 periods
Jbus/Modbus communi-cation (2) bauds	bauds	transmission speed	data + and - keys	300, 600, 1200 2400, 4800, 9600 19200, 38400
	station	Sepam station number in network	numeric keys	1 to 255
	parity	transmission format	data + and - keys	even, odd, no parity
Jbus/Modbus time-tagging (2)	synchro	type of synchronization used	data + and - keys	by: ■ network ■ logic inputs I11 or I21
	event	data to be or not to be time-tagged I1, I2 I11 to I18 I21 to I28 I31 to I38 KTS1 to KTS32 KTS33 to KTS64	numeric keys	0 = not time-tagged 1 = time-tagged

For the other parameters, refer to the user's documentation.
(1) incomer , feeder

* for versions prior to SFT 2800 9802 (S25/S35), Ino is set using the data + and - command.
** for versions prior to SFT 2800 9649, the values of the "number" of VTs wired parameter are: U21, U21-U32, 3U.
For versions between SFT 2800 9649 and SFT 2800 9802, the values of the «number» of VTs wired parameter are: V, 1U, 2U, 3U.
*** S25, S35 for earlier versions.
**** Available as of version 9940 SFT 2800.
Set to 6 network periods for SFT 2800 versions earlier than 9940.

General parameter settings (cont'd)

heading	name	function	command	selection
IEC 870-5 communication	bauds	transmission speed	data + and - keys	9600, 19200, 38400 bauds
	station	Sepam station number in network	numeric keys	0 to 254
FIP communication	station	Sepam station number in network	numeric keys	1 to 62
FIP time-tagging	synchro	type of synchronization used	data + and - keys	by logic input I11 or I21
	event	data to be or not to be time-tagged I1, I2 I11 to I18 I21 to I28 I31 to I38 KTS1 to KTS32 KTS33 to KTS64	numeric keys	0 = not time-tagged 1 = time-tagged

Remote reading of parameters *

function		function n°	parameter	unity
phase CT setting phase CT' setting phase CT" setting		D0h D9h DAh	rated primary current load basis current number of CTs	A A index (1)
phase VT setting phase VT' setting		D1h D8h	number of VTs wired rated primary voltage Unp rated secondary voltage Uns type of secondary for Vnso	index (2) V V index (3)
E/F sensor setting	Io Io' Io''	D2h DBh DFh	value of Ino type of Ino measurement	A index (4)
energy flow direction setting		D4h	type of cubicle	index (5)
rated frequency setting		D5h	frequency	Hz
transducer setting		DDh	EANA board input range	index (6)
disturbance recording**		DDh	recording time before triggering event	period
program logic timer setting		C3h	set points T1 to T60	10 x ms
parameter setting		C7h	KP1 to KP16 and KP33 to KP48	(7)

(1) meaning of the number of CTs index
2 : (I1 - I3)
3 : (I1 - I2 - I3)
(2) meaning of the number of the number of VTs wired index (base 10)

S26/S36	S46
1: V	1: V1
3: 1U	2: V2
7: 2U	4: V3
15: 3U	7: V1-V2-V3

(3) meaning of the Vnso index
0: Uns /$\sqrt{3}$ (gain = 1)
1: Uns / 3 (gain = 1/$\sqrt{3}$)
2: 3V (sum of 3 phase-to-neutral voltages V1, V2, V3)
(4) meaning of type of Ino measurement index
0: 3I (sum of 3 phases I1, I2, I3)
1: by core balance CT
2: by CT + CHS30
3: core balance CT + ACE 990
(5) meaning of the index regarding the type of cubicle to detect the normal direction of current flow:
0: incomer
1: feeder
(6) meaning of EANA board input index
0: 0-20 mA
1: 0-10 mA
2: 4-20 mA
3: -10 +10 mA
(7) each parameter KP is coded in double word (value: 0 or 1).

* The data formats remotely read are defined in the manuals that describe each communication protocol.
**** Available as of version 9940 SFT2800.

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