Sepam™ Series 80 Protective Relays

Reference Manual

Instruction Bulletin
63230-216-230B1



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Safety Instructions

Safety Symbols and Messages

Read these instructions carefully and look at the equipment to become familiar with the device before trying to install, operate, service or maintain it. The following special messages may appear throughout this bulletin or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.



ANSI symbol



IEC symbol

Risk of Electric Shock

The addition of either symbol to a “Danger” or “Warning” safety label on a device indicates that an electrical hazard exists, which will result in death or personal injury if the instructions are not followed.



Safety Alert

This is the safety alert symbol. It is used to alert you to potential personal injury hazards and prompt you to consult the manual. Obey all safety instructions that follow this symbol in the manual to avoid possible injury or death.

Safety Messages

⚠ DANGER

DANGER indicates an imminently hazardous situation which, if not avoided, will result in death, serious injury or property damage.

⚠ WARNING

WARNING indicates a potentially hazardous situation which, if not avoided, **could result in** death, serious injury or property damage.

⚠ CAUTION

CAUTION indicates a potentially hazardous situation which, if not avoided, minor or moderate injury or property damage.

Important Notes

Restricted Liability

Electrical equipment should be serviced and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this manual. This document is not intended as an instruction manual for untrained persons.

Device Operation

The user is responsible for checking that the rated characteristics of the device are suitable for its application. The user is responsible for reading and following the device’s operating and installation instructions before attempting to commission or maintain it. Failure to follow these instructions can affect device operation and constitute a hazard for people and property.

Protective Grounding

The user is responsible for compliance with all the existing international and national electrical codes concerning protective grounding of any device.

FCC Notice

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense. This Class A digital apparatus complies with Canadian ICES-003.

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Sepam™ Protective Relays
Overview

The Sepam™ range of protection relays is designed for all protection applications on medium-voltage public and industrial distribution networks.

It consists of three series of relays, with increasing levels of performance:
- *Sepam™ Series 20, for simple applications*
- *Sepam™ Series 40, for demanding applications*
- *Sepam™ Series 80, for custom applications*

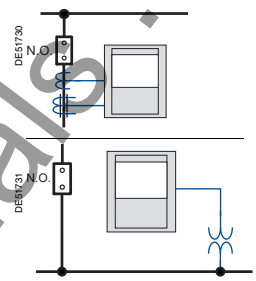
All information relating to the Sepam™ range can be found in the following documents:
- *Sepam™ Family Catalog, reference 63230-216-238*
- *Sepam™ Series 20 User's Manual, reference 63230-216-208*
- *Sepam™ Series 40 User's Manual, reference 63230-216-219*
- *Sepam™ Series 80 Reference Manual, reference 63230-216-230*
- *Sepam™ Series 80 Modbus Communication User's Manual, reference 63230-216-231*
- *Sepam™ Series 80 Operation Manual, reference 63230-216-229*
- *Sepam™ DNP3 Communication User's Manual, reference 63230-216-236*
- *Sepam™ IEC 60870-5-103 Communication User's Manual, reference 63230-216-237*

Sepam™ Series 20

For Simple Applications



Characteristics
- 10 logic inputs
- 8 relay outputs
- 1 communication port
- 8 temperature sensor inputs

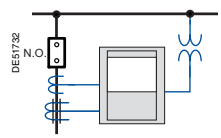


Sepam™ Series 40

For Demanding Applications



Characteristics
- 10 logic inputs
- 8 relay outputs
- Logic equation editor
- 1 communication port
- 16 temperature sensor inputs

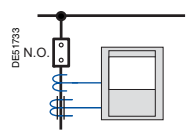


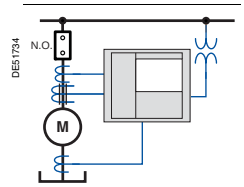
Sepam™ Series 80

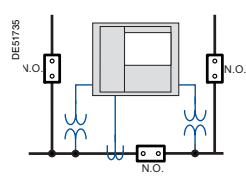
For Custom Applications

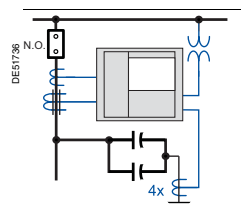


Characteristics
- 42 logic inputs
- 23 relay outputs
- Logic equation editor
- 2 communication ports for multimaster or redundant architecture
- 16 temperature sensor inputs
- Removable memory cartridge with parameters and settings for quick return to service after replacement
- Battery for storing logs and recording data
- Mimic-based User Machine Interface for local control of the device in complete safety
- Optional Logipam programming software, for programming dedicated functions









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Sepam™ Protective Relays
Overview

Protection		Applications					
Standard	**Specific**	**Substation**	**Bus**	**Transformer**	**Motor**	**Generator**	**Capacitor**
Current protection	Breaker failure	**S23**		**T23**	**M20**		
Voltage and frequency protection			**B21**				
	Disconnection (ROCOF)		**B22**				
Current, voltage, and frequency protection		**S40**		**T40**		**G40**	
	Directional ground fault	**S41**			**M41**		
	Directional ground fault and phase overcurrent	**S42**		**T42**			
Current, voltage and frequency protection		**S80**	**B80**				
	Directional ground fault	**S81**		**T81**	**M81**		
	Directional ground fault and phase overcurrent	**S82**		**T82**		**G82**	
	Disconnection (ROCOF)	**S84**					
Current, voltage, and frequency protection	Transformer or machine-transformer unit differential			**T87**	**M88**	**G88**	
	Machine differential				**M87**	**G87**	
Current, voltage, and frequency protection	Voltage and frequency protection for two sets of busses		**B83**				
Current, voltage, and frequency protection	Capacitor bank unbalance						**C86**

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Presentation

The Sepam™ range of protection relays is designed for operating machines, the electrical distribution networks of industrial installations, and utility substations at all levels of voltage. The Sepam™ family includes:

- *Sepam™ Series 20*
- *Sepam™ Series 40*
- *Sepam™ Series 80*

to cover all needs, from the simplest to the most complete.



Sepam™ Series 80 with integrated advanced UMI

Sepam™ Series 80: Intelligent Solutions for Custom Applications

Specially designed for demanding customers on large industrial sites, Sepam™ Series 80 provides proven solutions for electrical distribution and machine protection

Main Characteristics

The Sepam™ Series 80 offers these features:

- protects closed ring networks or networks with parallel mains by means of directional protection and zone selective interlocking
- directional ground fault protection for impedance-grounded and effectively ungrounded or compensated neutral systems (designed to compensate for system capacitance using a tuned inductor in the neutral. This is not common in North America).
- complete protection of transformers and machine-transformer units
  - stable, sensitive differential protection with neural network restraint
  - linked to all necessary backup protection functions
- complete protection of motors and generators
  - against internal faults:
    - stable, sensitive machine differential protection, with starting and instrument transformer loss restraint
    - field loss, stator ground fault
  - against network and process faults: pole slip, speed control, inadvertent energization
- sync-check between two networks before closing tie breaker
- measurement of harmonic distortion, current and voltage, to assess network power quality
- 42 inputs / 23 outputs for comprehensive equipment control
- mimic-based UMI for local switchgear control
- SFT2841 parameter setting and operating software, a simple and complete tool that is indispensable for all Sepam™ users:
  - assisted preparation of parameter and protection settings
  - complete information during commissioning
  - remote equipment management and diagnostics during operation
- logic equation editor built into the SFT2841 software to adapt the predefined control functions
- optional SFT2885 programming software (Logipam), to program specific control and monitoring functions
- two communication ports to integrate Sepam™ in two different networks or redundant architectures
- removable memory cartridge to get equipment in operation again quickly after the replacement of a faulty base unit
- battery backup to save historical and disturbance recording data

Selection Guide

The Sepam™ Series 80 family includes 16 types to offer the right solution for each application.

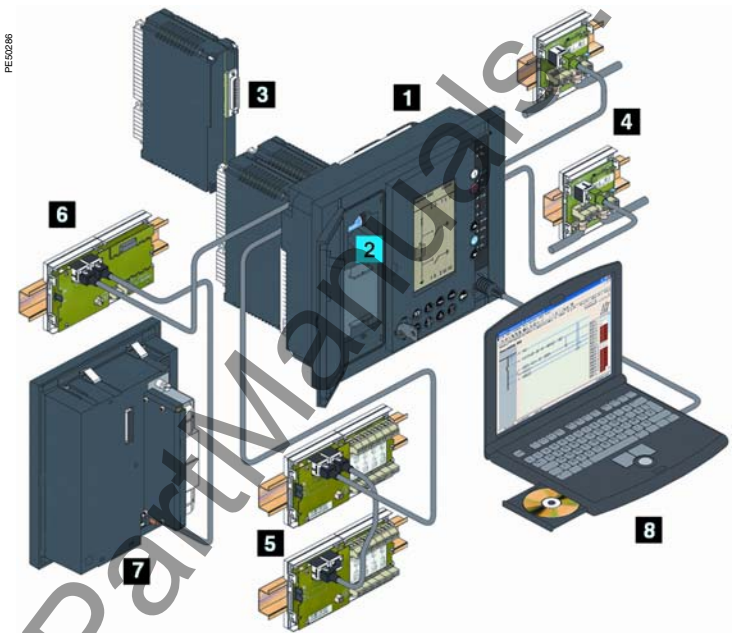
Specific Protection Functions Available	Applications					
General Performance	**Substation**	**Transformer**	**Motor**	**Generator**	**Bus**	**Capacitor**
Non-directional phase and ground faults	S80				B80	
Directional ground fault	S81	T81	M81			
Directional ground fault and phase overcurrent	S82	T82		G82		
Check on 3-phase voltages on two busses					B83	
Rate of change of frequency	S84					
Capacitor bank unbalance						C86
Transformer or machine differential		T87	M87	G87		
Machine-transformer unit differential			M88	G88		

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Flexibility and Upgrading Capability

The user can add optional modules to Sepam™ at any time for increased functionality. This gives Sepam™ exceptional versatility, adapting to as many situations as possible, and allowing for future installation upgrade,



1 **Base unit, with different types of User Machine Interfaces (UMI):**
- integrated mimic-based UMI
- integrated or remote advanced UMI

2 **Parameter and protection settings saved on removable memory cartridge.**

3 **42 logic inputs and 23 output relays**
with three optional modules providing 14 inputs and 6 outputs.

4 **Two independent communication ports**
- direct connection to 2-wire RS485, 4-wire RS485 and fiber optic networks
- connection to Ethernet TCP/IP network via PowerLogic Ethernet server (Transparent Ready™)

5 **Processing of data from 16 temperature sensors,**
Pt100, Ni100 or Ni120.

6 **1 low level analog output,**
0-10 mA, 4-20 mA or 0-20 mA

7 **Sync-check module**

8 **Software tools:**
- Sepam™ parameter and protection setting, and predefined control functions adaptation
- local or remote installation operation
- programming specific functions (Logipam)
- retrieval and display of disturbance recording data

Easy Installation

- light, compact base unit
- easy to integrate due to Sepam's adaptation capabilities:
  - universal supply voltage and logic inputs: 24 to 250 V DC
  - phase currents may be measured by 1A or 5A current transformers, or LPCT (Low Power Current Transducer) type CTs
  - residual current calculated or measured by a choice of methods to fit requirements
- the same, easy-to-install remote modules for all Sepam™ units:
  - mounted on DIN rail
  - connected to the Sepam™ base unit by prefabricated cords

Commissioning Assistance

- predefined functions implemented by simple parameter setting
- user-friendly, powerful SFT2841 PC setting software tool used on all Sepam™ units to provide users with all the possibilities offered by Sepam™.

Intuitive Use

- integrated or remote advanced User Machine Interface (UMI) installed in the most convenient place for the facility manager
- integrated mimic-based User Machine Interface for local control of switchgear
- user-friendly User Machine Interface, with direct access to data
- clear graphic LCD display of all data required for local operation and installation diagnosis
- working language may be customized to be understood by all users

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Selection Table

		Substation				Transformer			Motor			Generator			Bus		Cap.
Protection	**ANSI Code**	**S80**	**S81**	**S82**	**S84**	**T81**	**T82**	**T87**	**M81**	**M87**	**M88**	**G82**	**G87**	**G88**	**B80**	**B83**	**C86**
Phase overcurrent (1)	50/51	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Ground fault / Sensitive ground fault (1)	50N/51N 50G/51G	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Breaker failure	50BF	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Negative sequence / unbalance	46	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Thermal overload for cables	49RMS		2	2	2												
Thermal overload for machines (1)	49RMS					2	2	2	2	2	2	2	2	2			
Thermal overload for capacitors	49RMS																2
Capacitor bank unbalance	51C																8
Restricted ground fault	64REF					2	2	2				2		2			
Two-winding transformer differential	87T							1			1			1			
Machine differential	87M									1			1				
Directional phase overcurrent (1)	67			2	2		2	2				2	2	2			
Directional ground fault (1)	67N/67NC		2	2	2	2	2	2	2	2	2	2	2	2			
Directional active overpower	32P		2	2	2	2	2	2	2	2	2	2	2	2			
Directional reactive overpower	32Q								1	1	1	1	1	1			
Directional active underpower	37P				2							2					
Phase undercurrent	37								1	1	1						
Excessive starting time, locked rotor	48/51LR								1	1	1						
Starts per hour	66								1	1	1						
Field loss (underimpedance)	40								1	1	1	1	1	1			
Pole slip	78PS								1	1	1	1	1	1			
Overspeed (2 set points) (2)	12								□	□	□	□	□	□			
Underspeed (2 set points) (2)	14								□	□	□	□	□	□			
Voltage-restrained overcurrent	50V/51V											2	2	2			
Underimpedance	21B											1	1	1			
Inadvertent energization	50/27											1	1	1			
Third harmonic undervoltage / 100 % stator ground fault	27TN/64G2 64G											2	2	2			
Overexcitation (V / Hz)	24							2				2	2	2			
Positive sequence undervoltage	27D	2	2	2	4	2	2	2	2	2	2	2	2	2	4	4	4
Remnant undervoltage	27R	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Undervoltage (L-L or L-n)	27	4	4	4	2	4	4	4	4	4	4	4	4	4	2	2	2
Overvoltage (L-L or L-n)	59	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Neutral voltage displacement	59N	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Negative sequence overvoltage	47	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Overfrequency	81H	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Underfrequency	81L	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Rate of change of frequency	81R				2												
Recloser (4 shots) (2)	79	□	□	□	□												
Thermostat / Pressure (2)	26/63					□	□	□	□		□	□		□			
Temperature monitoring (16 RTDs) (3)	38/49T					□	□	□	□	□	□	□	□	□			□
Sync-check (4)	25	□	□	□	□	□	□	□				□	□	□	□	□	
Control and Monitoring																	
Circuit breaker / contactor control	94/69	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Automatic transfer (AT) (2)		□	□	□	□	□	□	□				□	□	□	□	□	
Load shedding / automatic restart									■	■	■						
De-excitation												■	■	■			
Genset shutdown												■	■	■			
Capacitor step control (2)																	□
Zone Selective Interlocking (2)	68	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Latching / acknowledgement	86	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Annunciation	30	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Switching of groups of settings		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Adaptation using logic equations		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Logipam programming (Ladder language)		□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□

The figures indicate the number of relays available for each protection function.

■ *standard*, □ *options.*

(1) *Protection functions with two groups of settings.*

(2) *According to parameter setting and optional MES120 input/output modules.*

(3) *With optional MET1482 temperature input modules.*

(4) *With optional MCS025 sync-check module.*

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Selection Table

		Substation				Transformer			Motor			Generator			Bus		Cap.
Metering		**S80**	**S81**	**S82**	**S84**	**T81**	**T82**	**T87**	**M81**	**M87**	**M88**	**G82**	**G87**	**G88**	**B80**	**B83**	**C86**
Phase current Ia, Ib, Ic, RMS		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Measured residual current Ir, calculated IrΣ		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Demand current Ia, Ib, Ic		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Peak demand current Iamax, Ibmax, Icmax		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Measured residual current I'r		■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Voltage Vab, Vbc, Vac, Van, Vbn, Vcn		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Residual voltage Vr		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Positive sequence voltage V1 / rotation direction		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Negative sequence voltage V2		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Frequency f		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Active power P, Pa, Pb, Pc		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Reactive power Q, Qa, Qb, Qc		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Apparent power S, Sa, Sb, Sc		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Peak demand power Pmax, Qmax		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Power factor pf		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Calculated active and reactive energy (±Wh, ±VARh)		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Active and reactive energy by pulse counting (2) (± Wh, ± VARh)		□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Phase current I'a, I'b, I'c, RMS								■		■	■		■	■			
Calculated residual current I'rΣ								■		■	■		■	■			
Voltage V'ab, V'an and frequency															■		
Voltage V'ab, V'bc, V'ac, V'an, V'bn, V'cn, V'1, V'2, and frequency																■	
Residual voltage V'r																■	
Temperature (16 RTDs) (3)						□	□	□	□	□	□	□	□	□			□
Rotation speed (2)									□	□	□	□	□	□			
Neutral point voltage Vnt									■	■	■	■	■	■			
Network and Machine Diagnosis																	
Tripping context		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Tripping current TripIa, TripIb, TripIc		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Phase fault and ground fault trip counters		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Unbalance ratio / negative sequence current I2		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Harmonic distortion (thd), current (Ithd) and voltage (Vthd)		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Phase displacement φr, φ'r, φrΣ		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Phase displacement φa, φb, φc		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Disturbance recording		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Thermal capacity used			■	■	■	■	■	■	■	■	■	■	■	■			■
Remaining operating time before overload tripping			■	■	■	■	■	■	■	■	■	■	■	■			■
Waiting time after overload tripping			■	■	■	■	■	■	■	■	■	■	■	■			■
Running hours counter / operating time						■	■	■	■	■	■	■	■	■			■
Starting current and time									■	■	■						
Start block time									■	■	■						
Number of starts before blocking									■	■	■						
Unbalance ratio / negative sequence current I'2								■		■	■		■	■			
Differential current Idiffa, Idiffb, Idiffc								■		■	■		■	■			
Through current Ita, Itb, Itc								■		■	■		■	■			
Current phase displacement θr								■		■	■		■	■			
Apparent positive sequence impedance Z1			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Apparent phase-to-phase impedances Zab Zbc, Zac			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Third harmonic voltage, neutral point (VntH3) or residual (VrH3)												■	■	■			
Difference in amplitude, frequency and phase of voltages compared for sync-check (4)		□	□	□	□	□	□	□				□	□	□	□	□	
Capacitor unbalance current and capacitance																	■
Switchgear Diagnosis	**ANSI Code**																
CT / VT supervision	60/60FL	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Trip circuit supervision (2)	74	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Auxiliary power supply monitoring		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Cumulative breaking current		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Number of operations, operating time, charging time, number of racking out operations (2)		□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Modbus, IEC 60870-5-103 or DNP3 Communication*																	
Measurement readout (5)		□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Remote indication and time tagging of events (5)		□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Remote control commands (5)		□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Remote protection setting (5)		□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Transfer of disturbance recording data (5)		□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□

■ *standard,* □ *options.*

(2) *According to parameter setting and optional MES120 input/output modules.*

(3) *With optional MET1482 temperature input modules.*

(4) *With optional MCS025 sync-check module.*

(5) *With ACE9492, ACE959, ACE937, ACE969TP or ACE969FO communication interface.*

Note : ** Modbus, IEC60870-5-103, or DNP3 are available using ACE9492, ACE 959, ACE937, ACE969TP or ACE969FO.*

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1

Weight					
		Base Unit with Advanced UMI		**Base Unit with Mimic-Based UMI**	
Minimum weight (base unit without MES120)		5.29 lb. (2.4 kg)		6.61 lb. (3.0 kg)	
Maximum weight (base unit with 3 MES120)		8.82 lb. (4.0 kg)		10.1 lb. (4.6 kg)	
Instrument Transformer Inputs					
Phase Current Inputs		**1A or 5A CT**			
Input impedance		< 0.02 Ω			
Burden		< 0.02 VA (1A CT) < 0.5 VA (5A CT)			
Continuous thermal withstand		4 In			
1 second overload		100 In			
Voltage Inputs		**Phase**		**Residual**	
Input impedance		> 100 kΩ		> 100 kΩ	
Burden		< 0.015 VA (100 V VT)		< 0.015 VA (100 V VT)	
Continuous thermal withstand		240 V		240 V	
1-second overload		480 V		480 V	
Isolation of inputs from other isolated groups		Enhanced		Enhanced	
Relay Outputs					
Control Relay Outputs O1 to O4 and Ox01 (1)					
Voltage	DC	24/48 V DC	125 V DC	250 V DC	
	AC (47.5 to 63 Hz)				100 to 240 V AC
Continuous current		8 A	8 A	8 A	8 A
Breaking capacity	Resistive load	8 A / 4 A	0.7 A	0.3 A	
	Load L/R < 20 ms	6 A / 2 A	0.5 A	0.2 A	
	Load L/R < 40 ms	4 A / 1 A	0.2 A	0.1 A	
	Resistive load				8 A
	Load p.f. > 0.3				5 A
Making capacity		< 15 A for 200 ms			
Isolation of outputs from other isolated groups		Enhanced			
Annunciation Relay Outputs O5 and Ox02 to Ox06					
Voltage	DC	24/48 V DC	127 V DC	220 V DC	
	AC (47.5 to 63 Hz)				100 to 240 V AC
Continuous current		2 A	2 A	2 A	2 A
Breaking capacity	L/R load < 20 ms	2 A / 1 A	0.5 A	0.15 A	
	Load p.f. > 0.3				1 A
Isolation of outputs from other isolated groups		Enhanced			
Power Supply					
Voltage		24 to 250 V DC	–20 % / +10 %		
Maximum burden		< 16 W			
Inrush current		< 10 A 10 ms			
Acceptable ripple content		12 %			
Acceptable momentary outages		100 ms			
Battery					
Format		1/2 AA lithium 3.6 V			
Service life		10 years Sepam™ energized			
		8 years Sepam™ not energized			

***(1)** Relay outputs comply with clause 6.7 of standard C37.90, (30 A, 200 ms, 2000 operations).*

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Environmental Characteristics

Electromagnetic Compatibility	Standard	Level / Class	Value
Emission Tests			
Disturbing field emission	IEC 60255-25		
	EN 55022	A	
Conducted disturbance emission	IEC 60255-25		
	EN 55022	A	
Immunity Tests – Radiated Disturbances			
Immunity to radiated fields	ANSI C37.90.2 (1995)		35 V/m; 25 MHz - 1 GHz
	IEC 60255-22-3	III	10 V/m; 80 MHz - 1 GHz
	IEC 61000-4-3		10 V/m; 80 MHz - 2 GHz
Electrostatic discharge	ANSI C.37.90.3		8 kV air; 4 kV contact
	IEC 60255-22-2		8 kV air; 6 kV contact
Immunity to magnetic fields at network frequency	IEC 61000-4-8	4	30 A/m (continuous) - 300 A/m (1 - 3 s)
Immunity Tests – Conducted Disturbances			
Immunity to conducted RF disturbances	IEC 60255-22-6	III	10 V
Fast transient bursts	ANSI C37.90.1		4 kV; 2.5 kHz
	IEC 60255-22-4	A and B	4 kV; 2.5 kHz / 2 kV; 5 kHz
	IEC 61000-4-4	IV	4 kV; 2.5 kHz
1 MHz damped oscillating wave	ANSI C37.90.1		2.5 kV; 2.5 kHz
	IEC 60255-22-1		2.5 kV CM; 1kV DM
Surges	IEC 61000-4-5	III	2 kV CM; 1 kV DM
Voltage interruptions	IEC 60255-11		100 % during 100 ms
Mechanical Robustness	**Standard**	**Level / Class**	**Value**
In Operation			
Vibrations	IEC 60255-21-1	2	1 Gn; 10 Hz - 150 Hz
	IEC 60068-2-6	Fc	2 Hz - 13.2 Hz ; a = ±1 mm
Shocks	IEC 60255-21-2	2	10 Gn / 11 ms
Groundquakes	IEC 60255-21-3	2	2 Gn (horizontal axes)
			1 Gn (vertical axes)
De-Energized			
Vibrations	IEC 60255-21-1	2	2 Gn; 10 Hz - 150 Hz
Shocks	IEC 60255-21-2	2	27 Gn / 11 ms
Jolts	IEC 60255-21-2	2	20 Gn / 16 ms
Climatic Withstand	**Standard**	**Level / Class**	**Value**
In Operation			
Exposure to cold	IEC 60068-2-1	Ad	–25 °C (–13 °F)
Exposure to dry heat	IEC 60068-2-2	Bd	+70 °C (+158 °F)
Continuous exposure to damp heat	IEC 60068-2-78	Cab	10 days; 93 % RH; 40 °C (104 °F)
Salt mist	IEC 60068-2-52	Kb/2	6 days
Influence of corrosion/Gas test 2	IEC 60068-2-60		21 days; 75 % RH; 25 °C (77 °F); 0.5 ppm H_2S; 1 ppm SO_2
Influence of corrosion/Gas test 4	IEC 60068-2-60		21 days; 75 % RH; 25 °C (77 °F); 0.01 ppm H_2S; 0.2 ppm SO_2; 0.2 ppm NO_2; 0.01 ppm Cl_2
In Storage (3)			
Temperature variation with specified variation rate	IEC 60068-2-14	Nb	–25 °C to +70 °C, (–13 °F to +158 °F) 5 °C/min
Exposure to cold	IEC 60068-2-1	Ab	–25 °C (–13 °F)
Exposure to dry heat	IEC 60068-2-2	Bb	+70 °C (+158 °F)
Continuous exposure to damp heat	IEC 60068-2-78	Cab	56 days; 93 % RH; 40 °C (104 °F)
	IEC 60068-2-30	Db	6 days; 95 % RH; 55 °C (131 °F)
Safety	**Standard**	**Level / Class**	**Value**
Enclosure Safety Tests			
Front panel tightness	IEC 60529	IP52	Other panels IP20
	NEMA	Type 12	
Fire withstand	IEC 60695-2-11		650 °C (1200 °F) with glow wire
Electrical Safety Tests			
1.2/50 µs impulse wave	IEC 60255-5		5 kV (1)
Power frequency dielectric withstand	ANSI C37.90		1 kV 1 min (indication output) 1.5 kV 1 min (control output)
	IEC 60255-5		2 kV 1 min (2)
Certification			
CE	EN 50263 harmonized standard	European directives: ■ 89/336/EECElectromagnetic Compatibility (EMC) Directive □ 92/31/EECAmendment □ 93/68/EECAmendment ■ 73/23/EECLow Voltage Directive □ 93/68/EECAmendment	
UL	UL508 - CSA C22.2 no. 14-95		File E212533
CSA	CSA C22.2 no. 14-95 / no. 94-M91 / no. 0.17-00		File 210625

(1) *Except for communication: 3 kV in common mode and 1 kV in differential mode.*
(2) *Except for communication: 1 kVrms.*
(3) *Sepam™ must be stored in its original packing.*

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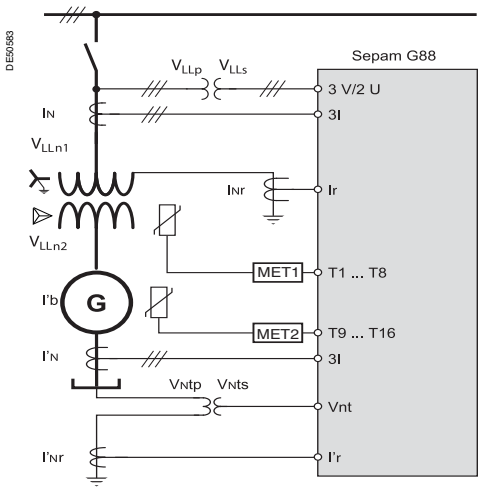
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Instrument Transformer Inputs



Example of Sepam™ G88 instrument transformer inputs

Sepam™ Series 80 has analog inputs that are connected to the measurement instrument transformers required for applications:

- main analog inputs, available on all types of Sepam™ Series 80:
  - three phase current inputs Ia, Ib, Ic
  - one residual current input Ir
  - three phase voltage inputs Van, Vbn, Vcn
  - one residual voltage input Vr
- additional analog inputs, dependent on the type of Sepam™:
  - three additional phase current inputs I'a, I'b, I'c
  - one additional residual current input I'r
  - three additional phase voltage inputs V'an, V'bn, Vcn
  - one additional residual voltage input V'r

The table below lists the analog inputs available according to the type of Sepam™ Series 80.

		S80, S81, S82, S84	T81, T82, M81, G82	T87, M87, M88, G87, G88	B80	B83	C86
Phase current inputs	Main channel	Ia, Ib, Ic	Ia, Ib, Ic	Ia, Ib, Ic	Ia, Ib, Ic	Ia, Ib, Ic	Ia, Ib, Ic
	Additional channels			I'a, I'b, I'c			
Residual current inputs	Main channel	Ir	Ir	Ir	Ir	Ir	Ir
	Additional channels	I'r	I'r	I'r	I'r		
Unbalance current inputs for capacitor steps							I'a, I'b, I'c, I'r
Phase voltage inputs	Main channel	Van, Vbn, Vcn, or Vab, Vbc	Van, Vbn, Vcn, or Vab, Vbc	Van, Vbn, Vcn, or Vab, Vbc	Van, Vbn, Vcn, or Vab, Vbc	Van, Vbn, Vcn, or Vab, Vbc	Van, Vbn, Vcn, or Vab, Vbc
	Additional channels				V'an or V'ab	V'a, V'b, V'c, or V'ab, V'bc	
Residual voltage inputs	Main channel	Vr	Vr	Vr	Vr (1)	Vr	Vr
	Additional channel					V'r	
Temperature inputs (on MET1482 module)			T1 to T16	T1 to T16			T1 to T16

***Note**: by extension, an additional measurement (current or voltage) is a value measured via an additional analog channel.*
***(1)** Available with phase voltage Vab, Vbc.*

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General Settings

The general settings define the characteristics of the measurement instrument transformers Sepam™ connects to. These settings also determine the performance of the metering and protection functions that Sepam™ uses. The user can access these settings in the SFT2841 setting software "General Characteristics", "CT-VT Sensors", and "Particular Characteristics" tabs.

General Settings		Selection	Value
I_N, I'_N	Rated phase current (instrument transformer primary current)	Two or three 1A / 5A CTs	1 A to 6250 A
		Three LPCTs	25 A to 3150 A (1)
I'_N	Unbalance current CT rating (capacitor application)	CT 1A / 2A / 5A	1 A to 30 A
I_B	Base current, according to rated power of equipment		0.2 to 1.3 I_N
I'_B	Base current on additional channels (not adjustable)	Applications with transformer	$I'_B = I_B \times V_{LLN}1/V_{LLN}2$
		Other applications	$I'_B = I_B$
I_{Nr}, I'_{Nr}	Rated residual current	Sum of three phase currents	See I_N(I'_N) rated phase current
		CSH120 or CSH200 zero sequence CT	2 A or 20 A rating
		1A / 5A CT	1 A to 6250 A
		Zero sequence CT + ACE990 (the zero sequence CT ratio 1/n must be such that 50 ≤ n ≤ 1500)	According to current monitored and use of ACE990
V_{LLp}, V'_{LLp}	Rated primary phase-to-phase voltage (Vnp: rated primary phase-to-neutral voltage Vnp = $V_{LLp}/\sqrt{3}$)		220 V to 250 kV
V_{LLs}, V'_{LLs}	Rated secondary phase-to-phase voltage	3 VTs: Van, Vbn, Vcn	90 to 230 V_{LL}
		2 VTs: Vab, Vbc	90 to 230 V_{LL}
		1 VT: Vab	90 to 230 V_{LL}
		1 VT: Van	90 to 230 V_{LL}
$V_{LLs}0$, $V'_{LLs}0$	Secondary zero sequence voltage for primary zero sequence voltage $V_{LLp}/\sqrt{3}$		$V_{LLs}/3$ or $V_{LLs}/\sqrt{3}$
Vntp	Neutral point voltage transformer primary voltage (generator application)		220 V to 250 kV
Vnts	Neutral point voltage transformer secondary voltage (generator application)		57.7 V to 133 V
f_N	Rated frequency		50 Hz or 60 Hz
	Phase rotation direction		a-b-c or a-c-b
	Integration period (for demand current and peak demand current and power)		5, 10, 15, 30, 60 min
	Pulse-type accumulated energy meter	Increments active energy	0.1 kWh to 5 MWh
		Increments reactive energy	0.1 kVARh to 5 MVARh
P	Rated transformer power		100 kVA to 999 MVA
$V_{LLN}1$	Rated winding a voltage (main channels: I)		220 V to 220 kV
$V_{LLN}2$	Rated winding b voltage (additional channels: I')		220 V to 400 kV
I_N1	Rated winding a current (not adjustable)		$I_{Na} = P/(\sqrt{3}\ V_{LLN}1)$
I_N2	Rated winding b current (not adjustable)		$I_{Nb} = P/(\sqrt{3}\ V_{LLN}2)$
	Transformer vector shift		0 to 11
ω_N	Rated speed (motor, generator)		100 to 3600 rpm
R	Number of pulses per rotation (for speed acquisition)		1 to 1800 (Ωn x R/60 ⩽ 1500)
	Zero speed set point		5 to 20 % of Ωn
	Number of capacitor steps		1 to 4
	Connection of capacitor steps		Wye / Delta
	Capacitor step ratio	Step 1	1
		Step 2	1, 2
		Step 3	1, 2, 3, 4
		Step 4	1, 2, 3, 4, 6, 8

(1) *In values for LPCT, in Amps: 25, 50, 100, 125, 133, 200, 250, 320, 400, 500, 630, 666, 1000, 1600, 2000, 3150*

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Characteristics

Functions		Measurement Range	Accuracy (1)	MSA141	Saving
Metering					
Phase current		0.02 to 40 In	±0.5 %	■	
Residual current	Calculated	0.005 to 40 In	±1 %	■	
	Measured	0.005 to 20 Inn	±1 %	■	
Demand current		0.02 to 40 In	±0.5 %		
Peak demand current		0.02 to 40 In	±0.5 %		□
Phase-to-phase voltage	Main channels (V)	0.05 to 1.2 $V_{(L-L)}p$	±0.5 %	■	
	Additional channels (V')	0.05 to 1.2$V_{(L-L)}p$	±1 %		
Phase-to-neutral voltage	Main channels (Van, Vbn, Vcn)	0.05 to 1.2 $V_{(L-n)}p$	±0.5 %	■	
	Additional channels (V'an, Vbn, V'cn)	0.05 to 1.2 $V_{(L-n)}p$	±1 %		
Residual voltage		0.015 to 3 $V_{(L-n)}p$	±1 %		
Neutral point voltage		0.015 to 3 Vntp	±1 %		
Positive sequence voltage		0.05 to 1.2 Vnp	±2 %		
Negative sequence voltage		0.05 to 1.2 Vnp	±2 %		
Frequency	Main channels (f)	25 to 65 Hz	±0.01 Hz	■	
	Additional channels (f')	45 to 55 Hz (fn = 50 Hz) 55 to 65 Hz (fn = 60 Hz)	±0.05 Hz		
Active power (total or per phase)		0.008 Sn to 999 MW	±1 %	■	
Reactive power (total or per phase)		0.008 Sn to 999 MVAR	±1 %	■	
Apparent power (total or per phase)		0.008 Sn to 999 MVA	±1 %	■	
Peak demand active power		0.008 Sn to 999 MW	±1 %		□
Peak demand reactive power		0.008 Sn to 999 MVAR	±1 %		□
Power factor		–1 to + 1 (CAP/IND)	±0.01	■	
Calculated active energy		0 to 2.1 x 10^8 MWh	±1 % ±1 digit		□ □
Calculated reactive energy		0 to 2.1 x 10^8 MVARh	±1 % ±1 digit		□ □
Temperature		–30 °C to +200 °C or –22 °F to +392 °F	±1 °C from +20 to +140 °C	■	
Rotation speed		0 to 7200 rpm	±1 rpm		
Network Diagnosis Assistance					
Tripping context					□
Tripping current		0.02 to 40 In	±5 %		□
Number of trips		0 to 65535	-		□ □
Negative sequence / unbalance		1 to 500 % of I_B	±2 %		
Total harmonic distortion, current		0 to 100 %	±1 %		
Total harmonic distortion, voltage		0 to 100 %	±1 %		
Phase displacement φr (between Vr and Ir)		0 to 359°	±2°		
Phase displacement φa, φb, φc (between V and I)		0 to 359°	±2°		
Disturbance recording					□
Amplitude difference		0 to 1.2 V_{LL}sync1	±1 %		
Frequency difference		0 to 10 Hz	±0.5 Hz		
Phase difference		0 to 359°	±2°		
Out-of-sync context					□

■ *available on MSA141 analog output module, according to setup*
□ □ *saved in the event of auxiliary supply outage, even without battery*
□ *saved by battery in the event of auxiliary supply outage*
(1) *Typical accuracy, see details on subsequent pages*

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Characteristics

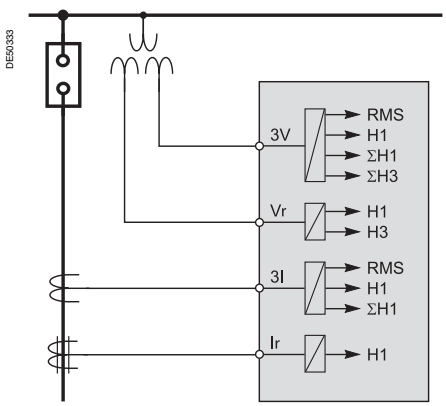
Functions	Measurement Range	Accuracy (1)	MSA141	Saving
Machine Operating Assistance				
Thermal capacity used	0 to 800 % (100 % for phase I = I_B)	±1 %	■	□ □
Remaining operating time before overload tripping	0 to 999 min	±1 min		
Waiting time after overload tripping	0 to 999 min	±1 min		
Running hours counter / operating time	0 to 65535 hours	±1 % or ±0.5 h		□ □
Starting current	1.2 Ib to 40 I_N	±5 %		□
Starting time	0 to 300 s	±300 ms		□
Number of starts before blocking	0 to 60			
Start block time	0 to 360 min	±1 min		
Differential current	0.015 to 40 I_N	±1 %		
Through current	0.015 to 40 I_N	±1 %		
Phase displacement θa, θb, θc (between I and I')	0 to 359°	±2°		
Apparent impedance Z1, Zab, Zbc, Zac	0 to 200 kΩ	±5 %		
Third harmonic neutral point voltage VntH3	0.2 to 30 % of $V_{Ln}p$	±1 %		
Third harmonic residual voltage VrH3	0.2 to 90 % of $V_{Ln}p$	±1 %		
Capacitance	0 to 30 F	±5 %		
Capacitor unbalance current	0.02 to 40 I'_N	±5 %		
Switchgear Diagnosis Assistance				
Cumulative breaking current	0 to 65535 kA²	±10 %		□ □
Number of operations	0 to 4 x 10^9	-		□ □
Operating time	20 to 100 s	±1 ms		□ □
Charging time	1 to 20 s	±0.5 s		□ □
Number of rackouts	0 to 65535	-		□ □

■ *available on MSA141 analog output module, according to setup*
□ □ *saved in the event of auxiliary supply outage, even without battery*
□ *saved by battery in the event of auxiliary supply outage*
(1) *Typical accuracy. See details on subsequent pages.*

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Processing Measured Signals



Values produced by Sepam™ from the signals measured

Measured Physical Values

Sepam™ measures the following physical values:
- phase currents (3I)
- residual current (Ir)
- phase voltages (3V)
- residual voltage (Vr)

Sepam™ processes each measured signal to produce all the values necessary for metering, diagnosis and protection.

The charts below identify (according to the various functions) the values produced from the signals measured, with:
- RMS = RMS value up to the 13th harmonic
- H1 = fundamental 50 Hz or 60 Hz component
- ΣH1 = vector sum of the fundamental components of the three phases
- H3 = 3rd harmonic component
- ΣH3 = vector sum of the 3rd harmonic components of the three phases.

Values Used by the Metering and Diagnosis Functions

		3I			Ir	3V				Vr	
Metering		**RMS**	**H1**	**ΣH1**	**H1**	**RMS**	**H1**	**ΣH1**	**ΣH3**	**H1**	**H3**
RMS phase current Ia, Ib, Ic		■									
Calculated residual current IrΣ				■							
Demand current Ia, Ib, Ic		■									
Peak demand current Iamax, Ibmax, Icmax		■									
Measured residual current Ir, I'r					■						
Voltage Vab, Vbc, Vac, Van, Vbn, Vcn, V'ab, V'bc, V'ac, V'an, V'bn, V'cn							■				
Residual voltage Vr								□		□	
Positive sequence voltage V1 / rotation direction							■				
Negative sequence voltage V2							■				
Frequency f							■				
Active power P, Pa, Pb, Pc			■				■				
Reactive power Q, Qa, Qb, Qc			■				■				
Apparent power S, Sa, Sb, Sc			■				■				
Peak demand power Pmax, Qmax			■				■				
Power factor (pf)			■				■				
Calculated active and reactive energy (± Wh, ± VARh)			■				■				
Phase current I'a, I'b, I'c RMS		■									
Calculated residual current I'rΣ				■							
Neutral point voltage $V_L$nt										■	
Network and Machine Diagnosis											
Tripping current Tripla, Triplb, Triplc			■								
Unbalance ratio / negative sequence current I2			■								
Harmonic distortion (THD), current Ithd		■	■								
Harmonic distortion (THD), voltage Vthd						■	■				
Phase displacement φr, φ'r, φrΣ				■	■			□		□	
Phase displacement φa, φb, φc			■				■				
Thermal capacity used		■									
Unbalance ratio / negative sequence current I'2			■								
Differential current Idiffa, Idiffb, Idiffc			■								
Through current Ita, Itb, Itc			■								
Angle between currents I and I'			■								
Starting current			■								
Third harmonic voltage, neutral point or residual	VntH3								■		■
Switchgear Diagnosis	**ANSI Code**										
CT / VT supervision	60/60FL		■				■				
Cumulative breaking current			■								

■ *standard*
□ *according to instrument transformers connected*

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Values Used by the Protection Functions

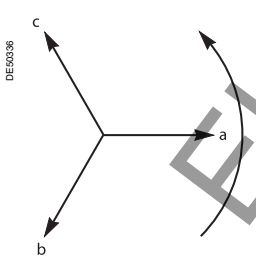
		3I			I0	3V				V0	
Protections	**ANSI Code**	**RMS**	**H1**	**ΣH1**	**H1**	**RMS**	**H1**	**ΣH1**	**ΣH3**	**H1**	**H3**
Phase overcurrent	50/51		■								
Ground fault Sensitive ground fault	50N/51N 50G/51G			□	□						
Breaker failure	50BF		■								
Negative sequence / current unbalance	46		■								
Thermal overload for cables	49RMS	■									
Thermal overload for machines	49RMS	■									
Thermal overload for capacitors	49RMS	■									
Capacitor bank unbalance	51C		■								
Restricted ground fault	64REF			■	■						
Two-winding transformer differential	87T		■								
Machine differential	87M		■								
Directional phase overcurrent	67		■				■				
Directional ground fault	67N/67NC			□	□			□		□	
Directional active overpower	32P		■				■				
Directional reactive overpower	32Q		■				■				
Directional active underpower	37P		■				■				
Phase undercurrent	37		■								
Excessive starting time, locked rotor	48/51LR		■								
Starts per hour	66		■								
Field loss (underimpedance)	40		■				■				
Pole slip	78 PS		■				■				
Voltage-restrained overcurrent	50V/51V		■				■				
Underimpedance	21B		■				■				
Inadvertent energization	50/27		■				■				
Third harmonic undervoltage / 100 % stator ground fault	27TN/64G2 64G								□		■
Overexcitation (V / Hz)	24						■				
Positive sequence undercurrent	27D						■				
Remnant undervoltage	27R						■				
Undervoltage (L-L or L-n)	27						■				
Overvoltage (L-L or L-n)	59						■				
Neutral voltage displacement	59N							□		□	
Negative sequence overvoltage	47						■				
Overfrequency	81H						■				
Underfrequency	81L						■				
Rate of change of frequency	81R						■				

■ *standard*
□ *according to instrument transformers connected*

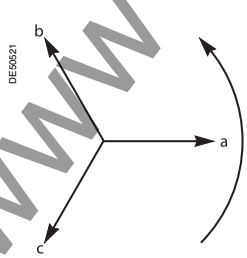
Phase Rotation Direction

The rotation direction of the three phases may be a-b-c, or a-c-b, the phase order in the trigonometric (counterclockwise) direction.

The phase rotation direction should be set for correct calculation of the symmetrical components (Va, Vb, VrΣ, Ia, Ib, IrΣ).



Phase rotation direction a-b-c



Phase rotation direction a-c-b

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2

Phase Current

Operation

This function provides an RMS value for the phase currents:

- Ia: phase a current, main channels
- Ib: phase b current, main channels
- Ic: phase c current, main channels
- I'a: phase a current, additional channels
- I'b: phase b current, additional channels
- I'c: phase c current, additional channels

It is based on RMS current measurement and considers up to the13th harmonic.
Different types of current transformers (CTs) can monitor phase current:

- 1A or 5A current transformers
- Low Power Current Transducer (LPCT) type current sensors

Readout

Access to the measurements is by one of the following:

- Sepam™ display via the key
- a PC loaded with SFT2841 software
- a communication link
- an analog converter with the MSA141 option

Characteristics

Measurement range	0.02 to 40 I_N (1)
Units	A or kA
Resolution	0.1 A
Accuracy	±0.5 % typical (2) ±1 % from 0.3 to 1.5 I_N ±2 % from 0.1 to 0.3 I_N
Display format	3 significant digits
Refresh interval	1 second (typical)

(1) *In rated current set in the general settings*
(2) *At In, under reference conditions (IEC 60255-6)*

Residual Current

Operation

This operation provides an RMS value of the residual current. It is based on measuring the fundamental component. Four types of residual current values are available, depending on the type of Sepam™ and CTs connected:

- two residual currents, IrΣ and I'rΣ, which are calculated by the vectoral sum of the three phase currents
- two measured residual currents, Ir and I'r

Different types of CTs can be used to measure residual current:

- CSH120 or CSH200 specific zero sequence CT
- conventional 1A or 5A current transformer
- any zero sequence CT with an ACE990 interface.

Readout

Access to the measurements is by one of the following:

- a Sepam™ display via the key
- a PC with SFT2841 software
- a communication link
- an analog converter with the MSA141 option.

Characteristics

Measurement range	IrΣ or I'rΣ			0.005 to 40 I_N (1)
	Ir or I'r measured by CSH zero sequence CT	Rating	I_{Nr} = 2 A	0.005 to 20 I_{Nr} (1)
			I_{Nr} = 20 A	0.005 to 20 I_{Nr} (1)
	Ir or I'r measured by zero sequence CT with ACE990			0.005 to 20 I_{Nr} (1)
	Ir or I'r measured by CT			0.005 to 20 I_{Nr} (1)
Units				A or kA
Resolution				0.1 A or 1 digit
Accuracy (2)				±1 % typical at In0 ±2 % from 0.3 to 1.5 I_{Nr} ±5 % from 0.1 to 0.3 I_{Nr}
Display format				3 significant digits
Refresh interval				1 second (typical)

(1) *I_N, I_{Nr}: nominal rating set in the general settings.*
(2) *Under reference conditions (IEC 60255-6), excluding CT accuracy.*

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Demand Current/ Peak Demand Currents

Operation

Demand current and peak demand currents are calculated according to the three phase currents Ia, Ib, and Ic:

- demand current is calculated over an adjustable period, usually 5 to 60 minutes
- peak demand current is the greatest demand current and indicates the current drawn by peak loads

Peak demand current values can be cleared. They are saved in the event of power loss.

Readout

Access the measurements by any of the following:

- the Sepam™ display via the key
- a PC with SFT2841 software
- a communication link.

Resetting to Zero

The user can access zero reset:

- via the **clear button** on the Sepam™ display if a peak demand is displayed
- via the **clear command** in the SFT2841 software
- via the communication link (remote control command TC4)

Characteristics

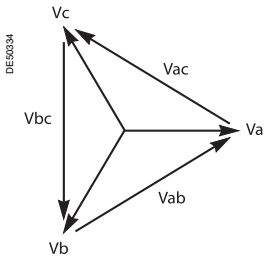
Measurement range	0.02 to 40 IN (1)
Units	A or kA
Resolution	0.1 A
Accuracy	±0.5 % typical (2) ±1 % from 0.3 to 1.5 IN ±2 % from 0.1 to 0.3 IN
Display format	3 significant digits
Integration period	5, 10, 15, 30, 60 min

(1) IN rated current set in the general settings.
(2) At IN, under reference conditions (IEC 60255-6).

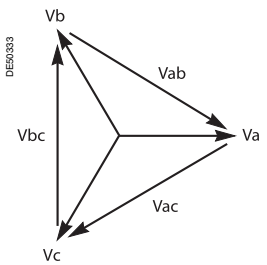
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Phase-to-Phase Voltage



a-b-c network: phase-to-neutral and phase-to-phase voltages



a-c-b network: phase-to-neutral and phase-to-phase voltages

Operation

This function gives the RMS value of the fundamental 50 Hz or 60 Hz component of:

- the main phase-to-phase voltages:
  - $(\vec{V}ab = \vec{V}a - \vec{V}b)$, voltage between phases a and b
  - $(\vec{V}bc = \vec{V}b - \vec{V}c)$, voltage between phases b and c
  - $(\vec{V}ca = \vec{V}c - \vec{V}a)$, voltage between phases a and c
- the additional phase-to-phase voltages:
  - $(\vec{V}'ab = \vec{V}'a - \vec{V}'b)$, voltage between phases a and b
  - $(\vec{V}'bc = \vec{V}'b - \vec{V}'c)$, voltage between phases b and c
  - $(\vec{V}'ac = \vec{V}'a - \vec{V}'c)$, voltage between phases a and c

Readout

Access to the measurements is by one of the following:

- the Sepam™ display via the key
- a PC with SFT2841 software
- communication link
- an analog converter with the MSA141 option

Characteristics

Measurement range	0.05 to 1.2 $V_{LL}p$ (1)
Units	V or kV
Resolution	1 V
Accuracy	±0.5 % typical (2) main channels ±1 % typical (2) additional channels ±1 % from 0.5 to 1.2 $V_{LL}p$ ±2 % from 0.06 to 0.5 $V_{LL}p$
Display format	3 significant digits
Refresh interval	1 second (typical)

(1) *Set in the general settings*
(2) *At $V_{LL}p$, under reference conditions (IEC 60255-6)*

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Phase-to-Neutral Voltage

Operation

This function gives the RMS value of the fundamental 50 Hz or 60 Hz component of:

- the main phase-to-neutral voltages Van, Vbn, and Vcn, measured on phases a, b, and c
- the additional phase-to-neutral voltages V'an, V'bn, and V'cn, measured on phases a, b, and c

Readout

Access to the measurements is by one of the following:

- the Sepam™ display via the key
- a PC with SFT2841 software
- the communication link
- an analog converter with the MSA141 option

Characteristics

Measurement Range	0.05 to 1.2 $V_{(L-n)p}$ (1)
Units	V or kV
Resolution	1 V
Accuracy	±0.5 % typical (2) main channels ±1 % typical (2) additional channels ±1 % from 0.5 to 1.2 $V_{Ln}p$ ±2 % from 0.06 to 0.5 $V_{Ln}p$
Display Format	3 significant digits
Refresh Interval	1 second (typical)

(1) $V_{(L-n)p}$*: primary rated phase-to-neutral voltage (*$V_{(L-n)p} = V_{LL}p/\sqrt{3}$*)*
(2) *At* $V_{Ln}p$*, under reference conditions (IEC 60255-6)*

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Residual Voltage
Neutral Point Voltage

Residual Voltage

Operation

This function provides the following values:

- main residual voltage $\vec{V}r = \vec{V}an + \vec{V}bn + \vec{V}cn$
- additional residual voltage $\vec{V}'r = \vec{V}'an + \vec{V}'bn + \vec{V}'cn$

Calculating residual voltage occurs in one of two ways:
- by an broken wye/delta voltage transformer (VT)
- by taking the internal vector sum of the three phase voltages

Measure the fundamental 50 Hz or 60 Hz component of the voltages to obtain the residual voltage value.

Readout

Access to the measurements is by one of the following:
- the Sepam™ display via the key
- a PC with SFT2841 software
- communication link

Characteristics

Measurement Range	0.015 to 3 $V_{(L-n)p}$ (1)
Units	V or kV
Resolution	1 V
Accuracy	±1 % from 0.5 to 3 $V_{(L-L)p}$ ±2 % from 0.05 to 0.5 $V_{(L-L)p}$ ±5 % from 0.02 to 0.05 $V_{(L-L)p}$
Display Format	3 significant digits
Refresh Interval	1 second (typical)

(1) $V_{Ln}p$: primary rated phase-to-neutral voltage ($V_{Ln}p = V_{(L-n)p}/\sqrt{3}$)

Neutral Point Voltage

Operation

This function gives the value of the zero sequence voltage *Vnt*, measured at the neutral point of a generator or motor by a dedicated VT:

$$\vec{V}nt = (\vec{V}an + \vec{V}bn + \vec{V}cn')/3$$

Readout

Access the measurements through:
- the Sepam™ display via the key
- a PC with SFT2841 software
- the communication link

Characteristics

Measurement Range	0.015 to 3 $V_{Ln}p$ (1)
Units	V or kV
Resolution	1 V
Accuracy	±1 % from 0.5 to 3 $V_{Ln}p$ ±2 % from 0.05 to 0.5 $V_{Ln}p$ ±5 % from 0.02 to 0.05 $V_{Ln}p$
Display Format	3 significant digits
Refresh Interval	1 second (typical)

***(1) $V_{Ln}p$** is an abbreviation that refers to neutral point voltage transformer primary voltage*

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Positive Sequence Voltage

Operation

This function calculates the value of the main positive sequence voltage V1:

- from the three main phase-to-neutral voltages:
  - phase rotation direction a-b-c: $\vec{V}1 = \frac{1}{3} \times (\vec{V}an + a\vec{V}bn + a^2\vec{V}cn)$
  - phase rotation direction a-c-b: $\vec{V}1 = \frac{1}{3} \times (\vec{V}an + a^2\vec{V}bn + a\vec{V}cn)$
- from the two main phase-to-phase voltages:
  - phase rotation direction a-b-c: $\vec{V}1 = \frac{1}{3} \times (\vec{V}ab - a^2\vec{V}bc)$
  - phase rotation direction a-c-b: $\vec{V}1 = \frac{1}{3} \times (\vec{V}ab - a\vec{V}bc)$

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

The additional positive sequence voltage **V'1** is calculated the same way:
- from the three additional phase-to-neutral voltages V'an, V'bn, and V'cn
- from the two additional phase-to-phase voltages V'ab and V'bc

Readout

Access to the measurements is by one of the following:
- the Sepam™ display via the key
- a PC with SFT2841 software
- communication link

Characteristics

Measurement Range	0.05 to 1.2 $V_{Ln}p$ (1)
Units	V or kV
Resolution	1 V
Accuracy	±2 % at $V_{Ln}p$
Display Format	3 significant digits
Refresh Interval	1 second (typical)

(1) $V_{Ln}p$: primary rated phase-to-neutral voltage ($V_{LL}p = V_{Ln}p/\sqrt{3}$)

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Negative Sequence Voltage

Operation

This function calculates the value of the main negative sequence voltage *Vi*:

- from the three main phase-to-neutral voltages:
  - phase rotation direction a-b-c: $\vec{V}2 = \frac{1}{3} \times (\vec{V}an + \mathbf{a}^2\vec{V}bn + \mathbf{a}\vec{V}cn)$
  - phase rotation direction a-c-b: $\vec{V}2 = \frac{1}{3} \times (\vec{V}an + \mathbf{a}\vec{V}bn + \mathbf{a}^2\vec{V}cn)$
- or from the two main phase-to-phase voltages:
  - phase rotation direction a-b-c: $\vec{V}2 = \frac{1}{3} \times (\vec{V}ab - \mathbf{a}\vec{V}bc)$
  - phase rotation direction a-c-b: $\vec{V}2 = \frac{1}{3} \times (\vec{V}ab - \mathbf{a}^2\vec{V}bc)$

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

The additional negative sequence voltage **V'2** is calculated the same way:
- from the three additional phase-to-neutral voltages V'an, V'bn, and V'cn
- or from the two additional phase-to-phase voltages V'ab and V'ac

Readout

Access to the measurements is by one of the following:
- the Sepam™ display via the key
- a PC with SFT2841 software
- a communication link

Characteristics

Measurement Range	0.05 to 1.2 $V_{Ln}p$ **(1)**
Units	V or kV
Resolution	1 V
Accuracy	±2 % at $V_{Ln}p$
Display Format	3 significant digits
Refresh Interval	1 second (typical)

(1) *V_{Np}: primary rated phase-to-neutral voltage ($V_{Np} = V_{Ln}p/\sqrt{3}$).*

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Frequency

Operation

Frequency is measured by the following means:

- based on Vab or Van, if only one phase-to-phase voltage connects to Sepam™
- based on positive sequence voltage in other cases

Frequency is *not* measured if:

- the voltage Vab (or Van) or positive sequence voltage **V1** is less than 40% of V_{LL}
- the frequency **f** is outside the measurment range

The measurement of the frequency *f* is calculated according to the same principle, from V'1 or V'ab or V'an.

Readout

Access to the measurements is by one of the following:

- the Sepam™ display via the key
- a PC with SFT2841 software
- communication link
- an analog converter with the MSA141 option

Characteristics

Main Channels	
Rated Frequency	50 Hz, 60 Hz
Range	25 to 65 Hz
Resolution	0.01 Hz (1)
Accuracy (2)	±0.01 Hz
Display Format	3 significant digits
Refresh Interval	1 second (typical)
Additional Channels	
Rated Frequency fn	50 Hz, 60 Hz
Range	45 to 55 Hz (fn = 50 Hz)
	55 to 65 Hz (fn = 60 Hz)
Resolution (1)	0.01 Hz
Accuracy (2)	±0.05 Hz
Display Format	3 significant digits
Refresh Interval	1 second (typical)

***(1)** On SFT2841*
***(2)** At $V_{LL}p$, under reference conditions (IEC 60255-6)*

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Active, Reactive, and Apparent Power

Operation

Power values are calculated from the phase currents Ia, Ib and Ic:

- active power = $\sqrt{3}.V_{LL}$p.I. cos $\angle\theta$
- reactive power = $\sqrt{3}.V_{LL}$p.I. sin $\angle$
- apparent power = $\sqrt{3}.V_{LL}$p.I. S

Power calculations can be based on the two or three wattmeter method (see table below), depending on the CTs used.

The two wattmeter method is only accurate when there is no residual current. It is not applicable if the neutral is distributed.

The three wattmeter method gives an accurate calculation of 3-phase and phase by phase powers in all cases whether or not the neutral is distributed.

Connecting Voltage Channels	Connecting Main Current Channels	P, Q, S, Calculation Method	Power per Phase Pa, Pb, Pc Qa, Qb, Qc Sa, Sb, Sc
3 V	Ia, Ib, Ic	three wattmeters	Available
	Ia, Ic	two wattmeters	Not available
Vbc, Vab + Vr	Ia, Ib, Ic	three wattmeters	Available
	Ia, Ic	two wattmeters	Not available
Vbc, Vab without Vr	Ia, Ib, Ic, or Ia, Ic	two wattmeters	Not available
Vab	Ia, Ib, Ic, or Ia, Ic	two wattmeters The system voltage is considered to be balanced	Not available
Van	Ia, Ib, Ic, or Ia, Ic	No calculation	Pa, Qa, Sa only

Power calculation

- by three wattmeter method:

$$P = \vec{V}an\hat{I}a\cos(\vec{V}an,\hat{I}a) + \vec{V}bn\hat{I}b\cos(\vec{V}bn,\vec{I}b) + \vec{V}cn\hat{I}c\cos(\vec{V}cn,\vec{I}c)$$

$$Q = \vec{V}an\hat{I}a\sin(\vec{V}an,\vec{I}a) + \vec{V}bn\hat{I}b\sin(\vec{V}bn,\vec{I}b) + \vec{V}cn\hat{I}c\sin(\vec{V}cn,\hat{I}c)$$

- by two wattmeter method:

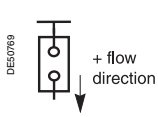
$$P = \vec{V}ab\hat{I}a\cos(\vec{V}ab,\hat{I}a) - \vec{V}bc\hat{I}c\cos(\vec{V}bc\hat{I}c)$$

$$Q = \vec{V}ab\hat{I}a\sin(\vec{V}ab,\hat{I}a) - \vec{V}bc\hat{I}c\sin(\vec{V}bc,\hat{I}c)$$

- $S = \sqrt{P^2 + Q^2}$.

According to standard practice:

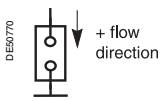
- for the outgoing circuit (1):
  - power supplied by the bus is positive
  - power supplied to the bus is negative



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- for the incoming circuit (1):
  - power supplied to the bus is positive
  - power supplied by the bus is negative.



(1) *Choice made in the general settings*

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Active, Reactive, and Apparent Power

Readout

Access to the measurements is by one of the following:

- the Sepam™ display via the key
- a PC with SFT2841 software
- communication link
- an analog converter with the MSA141 option

Characteristics

	Active Power P, Pa, Pb, Pc	**Reactive Power Q, Qa, Qb, Qc**	**Apparent Power S, Sa, Sb, Sc**
Measurement Range	±(0.8 % Sn at 999 MW) (1)	±(0.8 % Sn at 999 MVAR) (1)	0.8 % Sn at 999 MVA (1)
Units	kW, MW	kVAR, MVARr	kVA, MVA
Resolution	0.1 kW	0.1 kvar	0.1 kVA
Accuracy	±1 % from 0.3 to 1.5 Sn (2) ±3 % from 0.1 to 0.3 Sn (2)	±1 % from 0.3 to 1.5 Sn (3) ±3 % from 0.1 to 0.3 Sn (3)	±1 % from 0.3 to 1.5 Sn ±3 % from 0.1 to 0.3 Sn
Display Format	3 significant digits	3 significant digits	3 significant digits
Refresh Interval	1 second (typical)	1 second (typical)	1 second (typical)

(1) *Sn = $\sqrt{3} V_{LL}$ p.In.*
(2) *Cos φ > 0.8 under reference conditions (IEC 60255-6)*
(3) *Cos φ < 0.6 under reference conditions (IEC 60255-6)*

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Peak Demand Active and Reactive Power/Power Factor (pf)

Peak Demand Active and Reactive Power

Operation

The user determines the regular intervals at which peak demand is calculated for active or reactive power. These intervals generally range from 5 to 60 minutes, during which the current demand amount is calculated and compared with the most recent saved value. The larger of the two values is stored in memory until the next demand interval. The peak value is saved in the event of power loss.

Readout

Access to the measurements is by one of the following:

- the Sepam™ display via the key
- a PC with SFT2841 software
- communication link

Resetting to Zero

Access to zero reset is by one of the following:

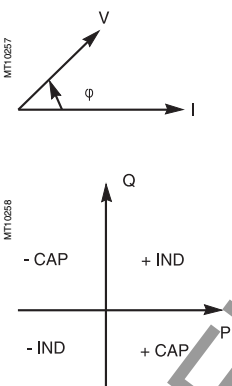
- via the **clear button** on the Sepam™ display if a peak demand is displayed
- via the **clear command** in the SFT2841 software
- via the communication link (remote control command TC5)

Characteristics

	Demand Active Power	Demand Reactive Power
Measurement range	±(1.5 % Sn at 999 MW) (1)	±(1.5 % Sn at 999 MVAR) (1)
Units	kW, MW	kvar, MVAR
Resolution	0.1 kW	0.1 kvar
Accuracy	±1 %, typical (2)	±1 % typical (3)
Display format	3 significant digits	3 significant digits
Integration period	5, 10, 15, 30, 60 minutes	5, 10, 15, 30, 60 minutes

(1) $S_N = \sqrt{3}\, V_{LL}p.I_N$.
(2) *At* I_N, $V_{LL}p$, $\cos\varphi > 0.8$ *under reference conditions (IEC 60255-6)*
(3) *At* I_N, $V_{LL}p$, $\cos\varphi < 0.6$ *under reference conditions (IEC 60255-6)*

Power Factor (cos $\angle\theta$)



Operation

The power factor is defined by: $\mathbf{Pf = P/\sqrt{P^2 + Q^2}}$. It expresses the phase displacement between the phase currents and phase-to-neutral voltages.

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

Readout

Access to the measurements is by one of the following:

- the Sepam™ display via the key
- a PC with SFT2841 software
- communication link.

Characteristics

Measurement Range	–1 at 1 IND/CAP
Resolution	0.01
Accuracy (1)	0.01 typical
Display Format	3 significant digits
Refresh Interval	1 second (typical)

(1) *At* I_N, $V_{LL}p$, *pf > 0.8 under reference conditions (IEC 60255-6)*

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Accumulated Active and Reactive Energy

Operation

Accumulated active and reactive energy values are calculated according to voltages and phase currents Ia, Ib, and Ic, which are derived from measuring the fundamental component . The results of the calculations provide the user with the value of accumulated energy in forward or reverse direction. The accumulated energy values are saved in case of power loss.

Readout

Access to the measurements is by one of the following:

- the Sepam™ display via the key
- a PC with SFT2841 software
- a communication link.

Characteristics

	Active energy	Reactive energy
Metering Capacity	0 to 2.1 10^8 MW	0 to 2.1 10^8 MVAR.h
Units	MW.h	Mvar.h
Resolution	0.1 MW.h	0.1 MVAR.h
Accuracy	±1 % typical (1)	±1 % typical (1)
Display Format	10 significant digits	10 significant digits

(1) *At I_N, $V_{LL}p$, pf > 0.8 under reference conditions (IEC 60255-6).*

Accumulated Active and Reactive Energy by Pulse Metering

Operation

Use this option to monitor energy from logic inputs. Energy incrementing is associated with each input (one of the general parameters to be set). Each input pulse increments the meter. Four inputs and four accumulated energy metering options are available:

- positive and negative active energy
- positive and negative reactive energy

The accumulated active and reactive energy values are saved if the system loses power.

Readout

Access to the measurements is by one of the following:

- a PC with SFT2841 software
- a communication link

Characteristics

	Active Energy	Reactive Energy
Metering Capacity	0 to 2.1 10^8 MW.h	0 to 2.1 10^8 MVAR.h
Units	MW.h	MVAR.h
Resolution	0.1 MW.h	0.1 MVAR.h
Display Format	10 significant digits	10 significant digits
Increment	0.1 kW.h to 5 MW.h	0.1 kVAR.h to 5 MVAR.h
Pulse	15 ms min.	15 ms min.

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Temperature

Operation

This function gives the temperature value measured by resistance temperature detectors (RTDs):

- platinum Pt100 (100 Ω at 0 °C or 32 °F) in accordance with IEC 60751 and DIN 43760 standards
- nickel Ni120 (100 Ω or 120 Ω at 0 °C or 32 °F).

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

The function also indicates RTD faults:

- RTD disconnected (t > 205 °C or t > 401 °F)
- RTD shorted (t < –35 °C or t < –31 °F).

If a fault occurs, display of the value is blocked. The associated monitoring function generates a maintenance alarm.

Readout

The measurements may be accessed via:

- the Sepam™ display via the key, in °C or °F
- the display of a PC with the SFT2841 software
- communication link
- an analog converter with the MSA141 option

Characteristics

Range	–30 °C to +200 °C	–22 °F to +392 °F
Resolution	1 °C	1 °F
Accuracy	±1 °C from +20 °C to +140 °C ±2 °C from –30 °C to +20 °C ±2 °C from +140 °C to +200 °C	±1.8 °F from +68 °F to +284 °F ±3.6 °F from –22 °F to +68 °F ±3.6 °F from +284 °F to +392 °F
Refresh interval	5 seconds (typical)	

Accuracy Derating According to Wiring

Connection in 3-wire mode: the error Δt is directly proportional to the length of the connector and inversely proportional to the connector cross-section:

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

- ±2.1 °C/km for a cross-section of 0.93 mm² (AWG 18)
- ±1 °C/km for a cross-section of 1.92 mm² (AWG 14)

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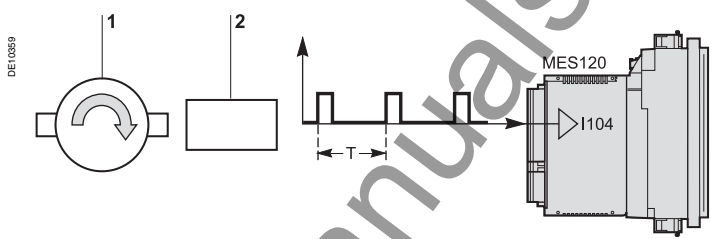
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Rotation Speed

Operation

Use this function to determine the rotation speed of a motor or generator rotor.

Whenever a rotation is made by the motor or generator shaft, two cams 180 º apart pass a proximity sensor. Each cam generates a pulse that is transmitted by the sensor. The time between the two pulses determines the frequency, or rotation speed of the motor or generator. The number of pulses per rotation is set in the "particular characteristics" screen of the SFT2841 software. The proximity sensor is connected to logic input I104.



1 Rotor with two cams.
2 Proximity sensor.

Readout

The measurements may be accessed via:

- the Sepam™ display via the key
- the display of a PC with the SFT2841 software
- the communication link.

Characteristics

Range		0 to 7200 rpm
Resolution		1 rpm
Accuracy		±1 rpm
Refresh Interval		1 second (typical)
Pulses per Rotation (R)		1 to 1800 with Ωn R/60 ≤ 1500 (Ωn: rated speed in rpm)
Proximity Sensor	Pass-band (in Hz)	> 2.ωN R/60
	Output	24 to 250 V DC, 3 mA minimum
	Leakage current in open status	< 0.5 mA
	Voltage dip in closed status	< 4 V (with 24 V DC power supply)
	Pulse duration	0 status > 120 µs
		1 status > 200 µs

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Phasor Diagram

Operation

The phasor diagram displays a vectoral picture of the fundamental component of the raw current and voltage measurements acquired by Sepam™. This enables the user to check cables and implement directional and differential protection functions. The phasor is programmable and the following choices equip the user to adapt the diagram according to requirements:

- measurements displayed in the phasor diagram
- reference phasor
- display mode.

Measurements to be Displayed

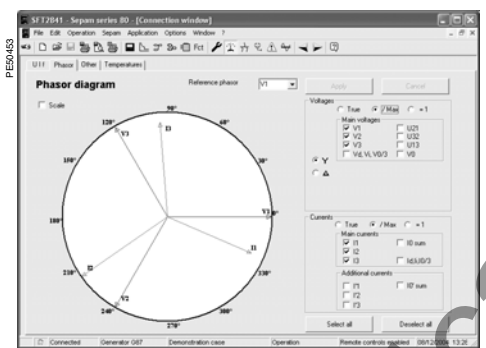
- phase currents on main and additional channel
- residual currents measured or with sum on main and additional channels
- symmetrical components of current I1, I2, IrΣ/3
- phase-to-neutral voltages on main and additional channels
- phase-to-phase voltages on main and additional channels
- residual voltages on main and additional channels
- symmetrical components of voltage V1, V2, Vr/3.

Reference Phasor

The phasor used as reference is chosen from the phase or residual current or voltage phasors. Phase shifts of the other phasors displayed are calculated according to this reference choice. When the reference phasor is too small (< 2 % I_N for currents or 5 % V_N for voltages), display is impossible.

Display Mode

- **Display as true values.** The measurements are displayed without any modification in a scale chosen in relation to the respective rated values:
  - 0 to 2 Max (I_N, I'_N) for currents
  - 0 to 2 Max ($V_{LL}p$, $V'_{LL}p$) for voltages.
- **Display as values normalized in relation to the maximum.** The measurements are normalized in relation to the greatest measurement of the same type. The greatest measurement is displayed full scale with a modulus equal to 1, and the others are displayed as relative values compared to the modulus 1 value. This display provides maximum angular resolution, regardless of the measured values, while maintaining the relative values between measurements.
- Display as values normalized to 1: all the measurements are normalized in relation to themselves and displayed with a modulus of 1, equal to full scale. This mode provides optimal display of the angles between phasors but does not allow moduli to be compared.
- Displaying phase-to-phase voltage values in a triangle arrangement: for a more common display of phase-to-phase voltage phasors.
- Displaying or eliminating the scale for better reading of displayed phasors.



Phasor diagram on SFT2841

Readout

All the possibilities described above can be accessed via the SFT2841 setting and operating software.

Two predefined displays are available on the mimic-based UMI:

- the three phase currents and three phase-to-neutral voltages of the main channels
- the three phase currents of the main channels and the three phase currents of the additional channels

Characteristics

Diagram Display Options of an SFT2841 Phasor Diagram	
Measurements to be Displayed	
Multiple selection from:	Ia, Ib, Ic, ir, IrΣ, I1, I2, IrΣ/3, I'a, I'b, I'c, I'r, I'rΣ Van, Vbn, Vcn, Vr, Vab, VbcΣ, Vac, V1, V2, Vr/3 V'an, V'bn, V'cn, V'r, V'ab, V'bc, V'ac
Reference Phasor	
Single choice from:	Ia, Ib, Ic, Ir, IrΣ, I'r, I'rΣ Van, Vbn, Vcn, Vr, Vab, Vbc, Vac, V'an, V'bn, V'cn, V'r, V'ab, V'bc, V'ac
Display Mode	
Current display	true (true value) / max (value normalized in relation to maximum) = 1 (normalized to 1)
Voltage display	true (true value) / max (value normalized in relation to maximum) = 1 (normalized to 1)
Phase-to-phase voltage	wye/delta
Display of scale	yes/no

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Network Diagnosis
Tripping Context/Tripping Current

Tripping Context

Operation

This function records the values at the time of tripping (activation of the tripping contact on output O1). This allows the user to conduct fault analysis to determine the cause.

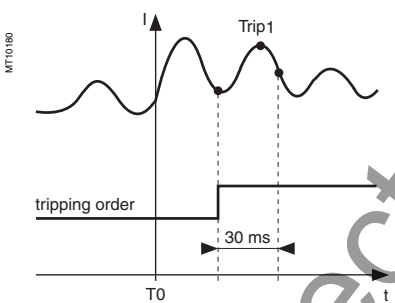
The values available from the Sepam™ display are:
- tripping currents
- residual currents Ir, I'r, IrΣ and I'rΣ
- differential and through currents
- phase-to-phase voltages
- residual voltage
- neutral point voltage
- third harmonic neutral point or residual voltage
- frequency
- active power
- reactive power
- apparent power

In addition to these, the following values are available from the SFT2841 software:
- phase-to-neutral voltages
- negative sequence voltage
- positive sequence voltage

The values for the last five events are saved with the date and time of tripping in case of a power failure. Each new trip value overwrites the oldest event stored in memory.

Readout

The measurements may be accessed via:
- the Sepam™ display via the icon
- a PC with SFT2841 software loaded
- the communication link



Tripping current (TripIa) acquisition.

Tripping Current

Operation

This function gives the RMS value of currents at the time of the last trip:
- TripIa: phase a current (main channels)
- TripIb: phase b current (main channels)
- TripIc: phase c current (main channels)
- TripI'a: phase a current (additional channels)
- TripI'b: phase b current (additional channels)
- TripI'c: phase c current (additional channels)

The measurement is defined as the maximum RMS value measured during a 30 ms interval after the activation of the tripping contact on output O1. It is based on measuring the fundamental component.

Readout

The measurements may be accessed via:
- the Sepam™ display through the icon
- a PC with SFT2841 software loaded
- communication link

Characteristics

Measurement Range	0.1 to 40 I_N (1)
Units	A or kA
Resolution	0.1 A
Accuracy	±5 % ±1 digit
Display Format	3 significant digits

(1) *I_N, rated current set in the general settings.*

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Network Diagnosis
Number of Phase Fault Trips
Number of Ground Fault Trips

Number of Phase Fault Trips

Operation

This function counts the network phase faults that cause circuit breaker tripping. It counts only trips triggered by protection functions 50/51, 50V/51V, and 67. If there is discrimination between several circuit breakers, the fault is only counted by the Sepam™ that issues the trip command.

Transient faults cleared by the recloser are counted.

The number of phase fault trips is saved in the event of an auxiliary power failure. It can be reinitialized using the SFT2841 software.

Readout

The measurements may be accessed via:

- the Sepam™ display through the icon
- a PC with SFT2841 software loaded
- the communication link.

Characteristics

Measurement Range	0 to 65535
Units	None
Resolution	1
Refresh Interval	1 second (typical)

Number of Ground Fault Trips

Operation

This function counts the network ground faults that cause circuit breaker tripping. It counts only those trips that are triggered by protection functions 50N/51N and 67N. If there is discrimination between several circuit breakers, the fault is only counted by the Sepam™ that issues the trip command. Transient faults cleared by the recloser are counted.

The number of ground fault trips is saved in the event of an auxiliary power failure. It can be reinitialized using the SFT2841 software.

Readout

The measurements may be accessed via:

- the Sepam™ display through the icon
- a PC with SFT2841 software loaded
- the communication link.

Characteristics

Measurement Range	0 to 65535
Units	None
Resolution	1
RefreshInterval	1 second (typical)

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Network Diagnosis
Negative Sequence/ Current Unbalance

Operation

This function gives the negative sequence component: **T = I2/IB** or **T' = I'2/I'B**.
The negative sequence current is determined based on the phase currents:

- three phases:
  - phase rotation direction a-b-c: $\vec{I}2 = \frac{1}{3} \times \left(\vec{I}a + \mathbf{a^2}\vec{I}b + \mathbf{a}\vec{I}c \right)$
  - phase rotation direction a-c-b: $\vec{I}2 = \frac{1}{3} \times \left(\vec{I}a + \mathbf{a}\vec{I}b + \mathbf{a^2}\vec{I}c \right)$
- two phases:
  - phase rotation direction a-b-c: $\left|\vec{I}2\right| = \frac{1}{\sqrt{3}} \times \left|\vec{I}a - \mathbf{a^2}\vec{I}c\right|$
  - phase rotation direction a-c-b: $\left|\vec{I}2\right| = \frac{1}{\sqrt{3}} \times \left|\vec{I}a - \mathbf{a}\vec{I}c\right|$

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

When there are no ground faults, the formulas for 2-phase currents are equivalent to those for 3-phase currents.

Readout

The measurements may be accessed via:

- the Sepam™ display via the icon
- a PC with SFT2841 software loaded
- communication link.

Characteristics

Measurement Range	10 to 500 %
Units	% IB or % I'B
Resolution	1 %
Accuracy	±2 %
Display Format	3 significant digits
Refresh Interval	1 second (typical)

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Network Diagnosis
Current Total Harmonic Distortion
Voltage Total Harmonic Distortion

Current Total Harmonic Distortion (Ithd)

Operation

Current total harmonic distortion is used to assess the quality of the current. It is calculated based on phase Ia, calculating up to the 13th harmonic.

Ithd is calculated over 50 periods using the following formula:

$$\text{Ithd} = 100\ \% \sqrt{\left(\frac{\text{RMS}}{\text{H1}}\right)^2 - 1}$$

with:
RMS = RMS value of current Ia up to the 13th harmonic
H1 = value of the fundamental of current Ia

Readout

The measurements may be accessed via:
- the Sepam™ display via the icon
- a PC with SFT2841 software loaded
- communication link.

Characteristics

Measurement Range	0 to 100 %
Units	%
Resolution	0.1 %
Accuracy (1)	±1 % at IN for Ithd > 2 %
Display Format	3 significant digits
Refresh Interval	1 second (typical)

(1) Under reference conditions (IEC 60255-6).

Voltage Total Harmonic Distortion (Vthd)

Operation

Voltage total harmonic distortion is used to assess the quality of the voltage. It is calculated based on the measurement of Vab or Va according to the configuration, calculating for 13th level harmonics.

Vthd is calculated over 50 periods using the following formula:

$$\text{Vthd} = 100\ \% \sqrt{\left(\frac{\text{RMS}}{\text{H1}}\right)^2 - 1}$$

with:
RMS = RMS value of voltage Vab or Van up to the 13th harmonic
H1 = value of the fundamental of voltage Vab or Van

Readout

The measurements may be accessed via:
- the Sepam™ display via the icon
- a PC with SFT2841 software loaded
- a communication link.

Characteristics

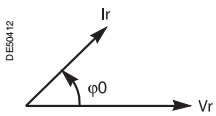
Measurement Range	0 to 100 %
Units	%
Resolution	0.1 %
Accuracy (1)	±1 % at $V_{LL}N$ or VN for Vthd > 2 %
Display Format	3 significant digits
Refresh Interval	1 second (typical)

(1) Under reference conditions (IEC 60255-6).

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Network Diagnosis
Phase Displacement φr, φ'r, φrΣ
Phase Displacement φa, φb, φc



Phase displacement φr

Phase Displacement φr, φ'r, φrΣ

Operation

This function gives the phase displacement measured between the residual voltage and residual current in the trigonometric (counter-clockwise) direction (see diagram). The measurement is used during commissioning to ensure the directional ground fault protection unit is connected correctly.
Three values are available:

- φr, angle between Vr and measured Ir
- φ'r, angle between Vr and measured I'r
- φrΣ, angle between Vr and IrΣ calculated as the sum of the phase currents.

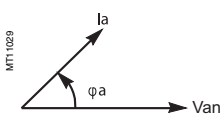
Readout

The measurements may be accessed via:

- the Sepam™ display through the Σ icon
- a PC with SFT2841 software loaded
- a communication link.

Characteristics

Measurement Range	0 to 359°
Resolution	1°
Accuracy	±2°
Refresh Interval	2 seconds (typical)



Phase displacement φa

Phase Displacement φa, φb, φc

Operation

This function calculates the phase displacement between the Van, Vbn, Vcn voltages and Ia, Ib, Ic currents respectively, in the trigonometric (counter-clockwise) direction (see diagram). The measurements are used when Sepam™ is commissioned to check voltage and current inputs for correct wiring.

When the phase-to-phase voltages Vab and Vbc are connected to Sepam™ and there is no measurement of residual voltage Vr, the residual voltage is presumed to be zero. The function does not operate when only the voltage Vab or Van is connected to Sepam™.

This function recognizes the convention regarding the direction of energy flow in the outgoing and incoming circuits (see "Power measurements"). Therefore, the angles φa, φb, and φc are adjusted 180° with respect to the values acquired by Sepam™ for the incoming circuits.

Readout

The measurements may be accessed via:

- the Sepam™ display through the Σ icon
- a PC with SFT2841 software loaded
- communication link.

Characteristics

Measurement Range	0 to 359°
Resolution	1°
Accuracy	±2°
Refresh Interval	2 seconds (typical)

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Network Diagnosis
Disturbance Recording

Operation

This function records analog signals and logical states. Record storing is initiated by one or more events set using the SFT2841 software. The stored event begins before the event (based on the pre-trigger programming) and continues afterwards. Recordings comprise the following information:

- values sampled from the different signals
- date
- characteristics of the recorded channels

The naming convention for logic input and output data that Logipam uses is also used in disturbance recording for ease of reading. The duration and number of recordings may be set using the SFT2841 software tool. The files are recorded in First In First Out (FIFO) type shift storage: when the maximum number of recordings is reached, the oldest recording is erased when a new recording is triggered.

Transfer

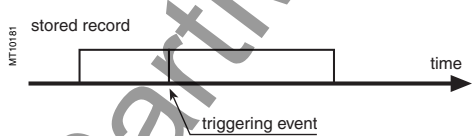
Files will transfer in one of two ways:

- **locally**, by using a PC connected to the front panel and includes the SFT2841 software tool
- **remotely**, by using a software tool specific to the remote monitoring and control system.

Recovery

The SFT2826 software gives the user the ability to recover a recording.

Block Diagram



Characteristics

Recording content	Set-up file: date, channel characteristics, measuring chain transformer ratio Sample file: recorded signals
Sampling frequency (1)	12 or 36 samples per network period
Analog signals recorded (2)	Ia, Ib, Ic, Ir, I'a, I'b, I'c, I'r current channels Van, Vbn, Vcn, or Vab, Vbc, V'an, V'bn, V'cn, V'ab, V'bc phase voltage channels Vr, VNt or V'r residual voltage channels
Logical states recorded (1) (3)	Maximum 32 of the following data: ■ all logic inputs / outputs ■ pick-up signal ■ 1 data item configurable by the logic equation editor or 15 data items configurable by Logipam (V_FLAGREC, V_FLAGREC2 to V_FLAGREC15)
Number of recordings stored (1)	1 to 19
Total duration of a recording (1)	1 s to 20 s
Maximum recording capacity (dist. rec. memory usage = 100 %)	22 s at 50 Hz, 12 samples per cycle 18 s at 60 Hz, 12 samples per cycle 7 s at 50 Hz, 36 samples per cycle 6 s at 60 Hz, 36 samples per cycle
Periods recorded before triggering event (1)	0 to 99 cycles3
File format	COMTRADE 97

(1) *To be set using the SFT2841 software.*
(2) *According to type and connection of CTs.*
(3) *According to Sepam™ hardware configuration.*

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Network Diagnosis
Sync-Check: Voltage Comparison and Out-of-Sync Context

Operation

Voltage Comparison

For the sync-check function, the MCS025 module continuously measures the amplitude, frequency and phase differences between V_{LL}sync1 and V_{LL}sync2.

Out-of-Sync Context

Out-of-sync context gives a precise indication as to why a synchronization request fails. The context is provided only when the switchgear control function with the "closing with sync-check" option is activated.

When a synchronization request fails, the amplitude, frequency, and phase differences of the V_{LL}sync1 and V_{LL}sync2 voltages measured by the MCS025 module are recorded, with the date and time, at the end of the switchgear control function "closing request time" delay.

Readout

The amplitude, frequency and phase differences and out-of-sync context can be accessed via:

- Sepam™ display by using the icon
- a PC with SFT2841 software loaded
- a communication link.

Characteristics

Amplitude Difference	
Measurement Range	0 to 120 % of V_{LL}sync1 (or V_{Ln}sync1)
Unit	% of V_{LL}sync1 (or V_{Ln}sync1)
Resolution	0.1 %
Accuracy	±2 %
Refresh Interval	1 second (typical)
Frequency Difference	
Measurement Range	0 to 10 Hz
Unit	Hz
Resolution	0.01 Hz
Accuracy	0.05 Hz
Refresh Interval	1 second (typical)
Phase Difference	
Measurement Range	0 to 359°
Unit	°
Resolution	1°
Accuracy	±2°
Refresh Interval	1 second (typical)

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Machine Operation Assistance
Thermal Capacity Used
Cooling Time Constant

Thermal Capacity Used

Operation

Thermal capacity used is calculated by the thermal overload protection function for cables, capacitors, or machines. The thermal capacity used is related to the load. The thermal capacity used measurement is given as a percentage of the rated thermal capacity. E is the calculated heat rise, Es is the heat rise setting.

Saving Thermal Capacity Used Values

The thermal capacity used values are saved in the event Sepam™ loses power. The saved value is used again after the outage.

Readout

Measurements are accessed via:

- the Sepam™ display through the icon
- a PC with SFT2841 software loaded
- a communication link
- an analog converter with the MSA141 option.

Resetting to Zero

The thermal capacity used can be reset to zero, after entering a password on:

- a Sepam™ display via the clear key
- a PC with SFT2841 software

Characteristics

Measurement Range	0 to 800 %
Units	%
Display Format	3 significant digits
Resolution	1 %
Refresh Interval	1 second (typical)

Cooling Time Constant

Operation

The machine thermal overload protection function (49 RMS machine) uses a cooling time constant (T2) the user can enter according to the data given by the machine manufacturer. It can also be information "learned" by Sepam™.

T2 is estimated under two conditions:

1 after a heating/cooling sequence:
- heating period detected by ES > 70 %
- followed by a shutdown detected by I < 10 % of I_B

2 when the machine temperature is measured by RTDs connected to MET1482 module number 1:
- RTD 1, 2, or 3 assigned to motor/generator stator temperature measurement
- RTD 1, 3, or 5 assigned to transformer temperature measurement.

After each new heating/cooling sequence is detected, a new T2 value is estimated and displayed in the related SFT2841 screen. Measurement accuracy may be improved by using RTD 8 to measure the ambient temperature.

The machine thermal overload function has two groups of thermal settings for cases such as natural or forced ventilation or two-speed motors. A time constant is estimated for each group of thermal settings.

Readout

Measurements are accessed via:

- the Sepam™ display by means of the key
- a PC with SFT2841 software loaded
- a communication link.

Characteristics

Measurement Range	5 to 600 min
Units	min
Resolution	1 min
Accuracy	±5 %
Display Format	3 significant digits

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Machine Operation Assistance
Operating Time Before Tripping
Waiting Time After Tripping

Remaining Operating Time Before Overload Tripping

Operation

ANSI code 49RMS requires time for the motor to cool sufficiently before allowing a start attempt. ANSI code 66 is a setting that limits the total number of starts (hot, cold, total starts) per hour.

Thermal capacity used is calculated by using the thermal overload protection function for cables, capacitors or machines. The time depends on the thermal capacity used.

Readout

The measurements may be accessed via:

- a Sepam™ display via the icon
- a PC with SFT2841 software loaded
- a communication link.

Characteristics

Measurement Range	0 to 999 min
Units	min
Display Format	3 significant digits
Resolution	1 min
Refresh Interval	1 second (typical)

Waiting Time After Overload Tripping

Operation

ANSI code 66 is a setting that limits the total number of starts (hot, cold, total starts) per hour. The thermal capacity used is calculated by the thermal overload protection function for cables, capacitors or machines. The time depends on the thermal capacity used.

Readout

The measurements may be accessed via:

- a Sepam™ display through the icon
- a PC with SFT2841 software loaded
- a communication link.

Characteristics

Measurement Range	0 to 999 min
Units	min
Display Format	3 significant digits
Resolution	1 min
Refresh Interval	1 second (typical)

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Machine Operation Assistance
Counter/Starting Current and Starting Time

Running Hours and Operating Time Counter

The counter gives the total running time the protected device (motor, generator, or transformer) has been operating, that is, whenever a phase current is over 0.1 IB. For capacitor applications, up to four counters are available for the running time of steps (1) to (4). These counters total the time that a capacitor step has been connected to the network (capacitor step switch closed).

The initial counter value can be modified using the SFT2841 software.

The counters are saved in case auxiliary power fails.

Readout

Measurements are accessed via:

- the Sepam™ display via the Σ icon
- a PC with SFT2841 software loaded
- a communication link.

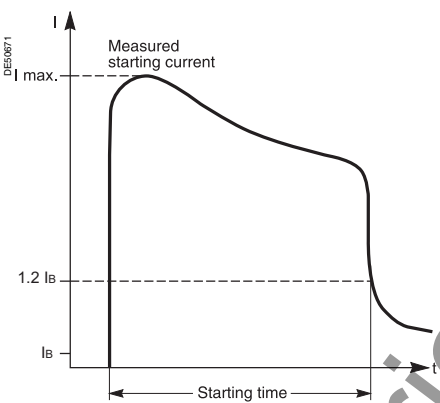
Characteristics

Range	0 to 65535
Units	hours

Starting Current and Starting Time

Operation

The starting time is the time between the moment at which one of the three phase currents exceeds 1.2 IB and the moment at which the three currents drop back below 1.2 IB. The maximum phase current obtained during this period is the starting current. The two values are saved in case auxiliary power fails.



Readout

Measurements are accessed via:

- the Sepam™ display via the Σ key
- a PC with SFT2841 software loaded
- a communication link.

Characteristics

Starting Time	
Measurement Range	0 to 300 s
Units	s or ms
Display Format	3 significant digits
Resolution	10 ms or 1 digit
Refresh Interval	1 second (typical)
Starting Current	
Measurement Range	1.2 IB at 24 IN (1)
Units	A or kA
Display Format	3 significant digits
Resolution	0.1 A or 1 digit
Refresh Interval	1 second (typical)

(1) *Or 65.5 kA.*

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Machine Operation Assistance
Number of Starts Before Block/ Start Block Time

Number of Starts Before Block

Operation

Blocking is defined as preventing the set number of starts (hot, cold, total starts) from being exceeded. The normally closed (N.C.) contacts of O2 open to prevent starting. The number of starts allowed before block is calculated by the number of starts protection function.

The number of starts depends on the thermal state of the motor.

Readout

The measurements may be accessed via:

- a Sepam™ display by means of the icon
- a PC with SFT2841 software
- a communication link.

Resetting to Zero

The number of starts counters may be reset to zero, after entry of a password, on:

- the Sepam™ display via the (clear) icon
- a PC with SFT2841 software loaded

Characteristics

Measurement Range	0 to 60
Units	None
Display Format	3 significant digits
Resolution	1
Refresh Interval	1 second (typical)

Start Block Time

Operation

Start block time is calculated by the number of starts protection function. This function indicates that starting is blocked when the allowed number of starts is reached and the circuit breaker is open. The time given represents the waiting time before starting is allowed.

Readout

The number of starts and waiting time may be accessed via:

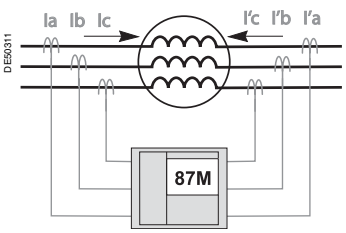
- the Sepam™ display via the key
- a PC with SFT2841 software loaded
- a communication link.

Characteristics

Measurement Range	0 to 360 min
Units	min
Display Format	3 significant digits
Resolution	1 min
Refresh Interval	1 second (typical)

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Differential Current

Operation

The differential current Id is calculated to facilitate the implementation of the ANSI 87T and ANSI 87M differential protection functions:

- for a rotating machine (ANSI 87M), it is calculated for each phase by:

$$|\vec{I}d| = |\vec{I} + \vec{I'}|$$

- when a transformer is used (ANSI 87T), the Id calculation takes into account the vector shift and transformation ratio:

$$|\vec{I}d| = |\overrightarrow{Irec} + \overrightarrow{I'rec}|$$

The Id value is expressed with respect to IN1, the rated current of the main channels.

Readout

The measurements may be accessed via:

- the Sepam™ display by using the icon
- a PC with SFT2841 software loaded
- a communication link.

Characteristics

Measurement Range	0.015 to 40 IN
Units	A or kA
Resolution	0.1 A
Accuracy (1)	±5 %
Display Format	3 significant digits
Refresh Interval	1 second (typical)

(1) *At IN, under reference conditions (IEC 60255-6).*

Through Current

Operation

The through current **It** is calculated to facilitate the implementation of the ANSI 87T and ANSI 87M differential protection functions:

- for a rotating machine (ANSI 87M), it is calculated for each phase by:

$$|\vec{I}t| = \left|\frac{\vec{I} - \vec{I'}}{2}\right|$$

- when a transformer is used (ANSI 87T), the It calculation takes into account the vector shift and transformation ratio:

$$|\vec{I}t| = \max(|\overrightarrow{Irec}|, |\overrightarrow{I'rec}|)$$

The It value is expressed with respect to In1, the rated current of the main channels.

Readout

The measurements may be accessed via:

- the Sepam™ display via the icon
- a PC with SFT2841 software loaded
- a communication link.

Characteristics

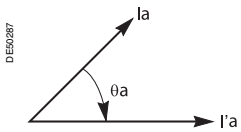
Measurement range	0.015 to 40 IN
Units	A or kA
Resolution	0.1 A
Accuracy (1)	±5 %
Display format	3 significant digits
Refresh interval	1 second (typical)

(1) *At IN, under reference conditions (IEC 60255-6).*

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Machine Operation Assistance
Current Phase Displacement



Operation

Current phase displacement between the main phase currents (I) and additional phase currents (I') (θa, θb, θc) is calculated for each phase.

The measurements are corrected by taking account of the connection and the direction of rotation of the phases to create an image of the vector shift, which must be set in order to use the ANSI 87T differential protection: θr/30 = vector shift (Setting ranges). This is the protectioin setting range.

Readout

The measurements may be accessed via:

- the Sepam™ display via the icon
- a PC with SFT2841 software loaded
- a communication link.

Characteristics

Measurement Range	0 to 359°
Units	°
Resolution	1°
Accuracy (1)	±2°
Display Format	3 significant digits
Refresh Interval	1 second (typical)

(1) *At IN, under reference conditions (IEC 60255-6).*

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Machine Operation Assistance
Apparent Positive Sequence and Phase-to-Phase Impedances

Apparent Positive Sequence Impedance

Operation

Apparent positive sequence impedance is used to facilitate the implementation of the underimpedance field loss protection function (ANSI 40).

$$Z1 = \frac{|V1|}{|I1|}$$

Readout

The measurement may be accessed via:
- a PC with SFT2841 software loaded
- a communication link.

Characteristics

Measurement Range	0 to 200 kΩ
Units	Ω
Resolution	0.001 Ω
Accuracy (1)	±5 %
Refresh Interval	1 second (typical)

(1) At IN, VN, under reference conditions (IEC 60255-6).

Apparent Phase-to-Phase Impedances

Operation

Apparent phase-to-phase impedances are used to facilitate the implementation of the backup underimpedance protection function (ANSI 21B). They are expressed as the ratio of phase-to-phase voltage to phase-to-phase current.

$$Zab = \frac{|\vec{V}ab|}{|\vec{I}ab|} \text{ with } \overrightarrow{Iab} = \vec{I}a - \vec{I}b$$

$$Zbc = \frac{|\vec{V}bc|}{|\vec{I}bc|} \text{ with } \overrightarrow{Ibc} = \vec{I}b - \vec{I}c$$

$$Zac = \frac{|\vec{V}ac|}{|\vec{I}ac|} \text{ with } \overrightarrow{Iac} = \vec{I}c - \vec{I}a$$

Readout

The measurement may be accessed via:
- a PC with SFT2841 software loaded
- a communication link.

Characteristics

Measurement Range	0 to 200 kΩ
Units	Ω
Resolution	0.001 Ω
Accuracy (1)	±5 %
Refresh Interval	1 second (typical)

(1) At IN, VN, under reference conditions (IEC 60255-6).

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Third Harmonic Neutral Point Voltage

Operation

Measuring the third harmonic component of the zero sequence voltage occurs at the neutral point of a generator or motor (V0ntH3). The value is used for implementing the third harmonic undervoltage protection function (ANSI 27TN/64G2).

Readout

The measurements may be accessed via:

- the Sepam™ display via the Σ key
- a PC with SFT2841 software loaded
- a communication link.

Characteristics

Measurement range	0.2 to 30 % of Vnt
Units	% of Vnt
Resolution	0.1 %
Accuracy (1)	±1 %
Refresh interval	1 second (typical)

(1) *Under reference conditions (IEC 60255-6).*

Third Harmonic Residual Voltage

Operation

This is a measurement of the third harmonic component of the residual voltage. The residual voltage is calculated by the vectoral sum of the phase-to-neutral voltages.

The value is used for implementing the third harmonic undervoltage protection function (ANSI 27TN/64G2).

Readout

The measurements may be accessed via:

- the Sepam™ display by using the Σ icon
- a PC with SFT2841 software loaded
- a communication link.

Characteristics

Measurement Range	0.2 to 90 % of $V_{Ln}p$
Units	% fo $V_{Ln}p$
Resolution	0.1 %
Accuracy (1)	±1 %
Refresh Interval	1 second (typical)

(1) *Under reference conditions (IEC 60255-6).*

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Machine Operation Assistance
Capacitance

Operation

This operation provides the user with the total capacitance for each phase of the connected capacitor bank steps. The user can then monitor the condition of the capacitors.

It covers wye and delta connections (a parameter that is set in the "Particular characteristics" screen of the SFT2841 setting and operating software). For this measurement, the installation is considered a perfect capacitance, without considering the resistances added by connecting the capacitor bank steps.

For capacitances measured for wye-connected capacitor bank steps:
- Ca: total capacitance phase a
- Cb: total capacitance phase b
- Cc: total capacitance phase c

For capacitances measured for delta-connected capacitor bank steps:
- Cab: total capacitance between phases a and b
- Cbc: total capacitance between phases b and c
- Cac: total capacitance between phases a and c.

Readout

The capacitance measurements can be accessed via:
- a PC with SFT2841 software loaded
- a communication link.

Characteristics

Measurement Range	0 to 30 F
Unit	µF, mF or F
Resolution	0.1 µF
Accuracy	±5 %
Refresh Interval	1 second (typical)

Accuracy

The measurement accuracy is valid if the resistance and inductance per phase of the capacitor bank connecting cable (cable between the Sepam™ CT and the capacitor bank) allow for the following conditions:

- for a wye-connected bank:

$$L\omega < 0.05 \times \left|\frac{1}{C\omega}\right| \qquad R < 0.027 \times \left|\frac{1}{C\omega}\right|$$

where **R** is the resistance per phase in ohms (Ω)
L is the inductance per phase in Henrys (H)
ω is the angular frequency in radians/s
C is the total capacitance per phase in Farads (F)

- for a delta-connected bank:

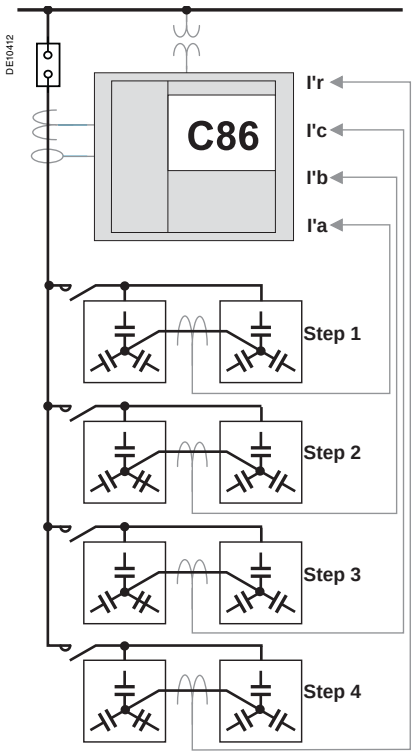
$$L\omega < 0.017 \times \left|\frac{1}{C\omega}\right| \qquad R < 0.009 \times \left|\frac{1}{C\omega}\right|$$

where **R** is the resistance per phase in ohms (Ω)
L is the inductance per phase in Henrys (H)
ω is the angular frequency in radians/s
C is the total capacitance between phases in Farads (F)

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Machine Operation Assistance
Capacitor Unbalance Current



Operation

This function measures the unbalance current of double wye-connected capacitor bank steps. Unbalanced current is a characteristic of capacitor module damage.

The measurement is carried out via the additional phase and zero sequence current channels:

- I'a: capacitor step 1 unbalance current measurement
- I'b: capacitor step 2 unbalance current measurement
- I'c: capacitor step 3 unbalance current measurement
- I'r: capacitor step 4 unbalance current measurement.

Readout

The measurements may be accessed through:

- the Sepam™ display Σ key
- a PC with SFT2841 software
- a communication link.

Characteristics

Measurement Range	0.02 to 20 I'_N
Unit	A
Resolution	0.1 A
Accuracy	±5 %
Refresh Interval	1 second (typical)

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Switchgear Diagnosis
VT Supervision
ANSI Code 60V

Operation

The Voltage Transformer (VT) supervision function is used to supervise the complete phase and residual voltage measurement chain:

- voltage transformers
- VT connection to Sepam™
- Sepam™ voltage analog inputs.

There are two units for the function, one for supervision of the main voltage channel VTs and the other for supervision of the additional voltage channel VTs.

The function processes the following failures:

- partial loss of phase voltages, detected by:
  - presence of negative sequence voltage
  - and absence of negative sequence current
- loss of all phase voltages, detected by:
  - presence of current on one of the three phases
  - and absence of all measured voltages
- tripping of the phase VT (and/or residual VT) protection relay, detected by the acquisition on a logic input of the fuse blown contact or auxiliary contact of the circuit breaker protecting the VTs
- other types of failures may be processed using the logic equation editor.

The "Phase voltage fault" and "Residual voltage fault" information disappear automatically when:

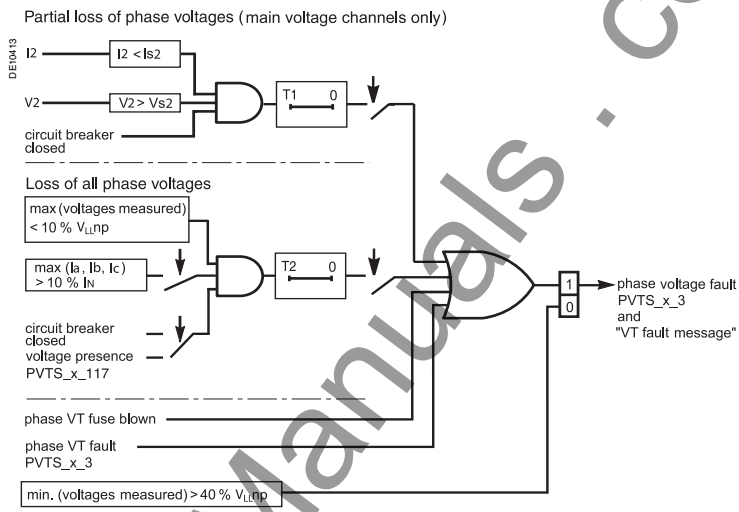
- the cause of the fault disappears
- all measured voltages are present.

Using of "Circuit Breaker Closed" Information

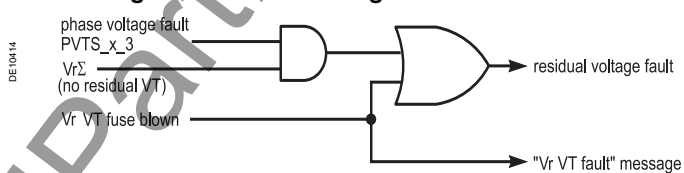
When connected to a logic input, the "circuit breaker closed" information is used to detect the loss of one, two, or three voltages.

In certain applications, the circuit breaker location is insufficient to determine the presence of voltages. In such cases, the equation editor can be used to precisely define the conditions for voltage presence.

Block Diagram: Phase Voltage Fault Detection.



Block Diagram: Residual Voltage Fault Detection.



Consequences of a VT Fault on Protection Functions

A **Phase voltage fault** affects the following protection functions:

- 21B, 27, 27D, 27TN, 32P, 32Q, 37P, 40, 47, 50/27, 51V, 78PS
- 59, only in cases where the protection function is set up for phase-to-neutral overvoltage, when the voltages are measured by two phase VTs + V0VTs
- 67.

A **residual voltage fault** affects the following protection functions:

- 59N
- 67N/67NC.

The behavior of the protection functions in the event of a "Phase voltage fault" or Residual voltage fault" is to be set up and the following choices are proposed:

- for protection functions 21B, 27, 27D, 27TN, 32P, 32Q, 37P, 40, 47, 50/27, 51V, 59N, 59, 78PS: blocking or no blocking
- for protection function 67: blocking or non-directional operation (50/51)
- for protection function 67N/67NC: blocking or non-directional operation (50N/ 51N).

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Switchgear Diagnosis
VT Supervision
ANSI Code 60V

Setting Advice

The partial loss of voltages is based on detecting the presence of negative sequence voltage and the absence of negative sequence current.
By default:

- the presence of negative sequence voltage is detected when: V2 > 10 % $V_{Ln}p$ (Vs2)
- the absence of negative sequence current is detected when: I2 < 5 % IN (Is2)
- time delay T1 is 1 second.

These default settings ensure the stability of the VT supervision function in the event of short-circuits or transient phenomena on the network. The **Is2** set point may be raised for highly unbalanced networks.

Time delay T1 is to be set shorter than the voltage and power protection function tripping times.

Time delay T2 for the detection of the loss of all voltages must be longer than the time it takes for a short-circuit to be cleared by the protection function 50/51 or 67, to avoid the detection of a VT loss of voltage fault triggered by a 3-phase short-circuit.

The time delay for the 51V protection function must be longer than the T1 and T2 time delays used for the detection of voltage losses.

Characteristics

Validating the Detection of Partial Loss of Phase Voltages	
Setting	Yes / No
Vs2 Set Point	
Setting	10 % to 100 % of V_{Lnp}
Accuracy	±5 %
Resolution	1 %
Pick-up / drop-out ratio	95 % ±2.5 %
Is2 Set Point	
Setting	5 % to 100 % of IN
Accuracy	±5 %
Resolution	1 %
Pick-up / drop-out ratio	105 % ±2.5 % or > (1 + 0.01 IN/Is2) x 100 %
Time Delay T1 (Partial Loss of Phase Voltages)	
Setting	0.1 s to 300 s
Accuracy	±2 % or ±25 ms
Resolution	10 ms
Validating the Detection of the Loss of All Phase Voltages	
Setting	Yes / No
Detecting the Loss of All Voltages with Verification of the Presence of Current	
Setting	Yes / No
Voltage Presence Detected by	
Setting	Breaker closed / Logic equation
Time Delay T2 (Loss of All Voltages)	
Setting	0.1 s to 300 s
Accuracy	±2 % or ±25 ms
Resolution	10 ms
Voltage and Power Protection Behavior	
Setting	No action / block
Protection 67 Behavior	
Setting	Non-directional / block
Protection 67N/67NC Behavior	
Setting	Non-directional / block

Inputs

Designation	Syntax	Equations	Logipam
Phase VT fault	PVTS_x_103	■	■
Blocking function	PVTS_x_113	■	■
Voltage presence	PVTS_x_117	■	■

Outputs

Designation	Syntax	Equations	Logipam	Matrix
Function output	PVTS_x_3	■	■	■
Function blocked	PVTS_x_16	■	■	

***Note**: x = unit number: x = 1: main channels (V).*
x = 2: additional channels (V').

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Switchgear Diagnosis
CT Supervision
ANSI Code 60C

Operation

The Current Transformer (CT) supervision function is used to supervise the complete phase current measurement chain:

- phase CTs (1A / 5A CTs or LPCTs)
- phase current CT connection to Sepam™
- Sepam™ phase current analog inputs

There are two units for the function, one for supervising the main current channel CTs (I) and the other for supervising the additional current channel CTs (I').

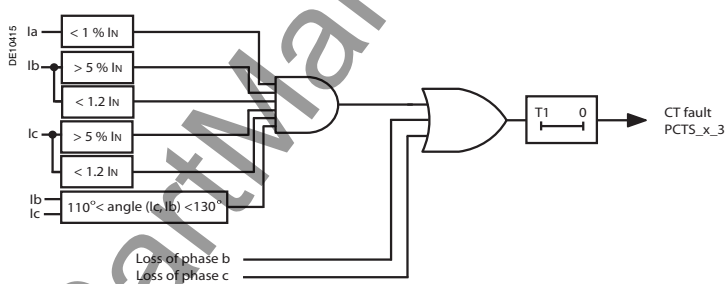
The function is inactive if only two phase CTs are connected.

The "Main CT fault" or "Additional CT fault" information disappears automatically when three phase currents are measured and have values greater than 10 % of In.

If a phase current is lost, the following protection functions can be blocked to avoid nuisance tripping:

- 21B, 46, 40, 32P, 37P, 32Q, 78PS, 64REF
- 51N and 67N, if Ir is calculated by the sum of the phase currents.

Block Diagram



Characteristics

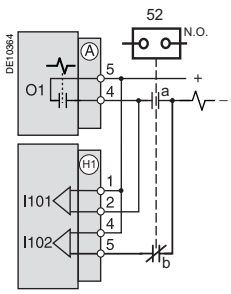
Time Delay				
Setting		0.15 s to 300 s		
Accuracy		±2 % or ± 25 ms		
Resolution		10 ms		
Blocking Protection Functions 21B, 32P, 32Q, 37P, 40, 46, 51N, 64REF, 67N, 78PS				
Setting		No action / block		
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Block function	PCTS_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Delayed output	PCTS_x_3	■	■	■
Phase a fault	PCTS_x_7	■	■	
Phase b fault	PCTS_x_8	■	■	
Phase c fault	PCTS_x_9	■	■	
Function blocked	PCTS_x_16	■	■	

***Note**: x = unit number: x = 1: main channels (I).*
x = 2: additional channels (I').

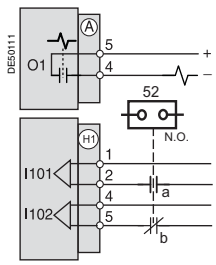
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Switchgear Diagnosis
Trip and Closing Circuit Supervision
ANSI Code 74



Connection when trip circuit is wired with NO contacts



Connection when trip circuit is wired with NC contacts

Trip Circuit Supervision and Open / Closed Matching

Operation

This supervision function operates with trip circuits that use either normally open (NO) or normally closed (NC) trip units. It blocks breaker operation under false conditions.

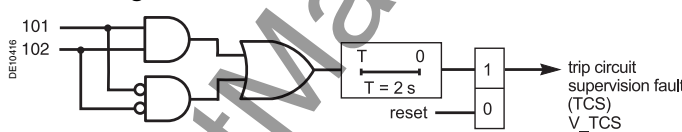
With NO units, the function detects:

- circuit continuity
- supply loss
- mismatching of position indication contacts

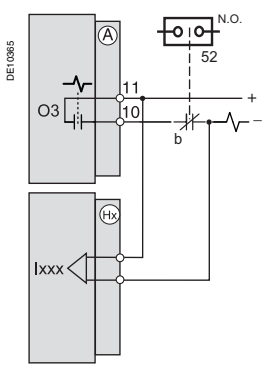
With NC units, the function only detects a mismatch of position indication contacts; it does not check for circuit continuity or supply loss. Trip unit supervision is considered unnecessary in this case.

The information is accessible in the matrix ("trip circuit" message) and by the remote indication TS1.

Block Diagram



Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Trip circuit supervision fault	V_TCS		■	■



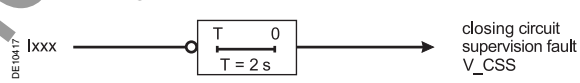
Connection for closing circuit supervision.

Closing Circuit Supervision

Operation

This function monitors closing coil continuity. It calls for the wiring diagram (opposite), connected to a logic input configured with the "Closing coil supervision" function. The information is accessible in the matrix ("closing circuit" message) and via remote indication TS234.

Block Diagram



Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Closing circuit supervision fault	V_CCS		■	■

Open and Close Supervision

Operation

After an open or close command to a circuit breaker occurs, the system waits 200 milliseconds before checking for compliance. If the circuit breaker status does not match the last command sent, the system generates a "Control fault" message and a remote indication TS2.

Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Control fault (circuit breaker monitoring)	V_CTRLFAUT		■	■

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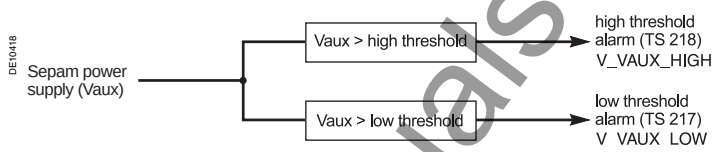
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Switchgear Diagnosis
Auxiliary Power Supply Monitoring

Operation

The auxiliary power supply is an important factor in cubicle operation. This function monitors the supply by measuring the Sepam™ power supply voltage and comparing the measured value to low and high thresholds. If the value is outside these limits, an alarm is generated. The related information is available in the matrix and in Logipam.

Block Diagram



Readout

The measurements can be accessed one of the following:

- the Sepam™ display via the icon
- a PC with SFT2841 software
- a communication link.

Characteristics

Measured Auxiliary Voltage Vaux, Low Threshold Alarm, High Threshold Alarm				
Measurement Range		20 to 275 V DC		
Units		V		
Resolution		0.1 V (1 V on display)		
Accuracy		±7 %		
Refresh Interval		1 second (typical)		
Rated Auxiliary Voltage				
Setting		24 to 250 V DC		
Resolution		1 V		
Low Threshold				
Setting		60 to 95 % of rated V (minimum 20 V)		
Resolution		1 V		
Accuracy		±7 %		
High Threshold				
Setting		105 to 150 % of rated V (maximum 275 V)		
Resolution		1 V		
Accuracy		±7 %		
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Auxiliary power supply monitoring on	V_VAUX_ON		■	
High threshold alarm	V_VAUX_HIGH		■	■
Low threshold alarm	V_VAUX_LOW		■	■

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Switchgear Diagnosis
Cumulative Breaking Current
Number of Operations

Cumulative Breaking Current Monitoring

Operation

This function gives the cumulative breaking current in $(kA)^2$ for five current ranges. It is based on measuring the fundamental component on main channels (I).
The current ranges displayed are:

- 0 < I < 2 In
- 2 In < I < 5 In
- 5 In < I < 10 In
- 10 In < I < 40 In
- I > 40 In.

Each value is monitored by an adjustable set point. When the set point is exceeded, an alarm is sent and is available in the matrix and by the remote indication TS235.

These values are saved in the event of an auxiliary power loss. The initial values can be set using the SFT2841 software tool to take into account the actual state of a breaking device used.

The higher number of trips at the higher currents causes more wear on breaker contacts and decreases their life. Refer to switchgear documentation for contact wear specifications.

Readout

The measurements may be accessed via:

- the Sepam™ display via the icon
- a PC with SFT2841 software
- a communication link.

Characteristics

Cumulative breaking current measured				
Range			0 to 65535 $(kA)^2$	
Units			primary $(kA)^2$	
Resolution			$1(kA)^2$	
Accuracy (1)			±10 % ±1 digit	
Alarm set point				
Setting			0 to 65535 $(kA)^2$	
Resolution			1(kA)2	
Accuracy (1)			±10 % ±1 digit	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Cumulative breaking current threshold overrun	V_MAXBRKCUR		■	■

***(1)** At IN, under reference conditions (IEC 60255-6).*

Number of Operations

Operation

The function also gives the total number of breaking device operations. It is activated by tripping the 01 contact.

The number of operations is saved in the event of an auxiliary power failure.
It may be reinitialized using the SFT2841 software.

Readout

The measurements may be accessed via:

- the Sepam™ display via the key
- a PC with the SFT2841 software
- communication link.

Characteristics

Range	0 to 4.10^9
Units	None
Resolution	1
Refresh Interval	1 second (typical)

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Operating Time

Operation

This function gives the value of the opening operating time of a breaking device (1) and change of status of the device open position contact connected to the I102 input (2) The value is saved in the event of an auxiliary power failure.

Readout

The measurements may be accessed by one of the following:

- a Sepam™ display through the icon
- a PC with SFT2841 software
- communication link.

(1) Refer to the vendor-provided documentation on the switchgear used for operating time parameter specifications.

(2) Optional I/O module.

Characteristics

Measurement Range	20 to 100
Units	millisecond (ms)
Resolution	1 ms
Accuracy	±1 ms typical
Display Format	3 significant digits

Charging Time

Operation

This function gives the charge time value of the breaking device (1) operating mechanism. This value is determined by the device closed position status change contact and the end of charging contact connected to the Sepam™ logic inputs (2). The value is saved in the event of an auxiliary power failure.

Readout

The measurements may be accessed via:

- the Sepam™ display via the key
- the display of a PC with the SFT2841 software
- the communication link.

(1) Refer to the vendor-provided documentation on the switchgear used for operating time parameter specifications.

(2) Optional I/O module.

Characteristics

Measurement Range	1 to 20
Units	seconds
Resolution	1 second
Accuracy	±0.5 second
Display Format	3 significant digits

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Switchgear Diagnosis
Number of Racking-Out Operations

Operation

This function keeps a count of circuit breaker or contactor "rackouts", or disconnects. The information can be used for breaking device maintenance. The breaking device's "racked out" or "disconnected" position contacts must be wired to a logic input and set up in the SFT2841 software in order for rackouts to be counted.

The number of disconnects is saved in case auxiliary power fails. It can be reinitialized using the SFT2841 software.

Readout

The measurements can be accessed by one of the following:

- Sepam™ display via the icon
- a PC with SFT2841 software loaded
- a communication link.

Characteristics

Measurement Range	0 to 65535
Units	None
Resolution	1
Refresh Interval	1 second (typical)

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Setting Ranges

Functions	Settings		Time Delays
ANSI 12 - Overspeed			
	100 to 160% of Ωn		1 to 300 s
ANSI 14 - Underspeed			
	10 to 100% of Ωn		1 to 300 s
ANSI 21B - Underimpedance			
Impedance Zs	0.05 to 2.00 V_N/I_B		
ANSI 24 - Overexcitation (V/Hz)			
Tripping curve	Definite time		
	IDMT type A, B or C		
Gs set point	1.03 to 2 pu	Definite time	0.1 to 20000 s
		Inverse Definite Minimum Time (IDMT)	0.1 to 1250 s
ANSI 25 - Sync-Check			
Measured voltages	Phase-to-phase	Phase-to-neutral	
Rated Primary Phase-to-Phase Voltage			
$V_{L\text{-}Lp}$sync1 ($V_{L\text{-}np}$ sync1 = $V_{L\text{-}Lp}$sync1/$\sqrt{3}$)	220 V to 250 kV	220 V to 250 kV	
$V_{L\text{-}Lp}$ sync2 ($V_{L\text{-}np}$sync2 = $V_{L\text{-}Lp}$sync2/$\sqrt{3}$)	220 V to 250 kV	220 V to 250 kV	
Rated Secondary Phase-to-Phase Voltage			
$V_{L\text{-}Ls}$ sync1	90 V to 120 V	90 V to 230 V	
$V_{L\text{-}Ls}$ sync2	90 V to 120 V	90 V to 230 V	
Sync-Check Setpoints			
dUs set point	3% to 30% of V_{LL}p sync1	3% to 30% of V_{Ln}p sync1	
dfs set point	0.05 to 0.5 Hz	0.05 to 0.5 Hz	
dPhi set point	5 to 80°	5 to 80°	
V_{LL}s high set point	70% to 110% V_{LL}p sync1	70% to 110% V_{Ln}p sync1	
V_{LL}s low set point	10% to 70% V_{LL}p sync1	10% to 70% V_{Ln}p sync1	
Other Settings			
Lead time	0 to 0.5 s	0 to 0.5 s	
Operating modes: no-voltage conditions for which tie breaking is allowed	Dead1 AND Live2	Dead1 AND Live2	
	Live1 AND Dead2	Live1 AND Dead2	
	Dead1 XOR Dead2	Dead1 XOR Dead2	
	Dead1 OR Dead2	Dead1 OR Dead2	
	Dead1 AND Dead2	Dead1 AND Dead2	

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Functions	Settings	Time delays
ANSI 27 - Undervoltage (L-L) or (L-n)		
Tripping curve	Definite time	
	IDMT	
Set point	5 to 100% of $V_{LL}p$	0.05 to 300 s
Measurement origin	Main channels (V) or additional channels (V')	
ANSI 27D - Positive Sequence Undervoltage		
Set point and time delay	15 to 60% of $V_{LL}p$	0.05 to 300 s
Measurement origin	Main channels (V) or additional channels (V')	
ANSI 27R - Remnant Undervoltage		
Set point and time delay	5 to 100% of $V_{LL}p$	0.05 to 300 s
Measurement origin	Main channels (V) or additional channels (V')	
ANSI 27TN/64G2 - Third Harmonic Undervoltage		
Vs set point (fixed)	0.2 to 20% of Vntp	0.5 to 300 s
K set point (adaptive)	0.1 to 0.2	0.5 to 300 s
Positive sequence undervoltage	50 to 100% of $V_{LL}p$	
Minimum apparent power	1 to 90% of Sb (Sb = $\sqrt{3}$ .V_{LL}.IB)	
ANSI 32P - Directional Active Overpower		
	1 to 120% of Sn (2)	0.1 s to 300 s
ANSI 32Q - Directional Reactive Overpower		
	5 to 120% of Sn (2)	0.1 s to 300 s
ANSI 37 - Phase Undercurrent		
	0.05 to 1 IB	0.05 s to 300 s
ANSI 37P - Directional Active Underpower		
	5 to 100% of Sn (2)	0.1 s to 300 s
ANSI 38/49T - Temperature Monitoring		
Alarm set point TS1	0 °C to 180 °C or 32 °F to 356 °F	
Trip set point TS2	0 °C to 180 °C or 32 °F to 356 °F	
ANSI 40 - Field Loss (Underimpedance)		
Common point: Xa	0.02 VN/IB to 0.2 V_{Ln}/IB + 187.5 kΩ	
Circle 1: Xb	0.2 VN/IB to 1.4 V_{Ln}/IB + 187.5 kΩ	0.05 to 300 s
Circle 2: Xc	0.6 VN/IB to 3 V_{Ln}/IB + 187.5 kΩ	0.1 to 300 s

(1) *Sn* = $\sqrt{3}$ IN.V_{LL}p

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Setting Ranges

Functions	Settings		Time delays	
ANSI 46 - Negative Sequence / Unbalance				
Tripping curve	Definite time			
	Schneider Electric			
	IEC: SIT/A, LTI/B, VIT/B, EIT/C			
	IEEE: MI (D), VI (E), EI (F)			
	RI² (setting constant from 1 to 100)			
Is set point	0. to 5 IB	Definite time	0.1 to 300 s	
	0.1 to 0.5 IB (Schneider Electric)	IDMT	0.1 to 1s	
	0.1 to 1 IB (IEC, IEEE)			
	0.03 to 0.2 IB (RI²)			
Measurement origin	Main channels (I) or additional channels (I')			
ANSI 47 - Negative Sequence Overvoltage				
Set point and time delay	1 to 50% of V_{LLp}		0.05 to 300 s	
Measurement origin	Main channels (V) or additional channels (V')			
ANSI 48/51LR - Locked Rotor / Excessive Starting Time				
Is set point	0.5 to 5 IB	ST starting time	0.5 s to 300 s	
		LT and LTS time delays	0.05 s to 300 s	
ANSI 49RMS - Thermal Overload for Cables				
Admissible current	1 to 1.73 IB			
Time constant T1	1 to 600 min			
ANSI 49RMS - Thermal Overload for Capacitors				
Alarm current		1.05 IB to 1.70 IB		
Trip current		1.05 IB to 1.70 IB		
Positioning of the hot tripping curve	Current setting	1.02 x trip current to 2 IB		
	Time setting	1 to 2000 minutes (variable range depending on the trip current and current setting)		
ANSI 49RMS - Thermal Overload for Machines			**Mode 1**	**Mode 2**
Accounting for negative sequence component		0 - 2.25 - 4.5 - 9		
Time constant	Heating		T1: 1 to 600 min	T1: 1 to 600 min
	Cooling		T2: 5 to 600 min	T2: 5 to 600 min
Alarm and tripping set points (Es1 and Es2)		0 to 300% of rated thermal capacity		
Initial thermal capacity used (Es0)		0 to 100%		
Switching of thermal settings condition		by logic input		
		by Is set point adjustable from 0.25 to 8 IB		
Maximum equipment temperature		140 °F to 392 °F (60 to 200 °C)		
Measurement origin	Main channels (I) or additional channels (I')			
ANSI 50BF - Breaker Failure				
Presence of current	0.2 to 2 IN			
Operating time	0.05 s to 3 s			
ANSI 50/27 - Inadvertent Energization				
Is set point	0.05 to 4 IN			
Vs set point	10 to 100% V_{LLp}		T1: 0 to 10 s	
			T2: 0 to 10 s	
ANSI 50/51 - Phase Overcurrent				
	Tripping time delay	**Timer hold**		
Tripping curve	Definite time	DT		
	SIT, LTI, VIT, EIT, UIT (1)	DT		
	RI	DT		
	IEC: SIT/A, LTI/B, VIT/B, EIT/C	DT or IDMT		
	IEEE: MI (D), VI (E), EI (F)	DT or IDMT		
	IAC: I, VI, EI	DT or IDMT		
	Customized	DT		
Is set point	0.05 to 24 IN	Definite time	Inst; 0.05 s to 300 s	
	0.05 to 2.4 IN	IDMT	0.1 s to 12.5 s at 10 Is	
Timer hold	Definite time (DT; timer hold)		Inst; 0.05 s to 300 s	
	IDMT (IDMT; reset time)		0.5 s to 20 s	
Measurement origin	Main channels (I) or additional channels (I')			
Confirmation	None			
	By negative sequence overvoltage			
	By phase-to-phase undervoltage			

(1) Tripping as of 1.2 Is.

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Functions	Settings		Time delays
ANSI 50N/51N or 50G/51G - Ground Fault			
	Tripping Time Delay	**Timer Hold**	
Tripping curve	Definite time	DT	
	SIT, LTI, VIT, EIT, UIT (1)	DT	
	RI	DT	
	CEI: SIT/A,LTI/B, VIT/B, EIT/C	DT or IDMT	
	IEEE: MI (D), VI (E), EI (F)	DT or IDMT	
	IAC: I, VI, EI	DT or IDMT	
	EPATR-B, EPATR-C	DT	
	Customized	DT	
Isr set point	0.01 to 15 Inr (min. 0.1 A)	Definite time	Inst; 0.05 s to 300 s
	0.01 to 1 Inr (min. 0.1 A)	IDMT	0.1 s to 12.5 s at 10 Isr
	0.6 to 5 A	EPATR-B	0.5 to 1 s
	0.6 to 5 A	EPATR-C	0.1 to 3 s
Timer hold	Definite time (DT; timer hold)		Inst; 0.05 s to 300 s
	IDMT (IDMT; reset time)		0.5 s to 20 s
Measurement origin	Ir input, I'r input, sum of phase currents IrΣ or sum of phase currents I'rΣ		
ANSI 50V/51V - Voltage-Restrained Overcurrent			
	Tripping Time Delay	**Timer Hold**	
Tripping curve	Definite time	DT	
	SIT, LTI, VIT, EIT, UIT (1)	DT	
	RI	DT	
	IEC: SIT/A, LTI/B, VIT/B, EIT/C	DT or IDMT	
	IEEE: MI (D), VI (E), EI (F)	DT or IDMT	
	IAC: I, VI, EI	DT or IDMT	
	Customized	DT	
Is set point	0.5 to 24 IN	Definite time	Inst; 0.05 s to 300 s
	0.5 to 2.4 IN	IDMT	0.1 s to 12.5 s at 10 Is
Timer hold	Definite time (DT; timer hold)		Inst; 0.05 s to 20 s
	IDMT (IDMT; reset time)		0.5 s to 300 s
Measurement origin	Main channels (I) or additional channels (I')		
ANSI 51C - Capacitor Bank Unbalance			
Is set point	0.05 A to 2 I'N	Definite time	0.1 to 300 s
ANSI 59 - Overvoltage (L-L) or (L-N)			
Set point and time delay	50 to 150% of V_{LLp}		0.05 to 300 s
Measurement origin	Main channels (V) or additional channels (V')		
ANSI 59N - Neutral Voltage Displacement			
Tripping curve	Definite time		
	IDMT		
Set point	2 to 80% of V_{LLp}	Definite time	0.05 to 300 s
	2 to 10% of V_{LLp}	IDMT	0.1 to 100 s
Measurement origin	Main channels (V), additional channels (V') or neutral-point voltage V_{Lnt}		
ANSI 64REF - Restricted Ground Fault Differential			
Isr set point	0.05 to 0.8 IB (IB ≥ 20 A)		
	0.1 to 0.8 IB (IB < 20 A)		
Measurement origin	Main channels (I, Ir) or additional channels (I', I'r)		
ANSI 66 - Starts per Hour			
Total number of starts	1 to 60	Period	1 to 6 h
Number of consecutive starts	1 to 60	T time delay stop/start	0 to 90 min

(1) *Tripping as of 1.2 Is.*

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Setting Ranges

Functions		Settings		Time Delays
ANSI 67 - Directional Phase Overcurrent				
Characteristic angle		30°, 45°, 60°		
		Tripping Time Delay	**Timer Hold Delay**	
Tripping curve		Definite time	DT	
		SIT, LTI, VIT, EIT, UIT (1)	DT	
		RI	DT	
		IEC: SIT/A, LTI/B, VIT/B, EIT/C	DT or IDMT	
		IEEE: MI (D), VI (E), EI (F)	DT or IDMT	
		IAC: I, VI, EI	DT or IDMT	
		Customized	DT	
Is set point		0.1 to 24 I_N	Definite time	Inst; 0.05 s to 300 s
		0.1 to 2.4 I_N	IDMT	0.1 s to 12.5 s at 10 Is
Timer hold		Definite time (DT; timer hold)		Inst; 0.05 s to 300 s
		IDMT (IDMT; reset time)		0.5 s to 20 s
ANSI 67N/67NC Type 1 - Directional Ground Fault, According to Ir Projection				
Characteristic angle		–45°, 0°, 15°, 30°, 45°, 60°, 90°		
Isr set point		0.01 to 15 I_{Nr} (mini. 0,1 A)	Definite time	Inst; 0.05 s to 300 s
Vsr set point		2 to 80% of $V_{LL}p$		
Memory time		T0mem time	0; 0.05 s to 300 s	
		Vrmem validity set point	0; 2 to 80% of $V_{LL}p$	
Measurement origin		Ir input, I'r input		
ANSI 67N/67NC Type 2 - Directional Ground Fault, According to Ir Vector Magnitude Directionalized on a Tripping Half-Plane				
Characteristic angle		-45°, 0°, 15°, 30°, 45°, 60°, 90°		
		Tripping Time Delay	**Timer Hold Delay**	
Tripping curve		Definite time	DT	
		SIT, LTI, VIT, EIT, UIT (1)	DT	
		RI	DT	
		IEC: SIT/A,LTI/B, VIT/B, EIT/C	DT or IDMT	
		IEEE: MI (D), VI (E), EI (F)	DT or IDMT	
		IAC: I, VI, EI	DT or IDMT	
		Customized	DT	
Isr set point		0.1 to 15 I_{Nr} (min. 0.1 A)	Definite time	Inst; 0.05 s to 300 s
		0.01 to 1 I_{Nr} (min. 0.1 A)	IDMT	0.1 s to 12.5 s at 10 Isr
Vsr set point		2 to 80% of $V_{LL}p$		
Timer hold		Definite time (DT; timer hold)		Inst; 0.05 s to 300 s
		IDMT (IDMT; reset time)		0.5 s to 20 s
Measurement origin		Ir input, I'r input or sum of phase currents $I_r\Sigma$		
ANSI 67N/67NC Type 3 - Directional Ground Fault, According to Ir Vector Magnitude Directionalized on a Tripping Sector				
Tripping sector start angle		0° to 359°		
Tripping sector end angle		0° to 359°		
Isr set point	CSH zero sequence CT (2A rating)	0.1 A to 30 A	Definite time	Inst; 0.05 to 300 s
	1A CT	0.005 to 15 I_{Nr} (min. 0.1 A)		
	Zero sequence CT + ACE990 (range 1)	0.01 to 15 I_{Nr} (min. 0.1 A)		
Vsr set point		Calculated Vr (sum of 3 voltages)	2 to 80% of $V_{LL}p$	
		Measured Vr (external VT)	0.6 to 80% of $V_{LL}p$	
Measurement origin		Ir input or I'r input		

(1) *Tripping from 1.2 Is.*

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Setting Ranges

Functions	Settings	Time Delays
ANSI 78PS - Pole Slip		
Time delay of the equal-area criterion	0.1 to 300 s	
Maximum number of power swings	1 to 30	
Time between two power swings	1 to 300 s	
ANSI 81H - Overfrequency		
Set point and time delay	50 to 55 Hz or 60 to 65 Hz	0.1 to 300 s
Measurement origin	Main channels (V) or additional channels (V')	
ANSI 81L - Underfrequency		
Set point and time delay	40 to 50 Hz or 50 to 60 Hz	0.1 to 300 s
Measurement origin	Main channels (V) or additional channels (V')	
ANSI 81R - Rate of Change of Frequency		
	0.1 to 10 Hz/s	0.15 to 300 s
ANSI 87M - Machine Differential		
Ids set point	0.05 to 0.5 In (In ≥ 20 A)	
	0.1 to 0.5 In (In < 20 A)	
ANSI 87T - Transformer Differential		
High set point	3 to 18 In1	
Percentage-Based Curve		
Ids set point	30 to 100% In1	
Slope Id/It	15 to 50%	
Slope Id/It2	Without, 50 to 100%	
Slope change point	1 to 18 In1	
Restraint on Energization		
Isinr set point	1 to 10%	
Delay	0 to 300 s	
Restraint on CT Loss		
Activity	On / Off	
Harmonic Restraints	**Conventional**	**Self-Adaptive**
Selection of restraint	Conventional	Self-adaptive
High set point	On	On / Off
Harmonic 2 percentage set point	Off, 5 to 40%	
Harmonic 2 restraint	Phase-specific/Global	
Harmonic 5 percentage set point	Off, 5 to 40%	
Harmonic 5 restraint	Phase-specific/Global	

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Overspeed
ANSI Code 12

Detecting excessive machine speeds to protect generators and processes.

Description

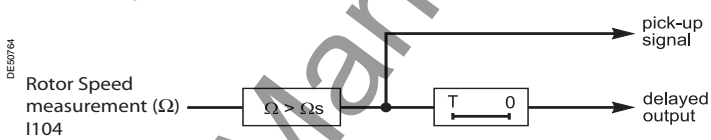
This function detects machine overspeed to identify synchronous generator racing due to loss of synchronism or process monitoring.

Rotation speed is calculated by measuring the time between pulses transmitted by a proximity sensor at each passage of one or more cams driven by the rotation of the motor or generator shaft (see a more in-depth description in the "Metering Functions" chapter of this manual).

The speed acquisition parameters must be set on the "Particular characteristics" screen of the SFT2841 software. The "Rotor speed measurement" function must be assigned to logic input I104 for the function to work.

The protection activates if the measured speed exceeds the speed set point. The protection includes a definite time delay T.

Block Diagram



Characteristics

Settings				
Set Point Ωs				
Setting range	100 to 160% of Ωn			
Accuracy (1)	±2%			
Resolution	1%			
Drop out/pick up ratio	95%			
Time Delay T				
Setting range	1 s to 300 s			
Accuracy (1)	±25 ms or ±(60000/(Ωs (2) x R (3))) ms			
Resolution	1 s			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P12_x_101	■	■	
Protection blocking	P12_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P12_x_1	■	■	
Delayed output	P12_x_3	■	■	■
Protection blocked	P12_x_16	■	■	

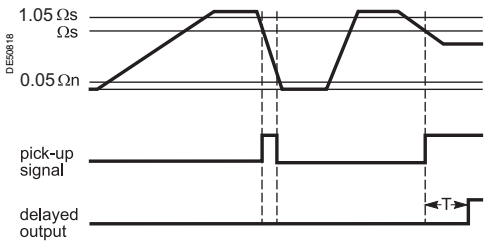
x: unit number.
(1) *Under reference conditions (IEC 60255-6).*
(2) *Ωs in rpm.*
(3) *R: Number of pulses (cam) per rotation.*

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Underspeed
ANSI Code 14

Monitoring underspeeds and detecting rotor locking.



Description

Rotation speed is calculated by measuring the time between pulses transmitted by a proximity sensor at each passage of one or more cams driven by the rotation of a motor or generator shaft (see a more in-depth description in the "Metering Functions" chapter of this manual).

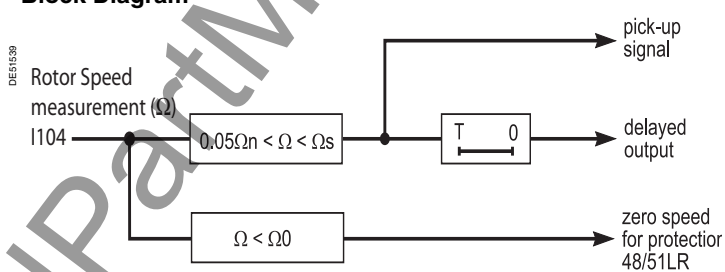
Monitoring machine speed involves:
- detecting machine underspeed after starting, for process monitoring, for example
- zero-speed data for detection of locked rotor.

The speed-acquisition and zero-speed detection parameters must be set on the "Particular characteristics" screen of the SFT2841 software.

The "Rotor speed measurement" function must be assigned to logic input I104 for the function to work.

The protection function picks up if the speed measured drops below the speed set point after having first exceeded the set point by 5%. Zero speed is detected by unit 1 and is used by protection function 48/51 LR to detect rotor locking.
The protection includes a definite (DT) time delay T.

Block Diagram



Characteristics

Settings				
Set Point Ωs				
Setting range	10 to 100% of Ωn			
Accuracy (1)	±2%			
Resolution	1%			
Drop out/pick up ratio	105%			
Time Delay T				
Setting range	1 s to 300 s			
Accuracy (1)	±25 ms or ± (60000/(Ωs (2) x R (3))) ms			
Resolution	1 s with T > (60/(Ωs (2) x R (3)))			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P14_x_101	■	■	
Protection blocking	P14_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P14_x_1	■	■	
Delayed output	P14_x_3	■	■	■
Protection blocked	P14_x_16	■	■	
Zero speed	P14_x_38	■	■	

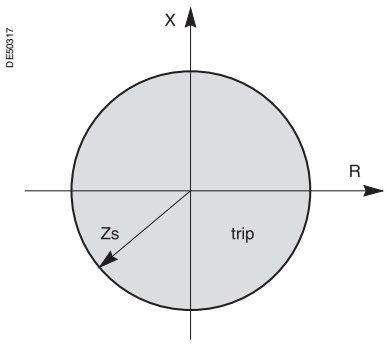
x: unit number.
***(1)** Under reference conditions (IEC 60255-6).*
***(2)** Ωs in rpm.*
***(3)** R: Number of pulses (cam) per rotation.*

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Underimpedance
ANSI Code 21B

Phase-to-phase short-circuit protection for generators.

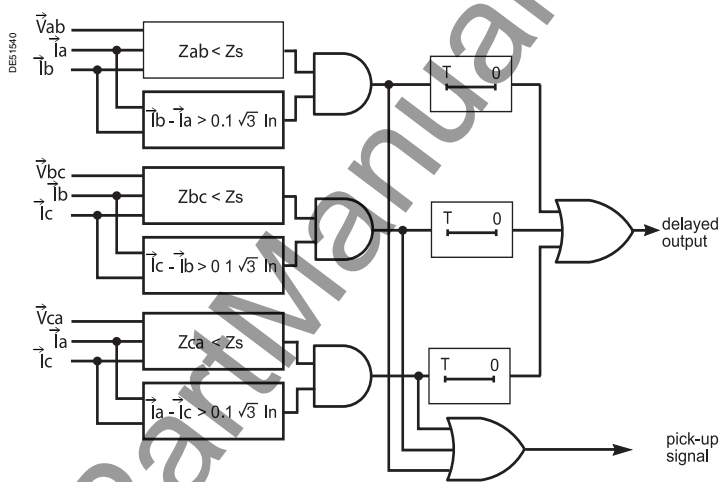


Description

The protection function is made up of a circular tripping characteristic on the impedance plane (R, X), with a definite time delay. It picks up when one of the apparent, phase-to-phase impedances enters the circular tripping characteristic.
The apparent impedances are:

$$\vec{Z}ab = \frac{\vec{V}ab}{\vec{I}a - \vec{I}b}, \quad \vec{Z}bc = \frac{\vec{V}bc}{\vec{I}b - \vec{I}c}, \quad \vec{Z}ac = \frac{\vec{V}ac}{\vec{I}c - \vec{I}a}.$$

Block Diagram



Characteristics

Settings				
Set Point Ωs				
Setting range	0.05VN/IB ≤ Zs ≤ 2 VN/IB or 0.001 Ω			
Accuracy (1)	±2%			
Resolution	0.001 Ω or 1 digit			
Drop out/pick up ratio	105%			
Time Delay T				
Setting range	200 ms ≤ T ≤ 300 s			
Accuracy (1)	±2% or from –10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Characteristic Times (1)				
Operation time	pick-up < 35 ms from infinite to Zs/2 (typically 25 ms)			
Overshoot time	< 40 ms			
Reset time	< 50 ms			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P21B_1_101	■	■	
Protection blocking	P21B_1_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P21B_1_1	■	■	
Delayed output	P21B_1_3	■	■	■
Protection blocked	P21B_1_16	■	■	

***(1)** Under reference conditions (IEC 60255-6).*

Example: Synchronous Generator

Synchronous generator data:
- S = 3.15 MVA
- $V_{LLN}1$ = 6.3 kV
- X_d = 233%
- X'_d = 21%

Protection Setting

Calculate the rated generator impedance to set the protection function:
- $I_B = S/(\sqrt{3}\ V_{LLN}1) = 289$ A
- $Z_N = V_{LLN}1/(\sqrt{3}\ I_B) = 12.59\ \Omega$.

The tripping parameter is typically set to 30% of the rated generator impedance:
$Zs = 0.30 \times Z_N = 3.77\ \Omega$.

This protection function is used to back up other protection functions. Its setting must ensure discrimination with the other protection functions.
T = 0.9 s, for example, for a network where faults are cleared in 0.6 s.

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Overexcitation (V/Hz)
ANSI Code 24

Protection of magnetic circuits in transformers and generators

Description

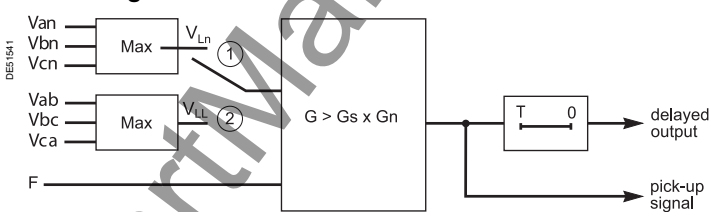
This protection monitors the overexcitation of transformer or generator magnetic circuits by calculating the ratio between the greatest phase-to-neutral or phase-to-phase voltage divided by the frequency.

Overexcitation of magnetic circuits is caused by machine operation with excessive voltage or insufficient frequency. It provokes saturation of the magnetic materials and results in temperature rise. In severe cases, a major flux leakage can occur and seriously damage the materials around the magnetic circuit.

The protection function picks up when the V_{LL}/f or V_{Ln}/f ratio (depending on VT configuration) exceeds the set point. The function is delayed (definite time (DT) or IDMT) according to three curves (see tripping curve equation on page 173).

The typical tripping set point is 1.05 pu.

Block Diagram



where G = V_{LL}/f or V_{Ln}/f depending on VT configuration
Gn = $V_{LL}n/fn$ or $V_{Ln}n/fn$ depending on the voltage
Gs = the set point

(1) *phase-to-neutral voltage, see the table below.*

(2) *phase-to-phase voltage, see the table below.*

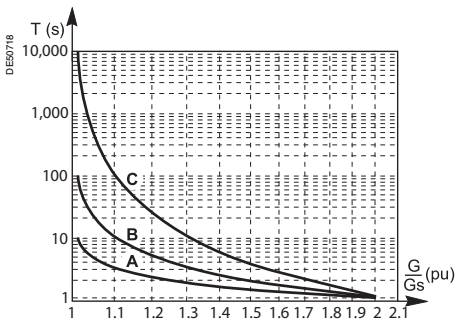
Voltage Transformer Configuration

This setting adapts the function voltage measurement to the magnetic circuit tie breaker, depending on the measurements made possible by Sepam™ wiring.

Voltage Used by the Protection Function							
VT Wiring	**3V**	**$2V_{LL}$ + Vr**	**$2V_{LL}$**	**$1V_{LL}$ + Vr**	**$1V_{LL}$**	**1V + Vr**	**1V**
Delta	(2)	(2)	(2)	(2)	(2)	(1)	(1)
Wye	(1)	(1)	(2)	(2)	(2)	(1)	(1)

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Overexcitation (V / Hz)
ANSI Code 24

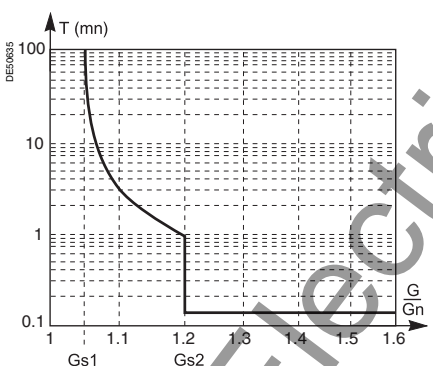


Voltage/frequency ratio Inverse Definite Minimum Time (IDMT) tripping curves

Characteristics

Settings					
VT Configuration					
Setting range		Delta / Wye			
Tripping Curve					
Setting range		Definite time IDMT: type A, type B, type C			
Gs Set Point					
Setting range		1.03 to 2.0 pu (2)			
Accuracy (1)		±2%			
Resolution		0.01 pu (2)			
Drop out/pick up ratio		98% ±1%			
Time Delay T (Operation Time at 2 pu)					
Definite time	Setting range	0.1 to 20000 s			
	Accuracy (1)	±2% or from –10 ms to +25 ms			
IDMT	Setting range	0.1 to 1250 s			
	Accuracy (1)	±2% or from –10 ms to +25 ms			
Resolution		10 ms or 1 digit			
Characteristic Times (1)					
Operation time		pick-up < 40 ms from 0.9 Gs to 1,1 Gs at fn			
Overshoot time		< 40 ms from 0.9 Gs to 1.1 Gs at fn			
Reset time		< 50 ms from 1.1 Gs to 0.9 Gs at fn			
Inputs					
Designation		**Syntax**	**Equations**	**Logipam**	
Protection reset		P24_x_101	■	■	
Protection blocking		P24_x_113	■	■	
Outputs					
Designation		**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)		P24_x_1	■	■	
Delayed output		P24_x_3	■	■	■
Protection blocked		P24_x_16	■	■	

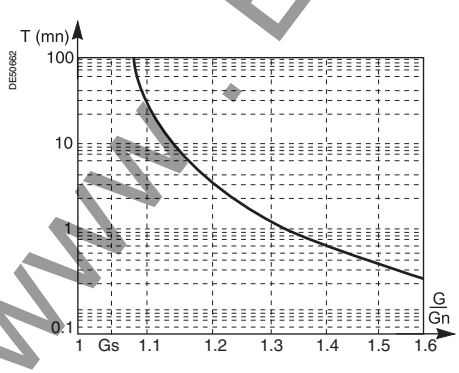
x: unit number.
***(1)** Under reference conditions (IEC 60255-6).*
***(2)** 1 pu represents 1 x Gn.*



Example 1. Synchronous Generator

A generator is often protected with two tripping set points:
- an IDMT set point, set to 1.05 Gn with a long delay
  Example: type B curve, Gs1 = 1.05 and T1 = 8 s
- a definite time (DT) set point, set to approximately 1.2 Gn with a tripping time of approximately ten seconds.

For example: DT, Gs2 = 1.2 and T2 = 5 s.



Example 2. Transformer

A transformer is generally protected by an IDMT set point, set to 1.05 Gn with a long delay

For example: type C curve, Gs = 1.05 and T = 4 s.

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Sync-Check
ANSI Code 25

This protection function checks the synchronization of the electrical networks upstream and downstream from a circuit breaker and allows closing when the differences in voltage, frequency or phase are within authorized limits.

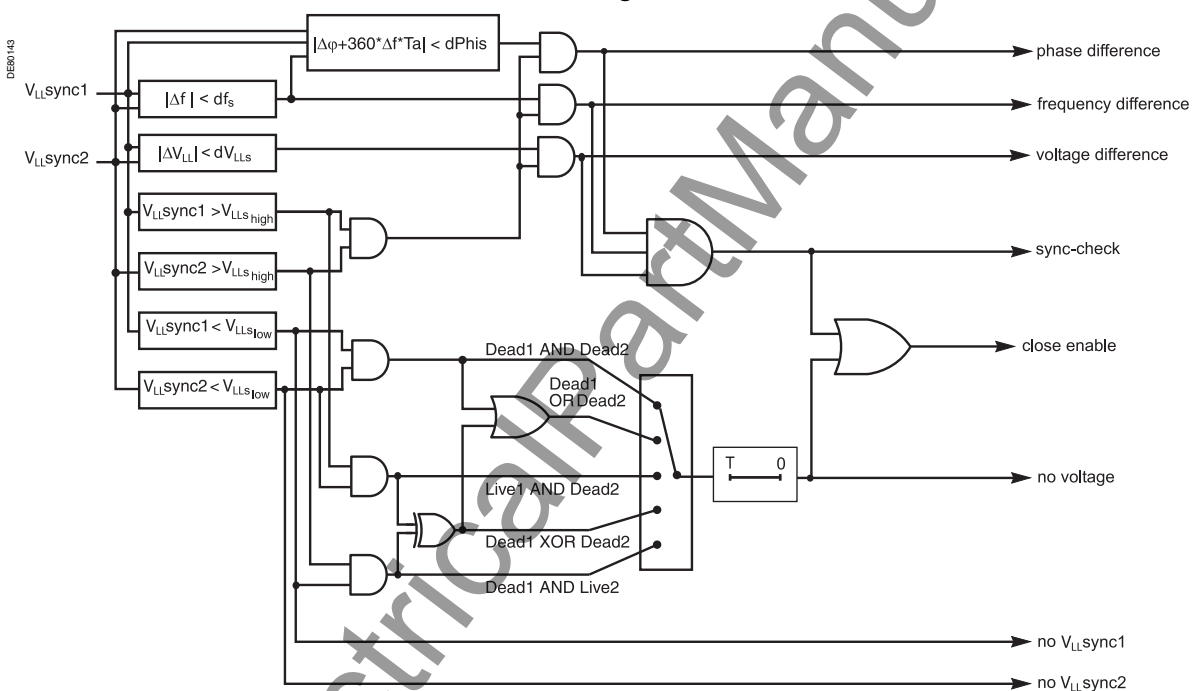
Operation

The sync-check function is designed to allow circuit breaker closing without any risk of dangerous closing between two voltages V_{LL}sync1 and V_{LL}sync2. The voltages compared may be two phase-to-phase voltages or two phase-to-neutral voltages (V_{Ln}).

The function enables when there is a phase, frequency or amplitude difference (within set limits) between the voltages that are compared.

The function is available in the optional MCS025 module. The "Close enable" logic data must connect to a logic input on the Sepam™. All other data and measurements are transmitted to the Sepam™ base unit through the CCA785 connection cord.

Block Diagram



Anticipation

It is possible to anticipate the function by a time, Ta, compensating for the frequency difference and the circuit breaker closing time in order to synchronize the voltages at the time of closing.

Voltage Checking

When one of the two voltages is absent, closing may be authorized according to one of five voltage checking modes.

- V_{LL}sync1 absent and V_{LL}sync2 present (Dead1 AND Live2)
- V_{LL}sync1 present and V_{LL}sync2 absent (Live1 AND Dead2)
- One voltage is present and the other is absent (Dead1 XOR Dead2)
- One or both of the two voltages are absent (Dead1 OR Dead2)
- Both voltages are absent (Dead1 AND Dead2).

The presence of each of the voltages is detected by comparing the voltage to the high set point (V_{LL}s high set point). The absence of either of the voltages is detected by comparing the voltage to the low set point (V_{LL}s low set point).

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Sync-Check
ANSI Code 25

User Information

The following measurements are available:
- voltage difference
- frequency difference
- phase difference.

Characteristics

Settings	
$dV_{LL}s$ Set Point	
Setting range	3% to 30% $V_{LL}sync1$
Accuracy (1)	±2.5% or 0,003 $V_{LL}sync1$
Resolution	1%
Drop out/pick up ratio	106%
dfs Set Point	
Setting range	0.05 Hz to 0.5 Hz
Accuracy (1)	±10 mHz
Resolution	0.01 Hz
Drop out/pick up	< 15 mHz
dPhis Set Point	
Setting range	5° to 50°
Accuracy (1)	±2°
Resolution	1°
Drop out/pick up ratio	120%
$V_{LL}s$ High Set Point	
Setting range	70% to 110% $V_{LL}sync1$
Accuracy (1)	±1%
Resolution	1%
Drop out/pick up ratio	93%
$V_{LL}s$ Low Set Point	
Setting range	10% to 70% $V_{LL}sync1$
Accuracy (1)	±1%
Resolution	1%
Drop out/pick up ratio	106%
Anticipating Circuit Breaker Closing Time	
Setting range	0.1 to 500 s
Accuracy (1)	±2% or ±25 ms
Resolution	10 ms or 1 digit
Voltage Checking	
Setting range	On / Off
Operating Mode with No Voltage	
Setting range	Dead1 AND Live2 Live1 AND Dead2 Dead1 XOR Dead2 Dead1 OR Dead2 Dead1 AND Dead2

Characteristic Times (1)	
Operation time	< 190 ms
dV_{LL} operation time	< 120 ms
df operation time	< 190 ms
dPhi operation time	< 190 ms
Reset time	< 50 ms

Outputs (1)

Designation	Syntax	Equations	Logipam	Matrix
Close enable				
Sync-check	P25_1_46	■	■	
No voltage	P25_1_47	■	■	
Phase difference	P25_1_49	■	■	
Frequency difference	P25_1_50	■	■	
Voltage difference	P25_1_51	■	■	
No $V_{LL}sync1$	P25_1_52	■	■	
No $V_{LL}sync2$	P25_1_53	■	■	

(1) *Under reference conditions (IEC 60255-6).*

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Undervoltage (L-L or L-N)
ANSI Code 27

Protection against phase-to-neutral or phase-to-phase undervoltages.

Description

Undervoltage monitoring protects motors against the negative effects of low system voltages. It also detects abnormally low network voltage in order to trigger automatic load shedding or source transfer:

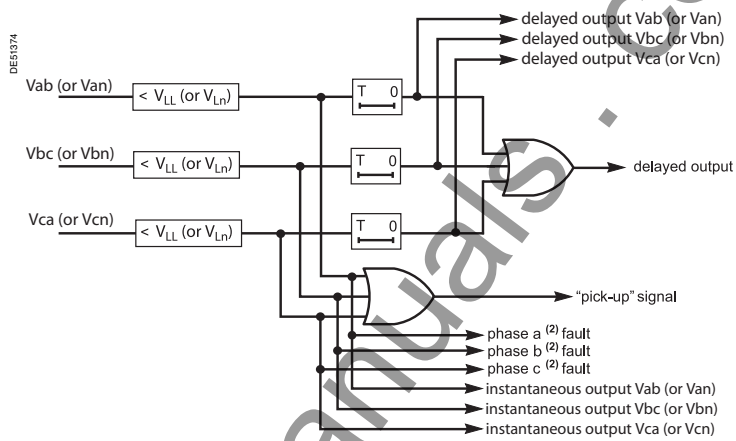
- the protection function is single-phase and operates with phase-to-neutral or phase-to-phase voltage
- it includes a definite (DT) or IDMT time delay T in phase-to-neutral operation (see tripping curve equation on page 173)
- it indicates the faulty phase in the alarm associated with the fault.

Operation with phase-to-neutral or phase-to-phase voltage depends on the connection selected for the voltage inputs.

Connection Conditions			
Type of connection	Van, Vbn, Vcn (1)	Vab, Vbc + Vr	Vab, Vbc
Phase-to-neutral operation	YES	YES	NO
Phase-to-phase operation	YES	YES	YES
Type of connection	Vab (1)	Va (1)	
Phase-to-neutral operation	NO	On Van only	
Phase-to-phase operation	On Vab only	NO	

(1) *With or without Vr*

Block Diagram



Characteristics

Settings				
Measurement Origin				
Setting range	Main channels (V_{LL}) / Additional channels (V_{LL}')			
Voltage Mode				
Setting range	Phase-to-phase voltage / Phase-to-neutral voltage			
Tripping Curve				
Setting range	Definite / IDMT			
V_{LL}s (or V_{Ln}s) Set Point				
Setting range	5% of V_{LL}p (or V_{Ln}p) to 100% of V_{LL}p (or V_{Ln}p)			
Accuracy (1)	±2% or ±0.005 V_{LL}p			
Resolution	1%			
Drop out/pick up ratio	103% ±2%			
Time Delay T (Tripping Time for Zero Voltage)				
Setting range	50 ms to 300 s			
Accuracy (1)	±2% or ±25 ms			
Resolution	10 ms or 1 digit			
Characteristic Times				
Operation time	Pick-up < 40 ms from 1.1 V_{LL}s (V_{Ln}s) to 0.9 V_{LL}s (V_{Ln}s) (typically 25 ms)			
Overshoot time	< 40 ms from 1.1 V_{LL}s (V_{Ln}s) to 0.9 V_{LL}s (V_{Ln}s)			
Reset time	< 50 ms from 0.9 V_{LL}s (V_{Ln}s) to 1.1 V_{LL}s (V_{Ln}s)			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P27_x_101	■	■	
Protection blocking	P27_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P27_x_1	■	■	
Delayed output	P27_x_3	■	■	■
Fault phase a(2)	P27_x_7	■	■	
Fault phase b (2)	P27_x_8	■	■	
Fault phase c(2)	P27_x_9	■	■	
Protection blocked	P27_x_16	■	■	
Instantaneous output Van or Vab	P27_x_23	■	■	
Instantaneous output Vbn or Vbc	P27_x_24	■	■	
Instantaneous output Vcn or Vac	P27_x_25	■	■	
Delayed output Van or Vab	P27_x_26	■	■	
Delayed output Vbn or Vbc	P27_x_27	■	■	
Delayed output Vcn or Vac	P27_x_28	■	■	

x: unit number.
(1) *Under reference conditions (IEC 60255-6).*
(2) *When the protection function is used for phase-to-neutral voltage.*

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Positive Sequence Undervoltage & Phase Rotation Direction Check
ANSI Code 27D

Motor protection against incorrect voltages.

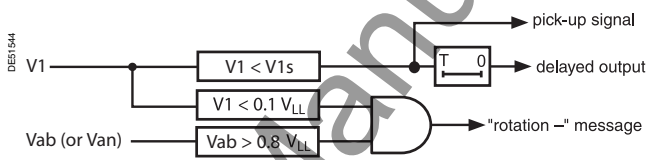
Description

This feature provides motor protection against faulty operation due to an insufficient or unbalanced network voltage. It is based on measuring the positive sequence voltage V1 and includes a definite time delay T.

It does not operate when only a single phase-to-neutral or phase-to-phase voltage is connected.

This protection also detects the phase rotation direction. The protection function considers that the phase rotation direction is reversed when the positive sequence voltage is less than 10% of $V_{LL}p$ and when the phase-to-phase voltage is greater than 80% of $V_{LL}p$. When this is the case, the alarm message "ROTATION –" is generated.

Block Diagram



Characteristics

Settings				
Measurement Origin				
Setting range	Main channels (V_{LL}) / Additional channels (V_{LL}')			
Vs1 Set Point				
Setting range	15% $V_{LL}p$ to 60% $V_{LL}p$			
Accuracy (1)	±2% or ±0.005 $V_{LL}p$			
Resolution	1%			
Drop out/pick up ratio	103% ±2%			
Time Delay T				
Setting range	50 ms to 300 s			
Accuracy (1)	±2% or ±25 ms			
Resolution	10 ms or 1 digit			
Characteristic Times				
Operation time	Pick-up < 40 ms from1.1 Vsd to 0.9 Vsd			
Overshoot time	< 40 ms from1.1 Vs1 to 0.9 Vs1			
Reset time	< 50 ms from 0.9 Vs1 to 1.1 Vs1			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P27D_x_101	■	■	
Protection blocking	P27D_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P27D_x_1	■	■	
Delayed output	P27D_x_3	■	■	■
Protection blocked	P27D_x_16	■	■	

x: unit number.
***(1)** Under reference conditions (IEC 60255-6).*

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Remnant Undervoltage
ANSI Code 27R

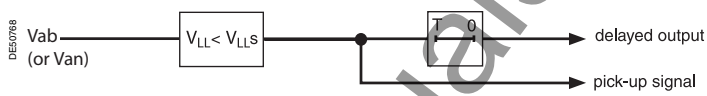
Detecting the remnant voltage sustained by rotating machines.

Description

This protection ensures that the remnant voltage sustained by rotating machines has been cleared before allowing the bus supplying the machines to be re-energized. This is to avoid electrical and mechanical transients.

This is single-phase protection. It enables when the Vab or Van voltage is less than the $V_{LL}s$ set point. The protection includes a definite time delay.

Block Diagram



Characteristics

Settings				
Measurement Origin				
Setting range	Main channels (V_{LL}) / Additional channels (V_{LL}')			
$V_{LL}s$ Set Point				
Setting range	5% to 100% $V_{LL}p$			
Accuracy (1)	±5% or 0.005 $V_{LL}p$			
Resolution	1%			
Drop out/pick up ratio	103% ±2%			
Time Delay T				
Setting range	50 ms to 300 s			
Accuracy (1)	±2% or ±25 ms			
Resolution	10 ms or 1 digit			
Characteristic Times				
Operation time	Pick-up < 45 ms from 1.1 $V_{LL}s$ to 0.9 $V_{LL}s$			
Overshoot time	< 35 ms from 1.1 to 0.9 $V_{LL}s$			
Reset time	< 35 ms from 0.9 to 1.1 $V_{LL}s$			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P27R_x_101	■	■	
Protection blocking	P27R_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P27R_x_1	■	■	
Delayed output	P27R_x_3	■	■	■
Protection blocked	P27R_x_16	■	■	

x: unit number.
***(1)** Under reference conditions (IEC 60255-6).*

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Third Harmonic Undervoltage
ANSI Code 27TN/64G2

Generator protection against insulation faults. This function should be combined with 59N or 51N to ensure 100% stator ground fault protection (64G).

Description

This function protects generators against phase-to-ground insulation faults by detecting any reduction of the third harmonic residual voltage.This function protects 10 to 20% of the stator winding on the neutral point end. Complete protection of the stator winding is ensured by combining this function with function 59N or 51N, which protects 85 to 95% of the winding on the terminal end.

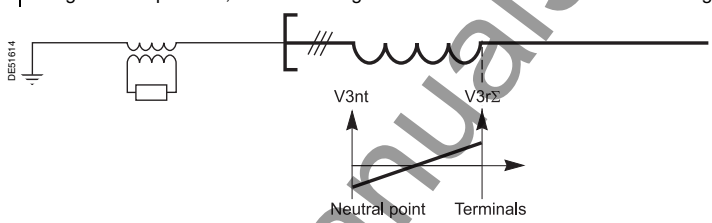
Due to their geometric characteristics, generators produce third-order harmonic voltages (VH3) in addition to the fundamental voltage. The amplitude of the VH3 voltage may vary from 0 to 10% of V_N, as a function of:

- network and generator characteristics
- the load on the generator. It is generally higher under full-load than under no-load conditions.

In the absence of a fault, the VH3 voltage must be at least 0.2% of V_N for protection function 27TN.

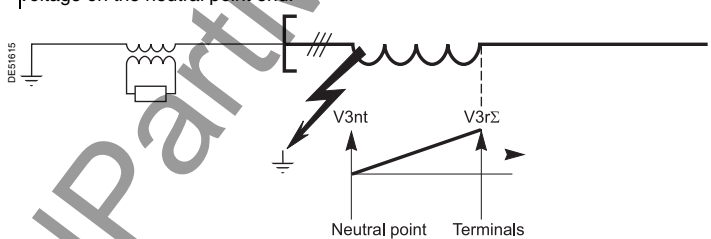
VH3 Voltage with No Fault

During normal operation, the VH3 voltage is measured at each end of the windings.



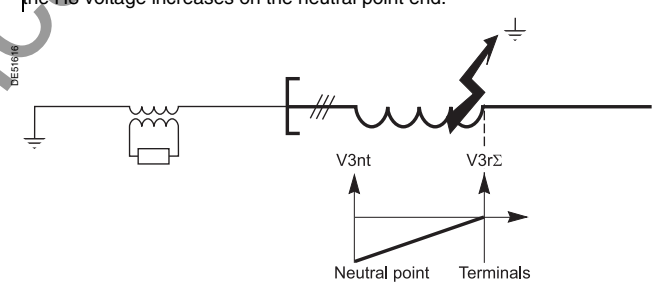
VH3 Voltage with a Fault on the Neutral Point End

When a single-phase fault occurs in the stator winding near the machine neutral point, the neutral point impedance is short-circuited. This causes a drop in the H3 voltage on the neutral point end.



VH3 Voltage with a Fault on the Terminal End

When a single-phase fault occurs in the stator winding near the machine terminals, the H3 voltage increases on the neutral point end.



The third harmonic undervoltage protection function detects the drop in the VH3 voltage caused by a single-phase fault on the neutral-point end.

Two types of tripping set points are available according to the VTs connected:

- fixed set point: tripping for VH3 neutral point undervoltage. The setting requires preliminary measurements.
- adaptive set point: tripping for VH3 neutral point undervoltage depending on a set point whose value depends on the VH3 residual voltage. The setting does not require preliminary measurements.

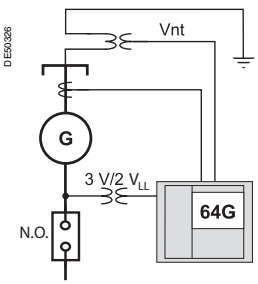
Availability of Set Points Depending on the VTs Used

Voltage Measurements		Available Types	
VT Neutral Point	**VT Terminals**	**27TN Fixed Set Point**	**27TN Adaptive Set Point**
-	All wiring	-	-
■	Van or Vab	-	-
■	Vab, Vbc	■	-
■	Van, Vbn, Vcn	■	■

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Third Harmonic Undervoltage
ANSI Code 27TN/64G2
Fixed Set Point



Operation (Fixed Set Point)

The delayed trip (DT) command is issued if the neutral point VntH3 voltage set point Vcnt is less than the Vs set point.

The protection function operates only if the neutral point VntH3 voltage before the fault is greater than 0.2% of the network phase-to-neutral voltage.

The protection function is blocked if the power (**S**) produced by the generator is low or if the positive sequence voltage (**V1**) is insufficient.

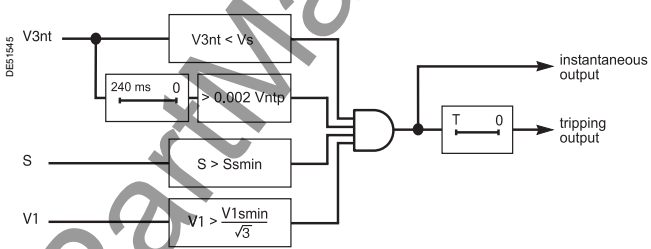
Adjustment

This function is adjusted according to a series of measurements on the neutral point VntH3 voltage of the generator. These measurements are used to determine the lowest VntH3 voltage value under normal operating conditions.
The measurements should be carried out:

- under no-load conditions, not connected to the network
- at a number of load levels because the H3 voltage level depends on the load

The parameter is set below the lowest H3 voltage value measured. The Sepam™ unit provides the neutral point VntH3 voltage measurement to facilitate adjustment of the protection function.

Block Diagram



Characteristics

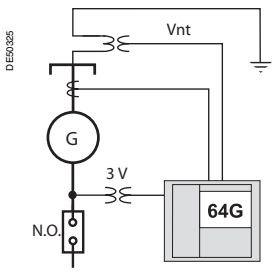
Settings				
Type of Set Point				
Setting range	Fixed			
Third Harmonic Voltage Set Point Vs				
Setting range	0.2 to 20% of Vntp			
Accuracy (1)	±5% or ±0.05 V of neutral point Vnts			
Resolution	0.1%			
Drop out/pick up ratio	105%			
Time Delay				
Setting range	0.5 to 300 s			
Accuracy (1)	±2% or from –10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Advanced Settings				
Ssmin Set Point				
Setting range	1% to 90% of $\sqrt{3}$.V_{LL}p.IB			
Accuracy (1)	±5%			
Resolution	1%			
Drop out/pick up ratio	105%			
V1smin Positive Sequence Undervoltage Set Point				
Setting range	50% to 100% of V_{LL}p			
Accuracy (1)	±5%			
Resolution	1%			
Drop out/pick up ratio	105%			
Characteristic Times (1)				
Operation time	typically 140 ms from 2 Vs to 0			
Overshoot time	< 65 ms			
Reset time	< 65 ms			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P27TN/64G2_x_101	■	■	
Protection blocking	P27TN/64G2_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Tripping output	P27TN/64G2_x_3	■	■	■
Protection blocked	P27TN/64G2_x_16	■	■	
Instantaneous output	P27TN/64G2_x_23	■	■	

x: unit number.
(1) *Under reference conditions (IEC 60255-6).*

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Third Harmonic Undervoltage
ANSI Code 27TN/64G2
Adaptive Set Point



Operation (Adaptive Set Point)

The H3 voltage (terminal end) VrH3Σ is compared to the H3 voltage VntH3 measured on the neutral point end. The protection function calculates the H3 residual voltage using the three phase-to-neutral voltages. Use of the H3 residual voltage is the means to adapt the tripping set point according to the normal H3 voltage level.
Time-delayed definite time (DT) tripping occurs when:

$$|\mathbf{VntH3}| \; y \; \frac{\mathbf{K}}{\mathbf{3(1-K)}} \times |\mathbf{VrH3\Sigma}|.$$

The protection function operates only if the neutral point H3 voltage before the fault is greater than 0.2% of the network phase-to-neutral voltage and if the positive sequence voltage is greater than 30% of the phase-to-neutral voltage.

Adjustment

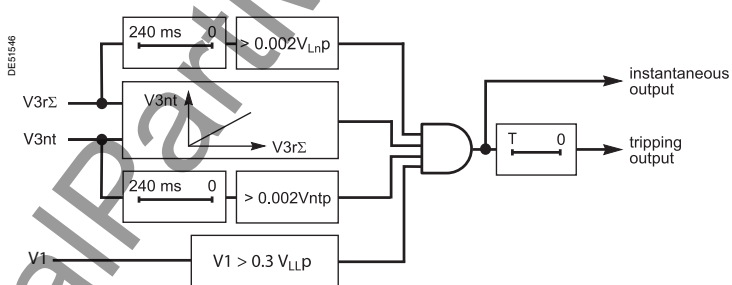
This function does not require any particular measurements but, in certain cases, it may be necessary to adjust the K setting.
The Sepam™ unit measures the neutral point H3 voltage V3nt and the H3 residual voltage VrH3Σ to facilitate adjustment of the protection function.

- V3nt is expressed in % of the primary voltage of the neutral point VT's Vntp
- V3ntΣ is expressed in % of the primary voltage of the terminal-side VT's $V_{Ln}p$.

If the primary voltages of the VTs are different, VntH3 must be adapted to the terminal-side primary voltage Vnp using the equation:

VntH3 (%V_{Ln}p) = **V3nt (%Vntp)** x $\frac{\mathbf{Vntp}}{\mathbf{VLnp}}$ (See the table on the following page

Block Diagram



Characteristics

Settings				
Type of Set Point				
Setting range	Adaptive			
Time Delay				
Setting range	0.5 to 300 s			
Accuracy (1)	±2% or from -10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Advanced Settings				
K Set Point				
Setting range	0.1 to 0.2			
Accuracy (1)	±1%			
Resolution	0.01			
Drop out/pick up ratio	105%			
Characteristic Times (1)				
Operation time	typically 140 ms (2)			
Overshoot time	< 65 ms			
Reset time	< 65 ms			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P27TN/64G2_x_101	■	■	
Protection blocking	P27TN/64G2_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Tripping output	P27TN/64G2_x_3	■	■	■
Protection blocked	P27TN/64G2_x_16	■	■	
Instantaneous output	P27TN/64G2_x_23	■	■	

x: unit number.
***(1)** Under reference conditions (IEC 60255-6).*
***(2)** Measured for a variation of 2V3nt to 0 with VrH3Σ = 30%.*

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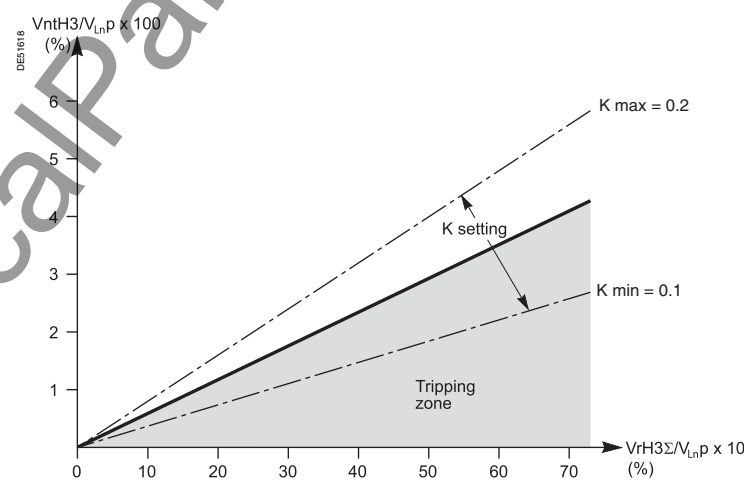
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Third Harmonic Undervoltage
ANSI Code 27TN/64G2
Adaptive Set Point

Curves $\frac{K}{3(1-K)} \times |V3r\Sigma|$

Table with Maximum Values of V3nt (%V_{Ln}p)

K V3rΣ (%V_{Ln}p)	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20
1	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08
2	0.07	0.08	0.09	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17
3	0.11	0.12	0.14	0.15	0.16	0.18	0.19	0.20	0.22	0.23	0.25
4	0.15	0.16	0.18	0.20	0.22	0.24	0.25	0.27	0.29	0.31	0.33
5	0.19	0.21	0.23	0.25	0.27	0.29	0.32	0.34	0.37	0.39	0.42
6	0.22	0.25	0.27	0.30	0.33	0.35	0.38	0.41	0.44	0.47	0.50
7	0.26	0.29	0.32	0.35	0.38	0.41	0.44	0.48	0.51	0.55	0.58
8	0.30	0.33	0.36	0.40	0.43	0.47	0.51	0.55	0.59	0.53	0.67
9	0.33	0.37	0.41	0.45	0.49	0.53	0.57	0.61	0.66	0.70	0.75
10	0.37	0.41	0.45	0.50	0.54	0.59	0.63	0.68	0.73	0.78	0.83
15	0.56	0.62	0.68	0.75	0.81	0.88	0.95	1.02	1.10	1.17	1.25
20	0.74	0.82	0.91	1.00	1.09	1.18	1.27	1.37	1.46	1.56	1.67
25	0.93	1.03	1.14	1.25	1.36	1.47	1.59	1.71	1.83	1.95	2.08
30	1.11	1.24	1.36	1.49	1.63	1.76	1.90	2.05	2.20	2.35	2.50
40	1.48	1.65	1.82	1.99	2.17	2.35	2.54	2.73	2.93	3.13	3.33
50	1.85	2.06	2.27	2.49	2.71	2.94	3.17	3.41	3.66	3.91	4.17
60	2.22	2.47	2.73	2.99	3.26	3.53	3.81	4.10	4.39	4.69	4.10
70	2.59	2.88	3.18	3.49	3.80	4.12	4.44	4.78	5.12	5.47	5.83
80	2.96	3.30	3.64	3.98	4.34	4.71	5.08	5.46	5.85	6.26	6.67
90	3.33	3.71	4.09	4.48	4.88	5.29	5.71	6.14	6.59	7.04	7.50



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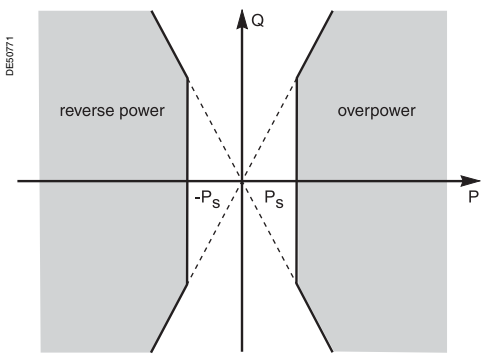
Directional Active Overpower
ANSI Code 32P

Protection against reverse power and overloads.

Description

Two-way protection based on calculated active power, for the following applications:

- active overpower protection to detect overloads and allow load shedding
- reverse active power protection:
  - against generators running like motors when the generators draw active power
  - against motors running like generators when the motors supply active power.



Operating zone

This protection function enables if the active power flowing in either direction (supplied or drawn) is greater than set point Ps. It includes a definite time delay, T, and is based on the two or three-wattmeter method of measurement, depending on the connection conditions:

- Van, Vbn, Vcn, and Ia, Ib, Ic: three wattmeters
- Vab, Vbn, Vcn, and Ia, Ic: two wattmeters
- Vab, Vbc with Vr, and Ia, Ib, Ic: three wattmeters
- Vab, Vbc with Vr and Ia, Ic: two wattmeters
- Vab, Vbc without Vr: two wattmeters
- other cases: protection function unavailable.

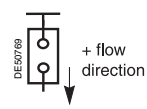
The function is enabled only if the following condition is met:

$P \geq 3.1\% Q$

This provides a high level of sensitivity and high stability in the event of short-circuits.
The power sign is determined according to the general feeder or main parameter, according to the convention:

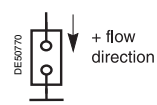
For the feeder circuit:

- power supplied by the bus is positive
- power supplied to the bus is negative

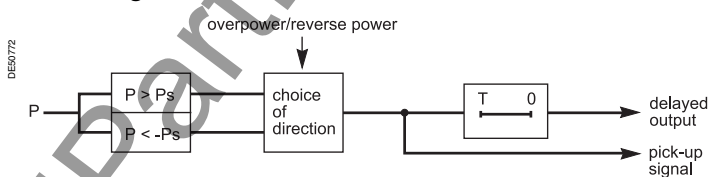


For the Main circuit:

- power supplied to the bus is positive
- power supplied by the busses is negative.



Block Diagram



Characteristics

Settings				
Tripping Direction				
Setting range	Overpower/reverse power			
Ps Set Point				
Setting range	1% of Sn (2) to 120% of Sn (2)			
Accuracy (1)	±0.3% Sn for Ps between 1% Sn and 5% Sn ±5% for Ps between 5% Sn and 40% Sn ±3% for Ps between 40% Sn and 120% Sn			
Resolution	0.1 kW			
Drop out/pick up ratio	93.5% ±5% or > (1 - 0.004 Sn/Ps) x 100%			
Time Delay T				
Setting range	100 ms to 300 s			
Accuracy (1)	±2% or -10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Characteristic Times				
Operation time	< 90 ms at 2 Ps			
Overshoot time	< 40 ms at 2 Ps			
Reset time	< 105 ms at 2 Ps			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P32P_x_101	■	■	
Protection blocking	P32P_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P32P_x_1	■	■	
Delayed output	P32P_x_3	■	■	■
Protection blocked	P32P_x_16	■	■	
Positive active power	P32P_x_19	■	■	
Negative active power	P32P_x_20	■	■	

x: unit number.
***(1)** Under reference conditions (IEC 60255-6).*
***(2)** Sn = $\sqrt{3}$ V_{LL} In.*

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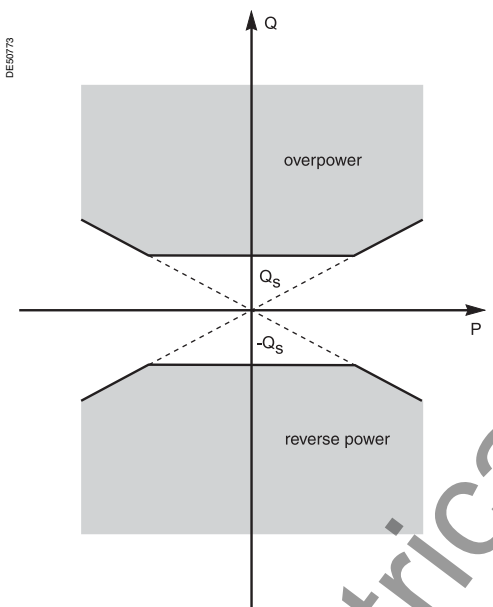
Directional Reactive Overpower
ANSI Code 32Q

Protection against field loss on synchronous machines.

Description

This two-way protection is based on calculated reactive power to detect field loss on synchronous machines:

- reactive overpower protection for motors that consume more reactive power following field loss
- reverse reactive overpower protection for generators that consume reactive power following field loss.



Operating zone.

The protection function picks up if the reactive power (Q) flowing in one direction or the other (supplied or drawn) is greater than the set point for reactive power.
It includes a definite time delay, T, and is based on the two or three-wattmeter method of measurement, depending on the connection conditions:

- Van, Vbn, Vcn, and Ia, Ib, Ic: three wattmeters
- Van, Vbn, Vcn and Ia, Ic: two wattmeters
- Vab, Vbc with Vr, and Ia, Ib, Ic: three wattmeters
- Vab, Vbc with Vr, and Ia, Ic: two wattmeters
- Vab, Vbc without Vr: two wattmeters
- other cases: protection function unavailable.

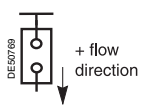
The function is enabled only if the following condition is met:

$Q \geq 3.1\% P$

This provides a high level of sensitivity and high stability in the event of short-circuits.
The power sign is determined according to the general feeder or main parameter, according to the convention:

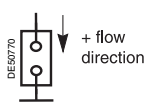
For the feeder circuit:

- power supplied by the busses is positive
- power supplied to the bus is negative

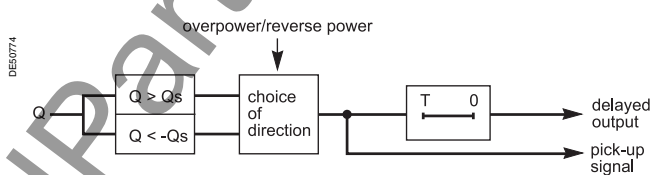


For the Main circuit:

- power supplied to the bus is positive
- power supplied by the busses is negative.



Block Diagram



Characteristics

Settings				
Tripping Direction				
Setting range	Overpower/reverse power			
Qs Set Point				
Setting range	5% of Sn (2) to 120% of Sn (2)			
Accuracy (1)	±5% for Qs between 5% Sn and 40% Sn ±3% for Qs between 40% Sn and 120% Sn			
Resolution	0.1 kW			
Drop out/pick up ratio	93.5%			
Time Delay T				
Setting range	100 ms to 300 s			
Accuracy (1)	±2% or -10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Characteristic Times				
Operation time	< 90 ms			
Overshoot time	< 95 ms			
Reset time	< 90 ms			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P32Q_1_101	■	■	
Protection blocking	P32Q_1_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P32Q_1_1	■	■	
Delayed output	P32Q_1_3	■	■	■
Protection blocked	P32Q_1_16	■	■	
Positive reactive power	P32Q_1_54	■	■	
Negative reactive power	P32Q_1_55	■	■	

(1) *Under reference conditions (IEC 60255-6).*
(2) *Sn = $\sqrt{3}$ V_{LL} In.*

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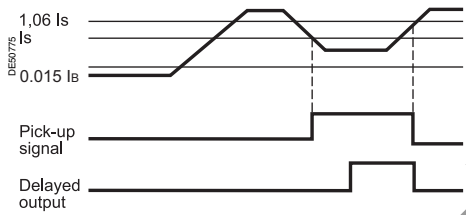
Phase Undercurrent
ANSI Code 37

Protection for pumps.

Description

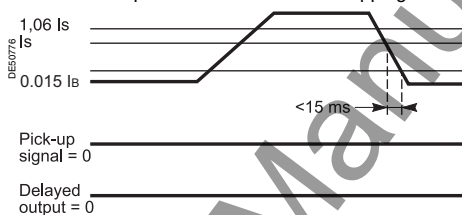
This function protects pumps against the results of a loss of priming by detecting motor no-load operations.

This protection is single-phase. It enables when phase "a" current (Ia) drops below its set point (Is).



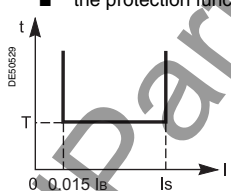
Current sag.

This protection is inactive when the current is less than 1.5% of IN. It is insensitive to current drops due to circuit breaker tripping.



Circuit breaker tripping.

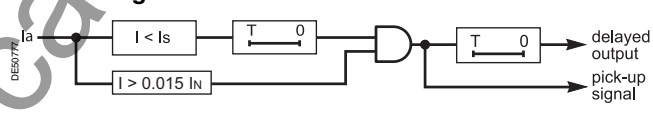
- the protection function includes a definite time delay.



This protection function may be blocked by a logic input.

It can be remotely reset by a remote control command (TC32).

Block Diagram



Characteristics

Settings				
Is Set Point				
Setting range	5% Ib to 100% IB			
Accuracy (1)	±5%			
Resolution	1%			
Drop out/pick up ratio	106%			
Time Delay T				
Setting range	50 ms to 300 s			
Accuracy (1)	±2% or ±25 ms			
Resolution	10 ms or 1 digit			
Characteristic Times				
Operation time	pick-up < 50 ms			
Overshoot time	< 40 ms			
Reset time	< 40 ms			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P37_1_101	■	■	
Protection blocking	P37_1_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P37_1_1	■	■	
Delayed output	P37_1_3	■	■	■
Protection blocked	P37_1_16	■	■	

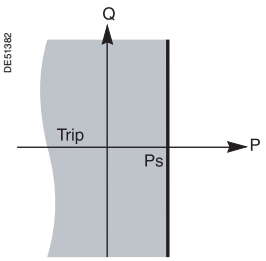
(1) *Under reference conditions (IEC 60255-6).*

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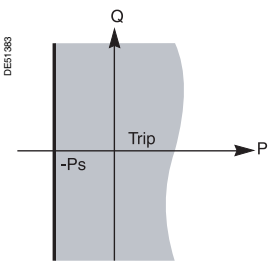
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Directional Active Underpower
ANSI Code 37P

Check on active power flow.



Tripping zone (normal direction).



Tripping zone (reverse direction).

Description

This two-way protection is based on monitoring the calculated active power flows, for two reasons:

1 to adapt the number of parallel sources to fit the network load power demand

2 to create an isolated system in an installation with its own generating unit.

The protection function enables if the active power flowing in one direction or the other (supplied or drawn) is less than the power set point, **Ps**.

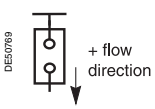
It includes a definite time delay, T,. and is based on the two or three-wattmeter method of measurement, depending on the connection conditions:

- Van, Vbn, Vcn, and Ia, Ib, Ic: three wattmeters
- Van, Vbn, Vcn, and Ia, Ic: two wattmeters
- Vab, Vbc with Vr, and Ia, Ib, Ic: three wattmeters
- Vab, Vbc with Vr, and Ia, Ic: two wattmeters
- Vab, Vbc without Vr: two wattmeters
- other cases: protection function unavailable.

The power sign is determined according to the general feeder or Main parameter, according to the convention:

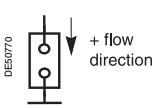
For the feeder circuit:

- power supplied by the bus is positive (normal direction)
- power supplied to the bus is negative

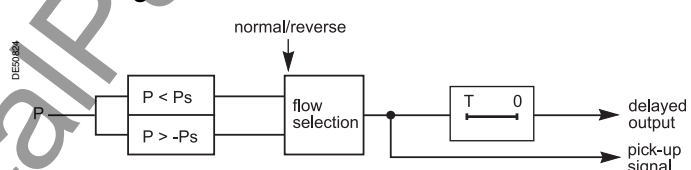


For the main circuit:

- power supplied to the bus is positive (normal direction)
- power supplied by the bus is negative.



Block Diagram



Characteristics

Settings				
Tripping Direction				
Setting range	Normal / reverse			
Ps Set Point				
Setting range	5% of Sn (2) to 100% of Sn (2)			
Accuracy (1)	±5% for Ps between 5% Sn and 40% Sn ±3% for Ps between 40% Sn and 120% Sn			
Resolution	0.1 kW			
Drop out/pick up ratio	106%			
Time Delay T				
Setting range	100 ms to 300 s			
Accuracy (1)	±2% or -10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Characteristic Times				
Operation time	< 120 ms			
Overshoot time	< 65 ms			
Reset time	< 60 ms			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P37P_x_101	■	■	
Protection blocking	P37P_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P37P_x_1	■	■	
Delayed output	P37P_x_3	■	■	■
Protection blocked	P37P_x_16	■	■	

x: unit number.

(1) *Under reference conditions (IEC 60255-6).*

(2) *Sn = $\sqrt{3}.V_{LL}$ In.*

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Temperature Monitoring
ANSI Code 38/49T

Protection against heat rise in equipment by measuring the temperature with a sensor.

Description

This protection detects abnormal heat rise by measuring the temperature inside equipment fitted with sensors:

- transformer: protection of primary and secondary windings
- motor and generator: protection of stator windings and bearings.

This protection function is associated with a Resistance Temperature Detector (RTD), type Pt100 platinum (100 Ω at 0° C or 32° F) or nickel (Ni100 or Ni120), conforming to IEC 60751 and DIN 43760 standards. It activates when the monitored temperature is greater than the temperature set point, Ts. It has two independent set points:

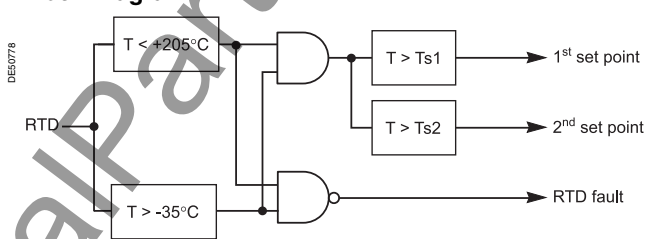
- alarm set point
- tripping set point

When the protection function is activated, it detects whether the RTD is shorted or disconnected:

- **RTD shorting** is detected if the measured temperature is less than –31 °F or –35 °C (measurement displayed "*****")
- **RTD disconnection** is detected if the measured temperature is greater than +205 °C or +401 °F (measurement displayed "-*****").

If an RTD fault is detected, the protection function is blocked and its output relays are set to zero. The "RTD fault" item is also made available in the control matrix and an alarm message is generated specifying the number of the MET1482 module for the faulty RTD.

Block Diagram



Characteristics

Settings				
Alarm and Trip Set Points TS1, TS2				
Setting range	0°C to 180°C		32°F to 356°F	
Accuracy (1)	±1.5°C		±2.7°F	
Resolution	1°C		1°F	
Pick up / drop out difference	3°C		5.4°F	
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P38/49T_x_101	■	■	
Protection blocking	P38/49T_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Protection output	P38/49T_x_3	■	■	■
Alarm	P38/49T_x_10	■	■	■
RTD fault	P38/49T_x_12	■	■	
Protection blocked	P38/49T_x_16	■	■	

x: unit number.
***(1)** Under reference conditions (IEC 60255-6).*

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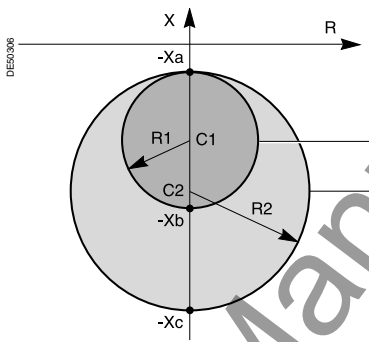
Loss of Field
ANSI Code 40

Protection against loss of field on synchronous motors or generators.

Description

The protection function is made up of two circular tripping characteristics on the impedance plane (R, X). It enables when the positive sequence impedance Z1 enters one of the circular tripping characteristics.

$$\vec{Z}1 = \frac{\vec{V}1}{\vec{I}1}$$



Circular Tripping Characteristics

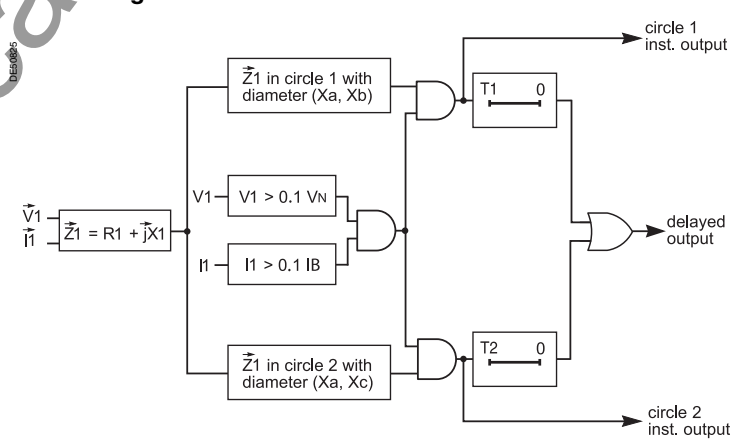
- Case of a generator main or motor feeder

	Circle 1	Circle 2
Center	C1 = -(Xa + Xb)/2	C2 = -(Xa + Xc)/2
Radius	R1 = (Xb - Xa)/2	R2 = (Xc - Xa)/2

- Case of a generator feeder or motor main:
  the tripping characteristics are symmetrical with respect to the R axis

	Circle 1	Circle 2
Center	C1 = (Xa + Xb)/2	C2 = (Xa + Xc)/2
Radius	R1 = (Xb - Xa)/2	R2 = (Xc - Xa)/2

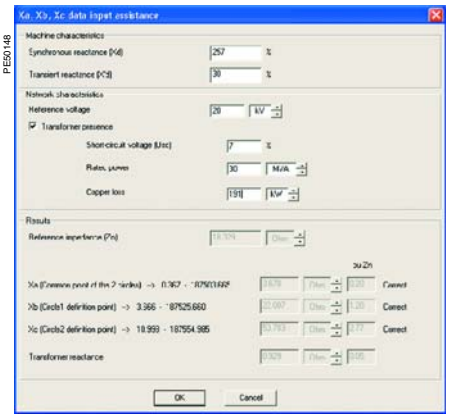
Block Diagram



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Loss of Field
ANSI Code 40



SFT2841 Setting Help

The SFT2841 software includes a setting assistance function to calculate the values of Xa, Xb and Xc according to the electrical characteristics of the machine (and transformer, when applicable).
Data used:

- synchronous machine:
  - synchronous reactance Xd in%
  - transient synchronous reactance X'd in%
- transformer:
  - winding 1 voltage $V_{LL}N1$ in V/kV
  - short-circuit voltage $V_{LL}sc$ in %
  - rated power in kVA/MVA
  - copper losses in kΩ/MΩ.

The proposed settings are circle one with a diameter Z_N if Xd ≥ 200% or a diameter Xd/2 in all other cases, and circle two with a diameter Xd.
The two circles are offset from zero by -X'd/2.
Z_N = the rated machine impedance:

$$Z_N = \frac{V_{LL}1}{\sqrt{3}I_B} \quad .$$

Characteristics

Settings				
Common Point: Xa				
Setting range	0.02V_N/I_B ≤ Xa ≤ 0.20V_N/I_B + 187.5 kΩ or 0.001 Ω			
Accuracy (1)	±5%			
Resolution	1%			
Circle 1: Xb				
Setting range	0.20V_N/I_B ≤ Xa ≤ 1.40V_N/I_B + 187.5 kΩ			
Accuracy (1)	±5%			
Resolution	0.001 Ω or 1 digit			
Drop out/pick up ratio	105% of circle 1 diameter			
Circle 2: Xc				
Setting range	0.60V_N/I_B ≤ Xa ≤ 3V_N/I_B + 187.5 kΩ			
Accuracy (1)	±5%			
Resolution	0.001 Ω or 1 digit			
Drop out/pick up ratio	105% of circle 2 diameter			
T1 Time: Tripping Time Delay Circle 1				
Setting range	50 ms ≤ T ≤ 300 s			
Accuracy (1)	±2% or from –10 ms to +25 ms			
Resolution	10 ms or 1 digit			
T2 time: Tripping Time Delay Circle 2				
Setting range	100 ms ≤ T ≤ 300 s			
Accuracy (1)	±2% or from –10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Characteristic Times (1)				
Operation time	Pick-up < 35 ms from 0 to C1 (typically 25 ms) Pick-up < 35 ms from 0 to C2 (typically 25 ms)			
Overshoot time	< 40 ms			
Reset time	< 50 ms (for T1 = 0)			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P40_1_101	■	■	
Protection blocking	P40_1_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P40_1_1	■	■	
Delayed output	P40_1_3	■	■	■
Protection blocked	P40_1_16	■	■	
Instantaneous protection 1 (circle 1)	P40_1_23	■	■	

***(1)** Under reference conditions (IEC 60255-6).*

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Example 1. Synchronous Generator

Synchronous Generator Data

- S = 3.15 MVA
- $V_{LLN}1$ = 6.3 kV
- Xd = 233%
- X'd = 21%

Protection setting

To set the protection function, it is necessary to calculate the rated generator impedance Z_N:

- **$I_B = S/(\sqrt{3}.V_{LLN}1) = 289$ A**
- **$Z_N = V_{LLN}1/(\sqrt{3}.IB) = 12.586\ \Omega$.**

Generally speaking, circle 1 is set with a diameter Z_N, offset by -X'd/2, and circle 2 is set with a diameter Xd, offset by -X'd/2:

- **$Xa = (X'd(\%)/200)Z_N = 1.321\ \Omega$**
- **$Xb = (X'd(\%)/200 + 1)Z_N = 13.907\ \Omega$**
- **$Xc = (X'd(\%)/200 + X1/100)Z_N = 30.646\ \Omega$.**

The faults detected in circle 1 are violent field-loss faults that must be cleared rapidly. Circle 2 may concern faults other than field-loss faults and its tripping time is longer:

- T1 = 70 ms
- T2 = 500 ms.

Example 2. Generator-Transformer Unit Applications

Synchronous Generator Data

- S_gen = 19 MVA
- $V_{LLN}2$ = 5.5 kV
- Xd = 257%
- X'd= 30%

Transformer Data

- S_tx = 30 MVA
- $V_{LLN}1$ = 20 kV / Vn2 = 5.5 kV
- % Z = 7%
- Pcu = 191 kW (Load Losses (in kW) from TX test report)

Protection Setting

To set the protection function, it is necessary to calculate the rated generator impedance at voltage Vn1:

- **$Z_N=(20kV)^2/19MVA$**
- **$Z_N = 21.05$.**

The transformer impedance at voltage Vn1 is:
Z_tx (in MVA)= %Z/100($kV_{LLN}1$)²/S_tx (in MVA) = 0.933 Ω.
The transformer resistance at voltage $V_{LLN}1$ is:
R_tx = Pcu/1000($V_{LLN}1$/S_tx)² = 0.085 Ω.
The transformer reactance at voltage $V_{LLN}1$ is:

$$\mathbf{Xtx} = \sqrt{\mathbf{Ztx}^2 - \mathbf{Rtx}^2} = 0.929\Omega$$

.

Circle 1 is set with a diameter Zn, offset by -X'd/2 and the transformer reactance.
Circle 2 is set with a diameter Xd, offset by -X'd/2 and the transformer reactance.

- **$Xa = (X'd(\%)/200)Z_N + X_tx = 4.09\ \Omega$**
- **$Xb = (X'd(\%)/200 + 1)Z_N + X_tx = 24.2\ \Omega$**
- **$Xc = (X'd(\%)/200 + X1(\%)/100)Z_N + X_tx = 57.1\ \Omega$.**

The faults detected in circle 1 are violent field-loss faults that must be cleared rapidly. Circle 2 may concern faults other than field-loss faults and its tripping time is longer:

- T1 = 70 ms
- T2 = 500 ms.

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Negative Sequence/ Current Unbalance
ANSI Code 46

Phase unbalance protection for lines and equipment.

Description

This function provides protection against phase unbalance, which is detected by measuring negative sequence current:

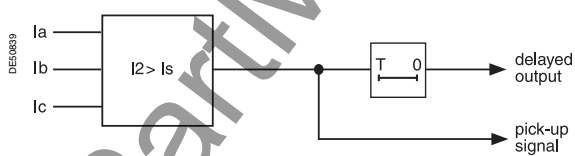
- sensitive protection to detect 2-phase faults at the ends of long lines
- protection of equipment against temperature rise, caused by an unbalanced power supply, phase inversion or loss of phase, and against phase current unbalance.

This function enables if the negative sequence current is greater than the operation set point.

The time delay may be definite time or IDMT, according to a standardized curve, a specially adapted Schneider curve, or an I^2R curve for generator protection.

Tripping Curve
Schneider IDMT
IEC inverse time SIT / A
IEC very inverse time VIT or LTI / B
IEC extremely inverse time EIT / C
IEEE moderately inverse (IEC / D)
IEEE very inverse (IEC / E)
IEEE extremely inverse (IEC / F)
I^2R curve

Block Diagram



Characteristics

Settings		
Measurement Origin		
Setting range		Main channels (I) Additional channels (I')
Tripping Curve		
Setting range		See list above
Is Set Point		
Setting range	definite time	10% to 500% of IB or I'B
	Schneider IDMT	10% to 50% of IB or I'B
	IEC or IEEE IDMT	10% to 100% of IB or I'B
	I^2R curve	3% to 20% of IB or I'B
Accuracy (1)		±5% or ±0.004 In
Resolution		1%
Drop out/pick up ratio		93.5% ±5% or > (1 - 0.005 In/Is) x 100%
Time Delay T		
Setting range	definite time	100 ms ≤ T ≤ 300 s
	IDMT	100 ms ≤ T ≤ 1 s or TMS (2)
Accuracy (1)	definite time	±2% or +25 ms
	IDMT	±5% or +35 ms
Resolution		10 ms or 1 digit
K (I_2^2t Curve Only)		
Setting range		1 to 100
Resolution		1
Characteristic Times		
Operation time		Pick-up < 55 ms at 2 Is
Overshoot time		< 50 ms at 2 Is
Reset time		< 55 ms at 2 Is

Inputs			
Designation	**Syntax**	**Equations**	**Logipam**
Protection reset	P46_x_101	■	■
Protection blocking	P46_x_113	■	■

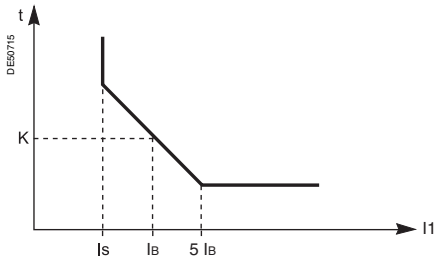
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P46_x_1	■	■	
Delayed output	P46_x_3	■	■	■
Protection blocked	P46_x_16	■	■	

x: unit number.
(1) *Under reference conditions (IEC 60255-6).*
(2) *Setting ranges in TMS (Time Multiplier Setting) mode:*
Inverse (SIT) and IEC SIT/A: 0.034 to 0.336
Very inverse (VIT) and IEC VIT/B: 0.067 to 0.666
Very inverse (LTI) and IEC LTI/B: 0.008 to 0.075
Ext. inverse (EIT) and IEC EIT/C: 0.124 to 1.237
IEEE moderately inverse : 0.415 to 4.142
IEEE very inverse : 0.726 to 7.255
IEEE extremely inverse : 1.231 to 12.30.

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Negative Sequence/ Current Unbalance
ANSI Code 46



I_2^2t curve.

Setting Example for I_2^2t curves

A generator can handle a certain level of negative sequence current on a continuous basis. The continuous level (Is), indicated by the manufacturer, is generally between 5 and 10% of the base current IB.
Typical values are:

Type of Generator		I2 permissible (% Ib)
Salient poles	with amortisseur windings	10
	without amortisseur windings	5
Cylindrical rotors	Indirectly cooled	10
	Sn ≤ 960 MVA	8
	960 MVA < Sn ≤ 1200 MVA	6
	1200 MVA < Sn	5

Reference IEEE C37.102-1987.

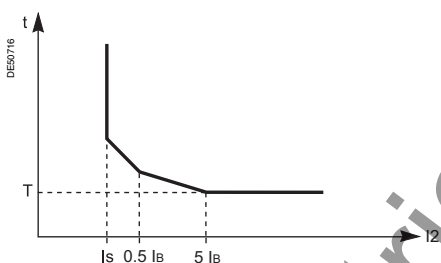
When this current level is exceeded, the generator can handle a negative sequence current I2 for a time td, corresponding to the following equation:

$$td = \frac{K}{\left(\frac{|\vec{I}_2|}{IB}\right)^2}$$

The K value is an adjustable constant that depends on the type of generator, generally between 1 and 40. Typical values of K are:

Type of Generator		K
Salient poles		40
Synchronous condenser		30
Cylindrical rotors	Indirectly cooled	20
	Sn ≤ 800 MVA	10
	800 MVA < Sn ≤ 1600 MVA	10 - 0.00625.(MVA - 800)

Reference IEEE C37.102-1987.



Schneider curve.

Schneider IDMT Curve

For I2 > Is, the time delay depends on the value of I2/IB (IB: base current of the protected equipment defined when the general parameters are set).

T corresponds to the time delay for I2/IB = 5.

The tripping curve is defined according to the following equations:

- for Is/IB ≤ I2/IB ≤ 0.5

$$t = \frac{3.19}{(I2/(IB))^{1.5}} \times T$$

- for 0.5 ≤ I2/IB ≤ 5

$$t = \frac{4.64}{(I2/IB)^{0.96}} \times T$$

- for I2/IB > 0.5

$$t = T$$

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Negative Sequence/ Current Unbalance
ANSI Code 46

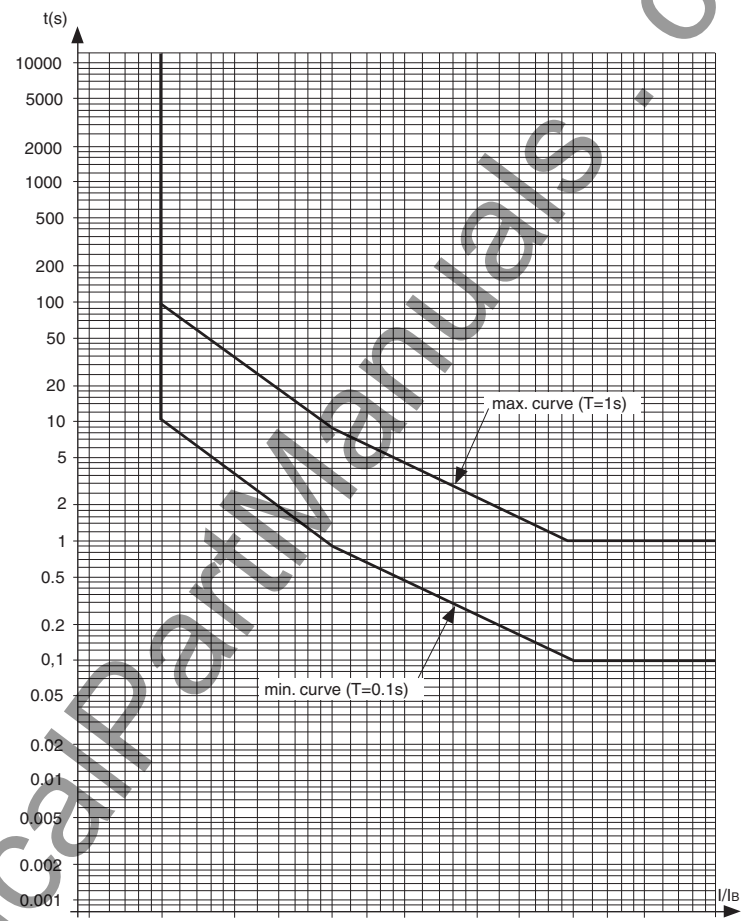
Determination of tripping time for different negative sequence current values for a given Schneider curve

Use the table to find the value of X that corresponds to the required negative sequence current. The tripping time is equal to XT.

Example

given a tripping curve with the setting T = 0.5 s.
What is the tripping time at 0.6 IB?
Use the table to find the value of X that corresponds to 60% of IB.
The table indicates X = 7.55. The tripping time is equal to: 0.5 x 7.55 = 3.755 s.

Schneider IDMT Tripping Curve



I2 (% IB)	10	15	20	25	30	33.33	35	40	45	50	55	57.7	60	65	70	75
X	99.95	54.50	35.44	25.38	19.32	16.51	15.34	12.56	10.53	9.00	8.21	7.84	7.55	7.00	6.52	6.11
I2 (% IB) cont.	80	85	90	95	100	110	120	130	140	150	160	170	180	190	200	210
X cont.	5.74	5.42	5.13	4.87	4.64	4.24	3.90	3.61	3.37	3.15	2.96	2.80	2.65	2.52	2.40	2.29
I2 (% IB) cont.	220	230	240	250	260	270	280	290	300	310	320	330	340	350	360	370
X cont.	2.14	2.10	2.01	1.94	1.86	1.80	1.74	1.68	1.627	1.577	1.53	1.485	1.444	1.404	1.367	1.332
I2 (% IB) cont.	380	390	400	410	420	430	440	450	460	470	480	490	⩾ 500			
X cont.	1.298	1.267	1.236	1.18	1.167	1.154	1.13	1.105	1.082	1.06	1.04	1.02	1			

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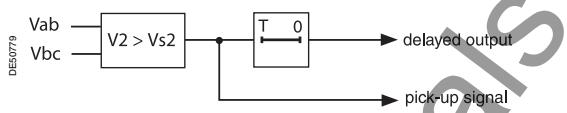
Negative Sequence Overvoltage
ANSI Code 47

Phase unbalance protection.

Description

This function provides protection against phase unbalance resulting from phase inversion, unbalanced supply or distant fault. Overvoltage is detected by measuring negative sequence voltage V2. It does not operate when Sepam™ uses only a single phase voltage. It includes a definite time delay T.

Block Diagram



Characteristics

Settings				
Measurement Origin				
Setting range	Main channels (V_{LL}) / Additional channels (V_{LL}')			
Vs2 Set Point				
Setting range	1% to 50% of V_{LLNp}			
Accuracy (1)	±2% or 0.005 V_{LLNp}			
Resolution	1%			
Drop out/pick up ratio	97% ±1% or > (1 - 0.006 V_{LLNp}/Vs2) x 100%			
Time Delay T				
Setting range	50 ms to 300 s			
Accuracy (1)	±2% or ±25 ms			
Resolution	10 ms or 1 digit			
Characteristic Times				
Operation time	Pick-up < 40 ms at 2 Vs2			
Overshoot time	< 50 ms at 2 Vs2			
Reset time	< 50 ms at 2 Vs2			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P47_x_101	■	■	
Protection blocking	P47_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P47_x_1	■	■	
Delayed output	P47_x_3	■	■	■
Protection blocked	P47_x_16	■	■	

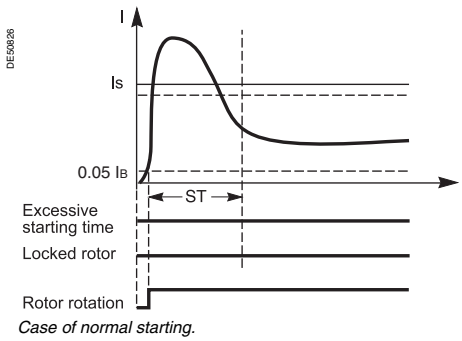
x: unit number.
(1) *Under reference conditions (IEC 60255-6).*

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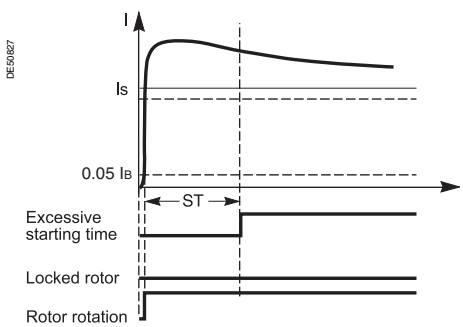
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Excessive Starting Time, Locked Rotor
ANSI Code 48/51LR

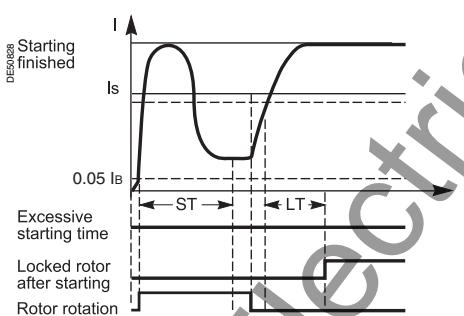
Detection of excessive starting time and locked rotors for motor protection.



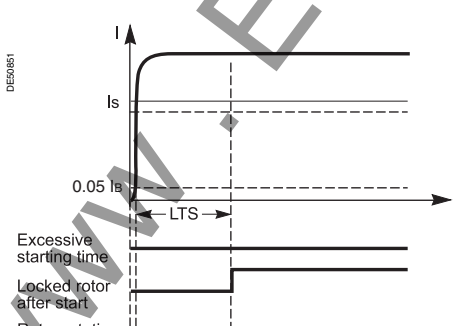
Case of normal starting.



Case of excessive starting time



Case of jammed or stalled rotor



Case of locked rotor at start

Operation

This function is three-phase:

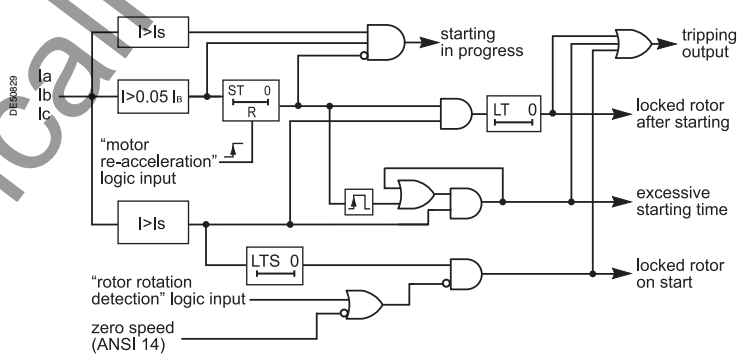
1. **Excessive starting time (ST).** During start sequence, the protection enables when one of the three phase currents is greater than the set point **Is** due to overloads (e.g. conveyor) or insufficient supply voltage
2. **Locked rotor (LT).** At the normal operating rate (after starting) the protection enables when one of the three phase currents is greater than the set point **Is** for a period of time that is longer than the LT time delay of the definite time type.
3. If the rotor is **locked on start (LTS)**: Large motors may have very long starting times (due to inertia) or a reduced voltage supply. This starting time is longer than the permissible rotor blocking time. To protect such a motor, the LTS timer initiates a trip if a start is detected (I > Is), or if the motor speed is zero. For a normal start, the input I23 (zero-speed-switch) disables this protection.

Motor Acceleration

When a motor accelerates, it consumes a level of current in the vicinity of the starting current (> Is) without the current first passing through a value less than 10% of IB. The ST time delay (which corresponds to the normal starting time) can be reinitialised by the logic input "motor re-acceleration."

This will reinitialize the **excessive starting time** protection and set the **locked rotor** protection LT time delay to a low value.

Block Diagram



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Excessive Starting Time, Locked Rotor
ANSI Code 48/51LR

Characteristics

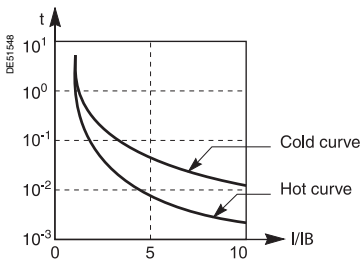
Settings				
Is Set Point				
Setting range		50% to 500% of IB		
Accuracy (1)		±5%		
Resolution		1%		
Drop out/pick up ratio		93%		
Time Delay T				
Setting range	ST	500 ms to 300 s		
	LT	50 ms to 300 s		
	LTS	50 ms to 300 s		
Accuracy (1)		2% or ±25 ms		
Resolution		10 ms		
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P48/51LR_1_101	■	■	
Motor re-acceleration	P48/51LR_1_102	■	■	
Protection blocking	P48/51LR_1_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Protection output	P48/51LR_1_3	■	■	■
Locked rotor	P48/51LR_1_13	■	■	■
Excessive starting time	P48/51LR_1_14	■	■	■
Locked rotor at start-up	P48/51LR_1_15	■	■	■
Protection blocked	P48/51LR_1_16	■	■	
Starting in progress	P48/51LR_1_22	■	■	

(1) *Under reference conditions (IEC 60255-6).*

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Thermal Overload for Cables
ANSI Code 49RMS

Protection of cables against thermal damage caused by overloads.



Tripping curves.

Description

This protection function is used to protect cables against overloads, based on measurement of the current drawn.
The current measured by the thermal protection is an RMS 3-phase current, which factors harmonics up to the 13th level. The highest current of the three phases is used to calculate for heat rise:

$$Iph = max(Ia, Ib, Ic).$$

The calculated heat rise, proportional to the square of the current drawn, depends on the current drawn and the previous temperature status. Under steady-state conditions, it is equal to:

$$E = \left(\frac{Iph}{IB}\right)^2 \times 100 \quad \text{in\%}$$

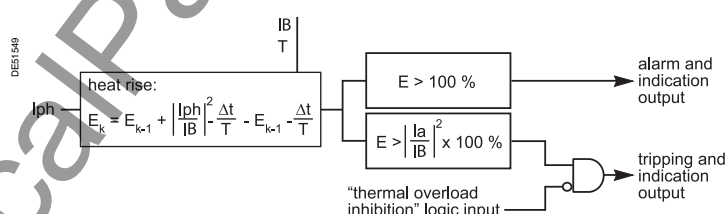
The protection function issues the trip command when the phase current is greater than the permissible current for the cable. The value of the base current IB must absolutely be less than the permissible current Ia. By default, we use IB ≈ Ia/1.4.
The protection tripping time is set by the time constant T.

Cold curve: $\frac{t}{T} = In\left(\frac{\left(\frac{I}{IB}\right)^2}{\left(\frac{I}{IB}\right)^2 - \left(\frac{Ia}{IB}\right)^2}\right)$ where In: natural logarithm.

Hot curve: $\frac{t}{T} = In\left(\frac{\left(\frac{I}{IB}\right)^2 - 1}{\left(\frac{I}{IB}\right)^2 - \left(\frac{Ia}{IB}\right)^2}\right)$ where In: natural logarithm.

The present heat rise is saved in the event of an auxiliary power failure.

Block Diagram



User Information

The following information is available for the user:
- heat rise
- time before tripping (with constant current).

Characteristics

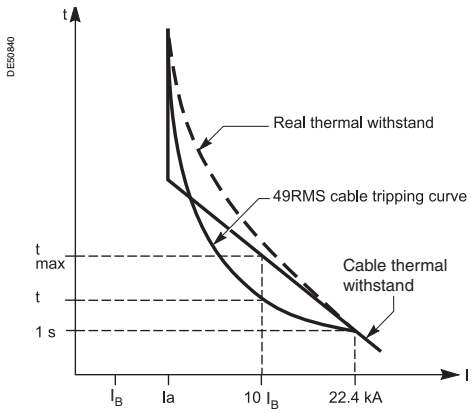
Settings				
Permissible Current Ia				
Setting range	< 1 to 1.73 IB			
Accuracy (1)	±2%			
Resolution	1 A			
Time Constant T				
Setting range	1 min. to 600 min.			
Resolution	1 min.			
Characteristic Times (1)				
Operation time accuracy	±2% or ±1 s			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P49RMS_1_101	■	■	
Protection blocking	P49RMS_1_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Delayed output	P49RMS_1_3	■	■	■
Alarm	P49RMS_1_10	■	■	■
Block closing	P49RMS_1_11	■	■	■
Protection blocked	P49RMS_1_16	■	■	
Hot state	P49RMS_1_18	■	■	
Block thermal overload	P49RMS_1_32	■	■	

***(1)** Under reference conditions (IEC 60255-6).*

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Thermal Overload for Cables
ANSI Code 49RMS



Example

Consider a copper cable, 350MCM, with a permissible current Ia = 485 A and a 1- second thermal withstand Ith_1 s = 22.4 kA.

The thermal time constant of a cable depends on its installation method. Typical time-constant values are between 10 and 60 minutes. For buried cables, the time constant is between 20 and 60 minutes, for non-buried cables, it is between 10 and 40 minutes.

For the cable in question, the selected values are T = 30 minutes and IB = 350 A.

Check compatibility between the 49RMS curve and the cable thermal withstand curve.

Conditions are correct at 10 IB.

In the range of currents close to the permissible current, the 1-second thermal withstand is used to estimate maximum thermal withstand for the cable, assuming there are no heat exchanges. The maximum tripping time is calculated as:

$$\mathbf{I^2 \times tmax = constant = (Ith_1\ s)^2 \times 1}.$$

For the cable in question and at 10 IB:

$$\mathbf{tmax = (Ith_1\ s/\ 10Ib)^2 = (22400 / 3500)^2 = 41\ s}.$$

For I = 10 IB = 3500 A and Ia/IB = 1.38, the value of k in the cold tripping curve table is k ≈ 0.0184.

The tripping time at 10 IB is therefore:

$$\mathbf{t = k \times T \times 60 = 0.0184 \times 30 \times 60 = 35.6s < tmax}.$$

For a 10 IB fault occuring after a rated operation phase, with 100% heat rise, the value of k is : k ≈ 0.0097.

The tripping time is:

$$\mathbf{t = k \times T \times 60 = 0.0097 \times 30 \times 60 = 17.5\ s}$$

Coordination Check

Coordination between 49RMS for the cable and the downstream protection curves (including 49RMS Protection Functions) must be checked to avoid any risk of nuisance tripping.

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Thermal Overload for Cables
ANSI Code 49RMS
Trip Curves

Curves for Initial Heat Rise = 0%(1)

Iph/IB Ia/IB	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30
0.50	1.7513	1.1856	0.8958	0.7138	0.5878	0.4953	0.4247	0.3691	0.3244	0.2877	0.2572	0.2314	0.2095	0.1907	0.1744	0.1601
0.55		1.8343	1.2587	0.9606	0.7717	0.6399	0.5425	0.4675	0.4082	0.3603	0.3207	0.2877	0.2597	0.2358	0.2152	0.1972
0.60			1.9110	1.3269	1.0217	0.8267	0.6897	0.5878	0.5090	0.4463	0.3953	0.3531	0.3178	0.2877	0.2619	0.2396
0.65				1.9823	1.3907	1.0793	0.8789	0.7373	0.6314	0.5491	0.4832	0.4295	0.3849	0.3473	0.3153	0.2877
0.70					2.0488	1.4508	1.1338	0.9287	0.7829	0.6733	0.5878	0.5191	0.4629	0.4159	0.3763	0.3424
0.75						2.1112	1.5075	1.1856	0.9762	0.8267	0.7138	0.6253	0.5540	0.4953	0.4463	0.4047
0.80							2.1699	1.5612	1.2349	1.0217	0.8687	0.7527	0.6615	0.5878	0.5270	0.4759
0.85								2.2254	1.6122	1.2819	1.0652	0.9091	0.7904	0.6966	0.6206	0.5578
0.90									2.2780	1.6607	1.3269	1.1069	0.9480	0.8267	0.7306	0.6526
0.95										2.3279	1.7070	1.3699	1.1470	0.9855	0.8618	0.7636
1.00											2.3755	1.7513	1.4112	1.1856	1.0217	0.8958
1.05												2.4209	1.7937	1.4508	1.2228	1.0566
1.10													2.4643	1.8343	1.4890	1.2587
1.15														2.5060	1.8734	1.5258
1.20															2.5459	1.9110
1.25																2.5844

Iph/IB Ia/IB	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00	2.20	2.40
0.50	0.1475	0.1365	0.1266	0.1178	0.1099	0.1028	0.0963	0.0905	0.0852	0.0803	0.0759	0.0718	0.0680	0.0645	0.0530	0.0444
0.55	0.1815	0.1676	0.1553	0.1444	0.1346	0.1258	0.1178	0.1106	0.1040	0.0980	0.0925	0.0875	0.0829	0.0786	0.0645	0.0539
0.60	0.2201	0.2029	0.1878	0.1744	0.1623	0.1516	0.1418	0.1330	0.1251	0.1178	0.1111	0.1051	0.0995	0.0943	0.0773	0.0645
0.65	0.2637	0.2428	0.2243	0.2080	0.1934	0.1804	0.1686	0.1581	0.1485	0.1397	0.1318	0.1245	0.1178	0.1116	0.0913	0.0762
0.70	0.3132	0.2877	0.2653	0.2456	0.2281	0.2125	0.1984	0.1858	0.1744	0.1640	0.1545	0.1459	0.1380	0.1307	0.1067	0.0889
0.75	0.3691	0.3383	0.3113	0.2877	0.2667	0.2481	0.2314	0.2165	0.2029	0.1907	0.1796	0.1694	0.1601	0.1516	0.1236	0.1028
0.80	0.4326	0.3953	0.3630	0.3347	0.3098	0.2877	0.2680	0.2503	0.2344	0.2201	0.2070	0.1952	0.1843	0.1744	0.1418	0.1178
0.85	0.5049	0.4599	0.4210	0.3873	0.3577	0.3316	0.3084	0.2877	0.2691	0.2523	0.2371	0.2233	0.2107	0.1992	0.1617	0.1340
0.90	0.5878	0.5332	0.4866	0.4463	0.4112	0.3804	0.3531	0.3289	0.3072	0.2877	0.2701	0.2541	0.2396	0.2263	0.1832	0.1516
0.95	0.6836	0.6170	0.5608	0.5127	0.4710	0.4347	0.4027	0.3744	0.3491	0.3265	0.3061	0.2877	0.2710	0.2557	0.2064	0.1704
1.00	0.7956	0.7138	0.6456	0.5878	0.5383	0.4953	0.4578	0.4247	0.3953	0.3691	0.3456	0.3244	0.3052	0.2877	0.2314	0.1907
1.05	0.9287	0.8267	0.7431	0.6733	0.6142	0.5633	0.5191	0.4804	0.4463	0.4159	0.3888	0.3644	0.3424	0.3225	0.2585	0.2125
1.10	1.0904	0.9606	0.8569	0.7717	0.7005	0.6399	0.5878	0.5425	0.5027	0.4675	0.4363	0.4082	0.3830	0.3603	0.2877	0.2358
1.15	1.2934	1.1231	0.9916	0.8862	0.7996	0.7269	0.6651	0.6118	0.5654	0.5246	0.4884	0.4563	0.4274	0.4014	0.3192	0.2609
1.20	1.5612	1.3269	1.1549	1.0217	0.9147	0.8267	0.7527	0.6897	0.6353	0.5878	0.5460	0.5090	0.4759	0.4463	0.3531	0.2877
1.25	1.9473	1.5955	1.3593	1.1856	1.0509	0.9425	0.8531	0.7780	0.7138	0.6583	0.6098	0.5671	0.5292	0.4953	0.3898	0.3165
1.30	2.6214	1.9823	1.6286	1.3907	1.2155	1.0793	0.9696	0.8789	0.8026	0.7373	0.6808	0.6314	0.5878	0.5491	0.4295	0.3473
1.35		2.6571	2.0161	1.6607	1.4212	1.2445	1.1069	0.9959	0.9041	0.8267	0.7604	0.7029	0.6526	0.6081	0.4725	0.3804
1.40			2.6915	2.0488	1.6918	1.4508	1.2727	1.1338	1.0217	0.9287	0.8502	0.7829	0.7245	0.6733	0.5191	0.4159
1.45				2.7249	2.0805	1.7220	1.4796	1.3001	1.1601	1.0467	0.9527	0.8733	0.8050	0.7458	0.5699	0.4542
1.50					2.7571	2.1112	1.7513	1.5075	1.3269	1.1856	1.0712	0.9762	0.8958	0.8267	0.6253	0.4953
1.55						2.7883	2.1410	1.7797	1.5347	1.3529	1.2106	1.0952	0.9992	0.9179	0.6859	0.5397
1.60							2.8186	2.1699	1.8074	1.5612	1.3783	1.2349	1.1185	1.0217	0.7527	0.5878
1.65								2.8480	2.1980	1.8343	1.5870	1.4031	1.2587	1.1414	0.8267	0.6399
1.70									2.8766	2.2254	1.8605	1.6122	1.4272	1.2819	0.9091	0.6966

(1) Ia is the permissible current for the cable.

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Thermal Overload for Cables
ANSI Code 49RMS
Trip Curves

Curves for Initial Heat Rise = 0%(1)

Iph/IB Ia/IB	2.60	2.80	3.00	3.20	3.40	3.60	3.80	4.00	4.20	4.40	4.60	4.80	5.00	5.50	6.00	6.50
0,50	0.0377	0.0324	0.0282	0.0247	0.0219	0.0195	0.0175	0.0157	0.0143	0.0130	0.0119	0.0109	0.0101	0.0083	0.0070	0.0059
0.55	0.0458	0.0393	0.0342	0.0300	0.0265	0.0236	0.0212	0.0191	0.0173	0.0157	0.0144	0.0132	0.0122	0.0101	0.0084	0.0072
0.60	0.0547	0.0470	0.0408	0.0358	0.0316	0.0282	0.0252	0.0228	0.0206	0.0188	0.0172	0.0157	0.0145	0.0120	0.0101	0.0086
0.65	0.0645	0.0554	0.0481	0.0421	0.0372	0.0331	0.0297	0.0268	0.0242	0.0221	0.0202	0.0185	0.0170	0.0141	0.0118	0.0101
0.70	0.0752	0.0645	0.0560	0.0490	0.0433	0.0385	0.0345	0.0311	0.0282	0.0256	0.0234	0.0215	0.0198	0.0163	0.0137	0.0117
0.75	0.0869	0.0745	0.0645	0.0565	0.0499	0.0444	0.0397	0.0358	0.0324	0.0295	0.0269	0.0247	0.0228	0.0188	0.0157	0.0134
0.80	0.0995	0.0852	0.0738	0.0645	0.0570	0.0506	0.0453	0.0408	0.0370	0.0336	0.0307	0.0282	0.0259	0.0214	0.0179	0.0153
0.85	0.1130	0.0967	0.0837	0.0732	0.0645	0.0574	0.0513	0.0462	0.0418	0.0380	0.0347	0.0319	0.0293	0.0242	0.0203	0.0172
0.90	0.1276	0.1091	0.0943	0.0824	0.0726	0.0645	0.0577	0.0520	0.0470	0.0427	0.0390	0.0358	0.0329	0.0271	0.0228	0.0194
0.95	0.1433	0.1223	0.1057	0.0923	0.0813	0.0722	0.0645	0.0581	0.0525	0.0477	0.0436	0.0400	0.0368	0.0303	0.0254	0.0216
1.00	0.1601	0.1365	0.1178	0.1028	0.0905	0.0803	0.0718	0.0645	0.0584	0.0530	0.0484	0.0444	0.0408	0.0336	0.0282	0.0240
1.05	0.1780	0.1516	0.1307	0.1139	0.1002	0.0889	0.0794	0.0714	0.0645	0.0586	0.0535	0.0490	0.0451	0.0371	0.0311	0.0264
1.10	0.1972	0.1676	0.1444	0.1258	0.1106	0.0980	0.0875	0.0786	0.0711	0.0645	0.0589	0.0539	0.0496	0.0408	0.0342	0.0291
1.15	0.2177	0.1848	0.1589	0.1383	0.1215	0.1076	0.0961	0.0863	0.0779	0.0708	0.0645	0.0591	0.0544	0.0447	0.0374	0.0318
1.20	0.2396	0.2029	0.1744	0.1516	0.1330	0.1178	0.1051	0.0943	0.0852	0.0773	0.0705	0.0645	0.0593	0.0488	0.0408	0.0347
1.25	0.2629	0.2223	0.1907	0.1656	0.1452	0.1285	0.1145	0.1028	0.0927	0.0842	0.0767	0.0702	0.0645	0.0530	0.0444	0.0377
1.30	0.2877	0.2428	0.2080	0.1804	0.1581	0.1397	0.1245	0.1116	0.1007	0.0913	0.0832	0.0762	0.0700	0.0575	0.0481	0.0408
1.35	0.3142	0.2646	0.2263	0.1960	0.1716	0.1516	0.1349	0.1209	0.1091	0.0989	0.0901	0.0824	0.0757	0.0621	0.0520	0.0441
1.40	0.3424	0.2877	0.2456	0.2125	0.1858	0.1640	0.1459	0.1307	0.1178	0.1067	0.0972	0.0889	0.0816	0.0670	0.0560	0.0475
1.45	0.3725	0.3122	0.2661	0.2298	0.2007	0.1770	0.1574	0.1409	0.1269	0.1150	0.1047	0.0957	0.0878	0.0720	0.0602	0.0510
1.50	0.4047	0.3383	0.2877	0.2481	0.2165	0.1907	0.1694	0.1516	0.1365	0.1236	0.1124	0.1028	0.0943	0.0773	0.0645	0.0547
1.55	0.4391	0.3659	0.3105	0.2674	0.2330	0.2050	0.1820	0.1627	0.1464	0.1325	0.1205	0.1101	0.1010	0.0828	0.0691	0.0585
1.60	0.4759	0.3953	0.3347	0.2877	0.2503	0.2201	0.1952	0.1744	0.1568	0.1418	0.1290	0.1178	0.1080	0.0884	0.0738	0.0625
1.65	0.5154	0.4266	0.3603	0.3091	0.2686	0.2358	0.2089	0.1865	0.1676	0.1516	0.1377	0.1258	0.1153	0.0943	0.0786	0.0666
1.70	0.5578	0.4599	0.3873	0.3316	0.2877	0.2523	0.2233	0.1992	0.1789	0.1617	0.1469	0.1340	0.1229	0.1004	0.0837	0.0709

Iph/IB Ia/IB	7.00	7.50	8.00	8.50	9.00	9.50	10.00	12.50	15.00	17.50	20.00
0.50	0.0051	0.0045	0.0039	0.0035	0.0031	0.0028	0.0025	0.0016	0.0011	0.0008	0.0006
0.55	0.0062	0.0054	0.0047	0.0042	0.0037	0.0034	0.0030	0.0019	0.0013	0.0010	0.0008
0.60	0.0074	0.0064	0.0056	0.0050	0.0045	0.0040	0.0036	0.0023	0.0016	0.0012	0.0009
0.65	0.0087	0.0075	0.0066	0.0059	0.0052	0.0047	0.0042	0.0027	0.0019	0.0014	0.0011
0.70	0.0101	0.0087	0.0077	0.0068	0.0061	0.0054	0.0049	0.0031	0.0022	0.0016	0.0012
0.75	0.0115	0.0101	0.0088	0.0078	0.0070	0.0063	0.0056	0.0036	0.0025	0.0018	0.0014
0.80	0.0131	0.0114	0.0101	0.0089	0.0079	0.0071	0.0064	0.0041	0.0028	0.0021	0.0016
0.85	0.0149	0.0129	0.0114	0.0101	0.0090	0.0080	0.0073	0.0046	0.0032	0.0024	0.0018
0.90	0.0167	0.0145	0.0127	0.0113	0.0101	0.0090	0.0081	0.0052	0.0036	0.0026	0.0020
0.95	0.0186	0.0162	0.0142	0.0126	0.0112	0.0101	0.0091	0.0058	0.0040	0.0030	0.0023
1.00	0.0206	0.0179	0.0157	0.0139	0.0124	0.0111	0.0101	0.0064	0.0045	0.0033	0.0025
1.05	0.0228	0.0198	0.0174	0.0154	0.0137	0.0123	0.0111	0.0071	0.0049	0.0036	0.0028
1.10	0.0250	0.0217	0.0191	0.0169	0.0151	0.0135	0.0122	0.0078	0.0054	0.0040	0.0030
1.15	0.0274	0.0238	0.0209	0.0185	0.0165	0.0148	0.0133	0.0085	0.0059	0.0043	0.0033
1.20	0.0298	0.0259	0.0228	0.0201	0.0179	0.0161	0.0145	0.0093	0.0064	0.0047	0.0036
1.25	0.0324	0.0282	0.0247	0.0219	0.0195	0.0175	0.0157	0.0101	0.0070	0.0051	0.0039
1.30	0.0351	0.0305	0.0268	0.0237	0.0211	0.0189	0.0170	0.0109	0.0075	0.0055	0.0042
1.35	0.0379	0.0329	0.0289	0.0255	0.0228	0.0204	0.0184	0.0117	0.0081	0.0060	0.0046
1.40	0.0408	0.0355	0.0311	0.0275	0.0245	0.0220	0.0198	0.0126	0.0087	0.0064	0.0049
1.45	0.0439	0.0381	0.0334	0.0295	0.0263	0.0236	0.0212	0.0135	0.0094	0.0069	0.0053
1.50	0.0470	0.0408	0.0358	0.0316	0.0282	0.0252	0.0228	0.0145	0.0101	0.0074	0.0056
1.55	0.0503	0.0437	0.0383	0.0338	0.0301	0.0270	0.0243	0.0155	0.0107	0.0079	0.0060
1.60	0.0537	0.0466	0.0408	0.0361	0.0321	0.0288	0.0259	0.0165	0.0114	0.0084	0.0064
1.65	0.0572	0.0496	0.0435	0.0384	0.0342	0.0306	0.0276	0.0176	0.0122	0.0089	0.0068
1.70	0.0608	0.0527	0.0462	0.0408	0.0363	0.0325	0.0293	0.0187	0.0129	0.0095	0.0073

(1) Ia is the permissible current for the cable.

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Thermal Overload for Cables
ANSI Code 49RMS
Trip Curves

Curves for Initial Heat Rise = 100%

Iph/IB Ia/IB	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	1.85	1.90
1.10	1.0531	0.6487	0.4673	0.3629	0.2948	0.2469	0.2113	0.1839	0.1622	0.1446	0.1300	0.1178	0.1074	0.0984	0.0907	0.0839
1.15		1.3203	0.8518	0.6300	0.4977	0.4094	0.3460	0.2984	0.2613	0.2316	0.2073	0.1871	0.1700	0.1555	0.1429	0.1319
1.20			1.5243	1.0152	0.7656	0.6131	0.5093	0.4339	0.3765	0.3314	0.2950	0.2650	0.2400	0.2187	0.2004	0.1846
1.25				1.6886	1.1517	0.8817	0.7138	0.5978	0.5126	0.4472	0.3954	0.3533	0.3185	0.2892	0.2642	0.2427
1.30					1.8258	1.2685	0.9831	0.8030	0.6772	0.5840	0.5118	0.4543	0.4073	0.3682	0.3352	0.3070
1.35						1.9433	1.3705	1.0729	0.8830	0.7492	0.6491	0.5713	0.5088	0.4576	0.4148	0.3785
1.40							2.0460	1.4610	1.1536	0.9555	0.8149	0.7092	0.6263	0.5596	0.5047	0.4586
1.45								2.1371	1.5422	1.2267	1.0218	0.8755	0.7647	0.6776	0.6072	0.5489
1.50									2.2188	1.6159	1.2935	1.0829	0.9316	0.8165	0.7257	0.6519
1.55										2.2930	1.6832	1.3550	1.1394	0.9838	0.8650	0.7708
1.60											2.3609	1.7452	1.4121	1.1921	1.0327	0.9106
1.65												2.4233	1.8027	1.4652	1.2415	1.0787
1.70													2.4813	1.8563	1.5150	1.2879

Iph/IB Ia/IB	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	4.80
1.10	0.0779	0.0726	0.0562	0.0451	0.0371	0.0312	0.0266	0.0230	0.0201	0.0177	0.0157	0.0141	0.0127	0.0115	0.0105	0.0096
1.15	0.1223	0.1137	0.0877	0.0702	0.0576	0.0483	0.0411	0.0355	0.0310	0.0273	0.0243	0.0217	0.0196	0.0177	0.0161	0.0147
1.20	0.1708	0.1586	0.1217	0.0970	0.0795	0.0665	0.0566	0.0488	0.0426	0.0375	0.0333	0.0298	0.0268	0.0243	0.0221	0.0202
1.25	0.2240	0.2076	0.1584	0.1258	0.1028	0.0858	0.0729	0.0628	0.0547	0.0482	0.0428	0.0382	0.0344	0.0311	0.0283	0.0259
1.30	0.2826	0.2614	0.1981	0.1566	0.1276	0.1063	0.0902	0.0776	0.0676	0.0594	0.0527	0.0471	0.0424	0.0383	0.0348	0.0318
1.35	0.3474	0.3204	0.2410	0.1897	0.1541	0.1281	0.1085	0.0932	0.0811	0.0713	0.0632	0.0564	0.0507	0.0458	0.0417	0.0380
1.40	0.4194	0.3857	0.2877	0.2253	0.1823	0.1512	0.1278	0.1097	0.0953	0.0837	0.0741	0.0661	0.0594	0.0537	0.0488	0.0445
1.45	0.4999	0.4581	0.3384	0.2635	0.2125	0.1758	0.1483	0.1271	0.1103	0.0967	0.0856	0.0763	0.0686	0.0619	0.0562	0.0513
1.50	0.5907	0.5390	0.3938	0.3046	0.2446	0.2018	0.1699	0.1454	0.1260	0.1104	0.0976	0.0870	0.0781	0.0705	0.0640	0.0584
1.55	0.6940	0.6302	0.4545	0.3491	0.2790	0.2295	0.1928	0.1646	0.1425	0.1247	0.1102	0.0982	0.0881	0.0795	0.0721	0.0657
1.60	0.8134	0.7340	0.5213	0.3971	0.3159	0.2589	0.2169	0.1849	0.1599	0.1398	0.1234	0.1098	0.0984	0.0888	0.0805	0.0734
1.65	0.9536	0.8537	0.5952	0.4492	0.3553	0.2901	0.2425	0.2063	0.1781	0.1555	0.1372	0.1220	0.1093	0.0985	0.0893	0.0814
1.70	1.1221	0.9943	0.6776	0.5059	0.3977	0.3234	0.2695	0.2288	0.1972	0.1720	0.1516	0.1347	0.1206	0.1086	0.0984	0.0897

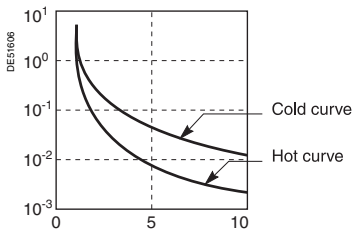
Iph/IB Ia/IB	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	12.50	15.00	17.50	20.00
1.10	0.0088	0.0072	0.0060	0.0051	0.0044	0.0038	0.0033	0.0030	0.0026	0.0024	0.0021	0.0014	0.0009	0.0007	0.0005
1.15	0.0135	0.0111	0.0093	0.0078	0.0067	0.0059	0.0051	0.0045	0.0040	0.0036	0.0033	0.0021	0.0014	0.0011	0.0008
1.20	0.0185	0.0152	0.0127	0.0107	0.0092	0.0080	0.0070	0.0062	0.0055	0.0049	0.0045	0.0028	0.0020	0.0014	0.0011
1.25	0.0237	0.0194	0.0162	0.0137	0.0118	0.0102	0.0090	0.0079	0.0071	0.0063	0.0057	0.0036	0.0025	0.0018	0.0014
1.30	0.0292	0.0239	0.0199	0.0169	0.0145	0.0126	0.0110	0.0097	0.0087	0.0078	0.0070	0.0045	0.0031	0.0023	0.0017
1.35	0.0349	0.0285	0.0238	0.0201	0.0173	0.0150	0.0131	0.0116	0.0103	0.0093	0.0083	0.0053	0.0037	0.0027	0.0021
1.40	0.0408	0.0334	0.0278	0.0235	0.0202	0.0175	0.0154	0.0136	0.0121	0.0108	0.0097	0.0062	0.0043	0.0031	0.0024
1.45	0.0470	0.0384	0.0320	0.0271	0.0232	0.0202	0.0177	0.0156	0.0139	0.0124	0.0112	0.0071	0.0049	0.0036	0.0028
1.50	0.0535	0.0437	0.0364	0.0308	0.0264	0.0229	0.0200	0.0177	0.0157	0.0141	0.0127	0.0081	0.0056	0.0041	0.0031
1.55	0.0602	0.0491	0.0409	0.0346	0.0297	0.0257	0.0225	0.0199	0.0177	0.0158	0.0143	0.0091	0.0063	0.0046	0.0035
1.60	0.0672	0.0548	0.0456	0.0386	0.0330	0.0286	0.0251	0.0221	0.0197	0.0176	0.0159	0.0101	0.0070	0.0051	0.0039
1.65	0.0745	0.0607	0.0505	0.0427	0.0365	0.0317	0.0277	0.0245	0.0218	0.0195	0.0176	0.0112	0.0077	0.0057	0.0043
1.70	0.0820	0.0668	0.0555	0.0469	0.0402	0.0348	0.0305	0.0269	0.0239	0.0214	0.0193	0.0122	0.0085	0.0062	0.0047

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Thermal Overload for Capacitors
ANSI Code 49RMS

Protection of equipment against thermal damage due to overloads.



Tripping curves.

Description

This function is used to protect capacitor banks with or without harmonic filters against overloads, based on the measurement of the current drawn.

The current measured by the thermal protection is an RMS 3-phase current that factors harmonics up to the13th.

The highest current of the three phases Ia, Ib, and Ic, subsequently called phase current Iph, is used to calculate the heat rise:

$$Iph = max(Ia, Ib, Ic)$$

Taking capacitor step ratio into account

When the number of steps (>1) and capacitor step ratio are set in the particular characteristics, the thermal overload protection function takes into account the participation of each step in the calculation of heat rise.

The rated current of step x (IBgx) is equal to the fraction of current that the step represents in relation to the rated current of the capacitor bank (IB).

$$IBgx = \frac{Kgx}{\sum_{x=1}^{n} Kgx} IB$$

where IB is the rated current of the capacitor bank
x is the step number
n is the total number of steps, between 2 and 4
Kgx is the capacitor step ratio value of step x

The rated current of the sequence of steps (IBseq) is calculated. It is the sum of the rated currents (IBgx) of the steps closed during the sequence.

$$IBseq = \sum_{x=1}^{n} p(x) IBgx$$

where x is the step number
n is the total number of steps, between 2 and 4
p(x) is the position of the step x:
- p(x) = 1 when the step switch x is closed
- p(x) = 0 when the step switch x is open.

The heat rise is proportional to the square of the current in relation to the rated current of the sequence. Under steady state conditions, it is equal to:

$$E = \left(\frac{Iph}{Ibseq}\right)^2 \times 100 \quad \text{as a\%}$$

If the closed positions of the steps are not acquired or if the number of steps set in the particular characteristics is 1, the rated current of the sequences is equal to the rated current of the capacitor bank. In such cases, the heat rise is proportional to the drawn current in relation to the rated current of the capacitor bank. Under steady state conditions, it is equal to:

$$E = \left(\frac{Iph}{Ib}\right)^2 \times 100 \quad \text{as a\%}$$

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Operation curve
The protection function gives a trip command when the current drawn is greater than the overload current, with respect to the rated current of the sequence.

Tripping time is set by assigning a hot tripping time to a setting current. This setting is used to calculate a time factor:

$$C = \frac{1}{\ln\left(\frac{\left(\frac{Is}{IB}\right)^2 - 1}{\left(\frac{Is}{IB}\right)^2 - \left(\frac{Itrip}{IB}\right)^2}\right)}$$ where ln: natural logarithm.

The tripping time with an initial heat rise of 0% is then given by:

$$t = C \times \ln\left(\frac{\left(\frac{Iph}{IBseq}\right)^2}{\left(\frac{Iph}{Ibseq}\right)^2 - \left(\frac{Itrip}{Ibseq}\right)^2}\right) \times Ts$$ where ln: natural logarithm.

$$= k \times Ts$$

The tripping time with an intial heat rise of 100% is then given by:

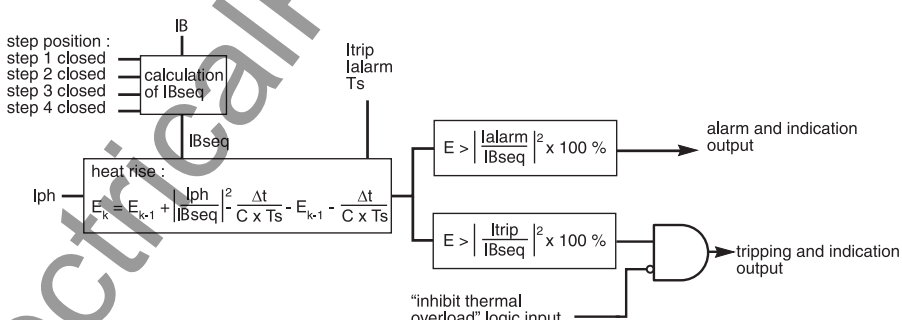
$$t = C \times \ln\left(\frac{\left(\frac{Iph}{Ibseq}\right)^2 - 1}{\left(\frac{Iph}{Ibseq}\right)^2 - \left(\frac{Itrip}{Ibseq}\right)^2}\right) \times Ts$$ where ln: natural logarithm.

$$= k \times Ts$$

The tripping curve tables give the values of k for an inital heat rise from 0% to 100%. The current heat rise is saved in the event of an auxiliary power failure.

Block Diagram

DE51555



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Thermal Overload for Capacitors
ANSI Code 49RMS

User Information

The following information is available for the user:
- heat rise
- time before tripping (with constant current).

Characteristics

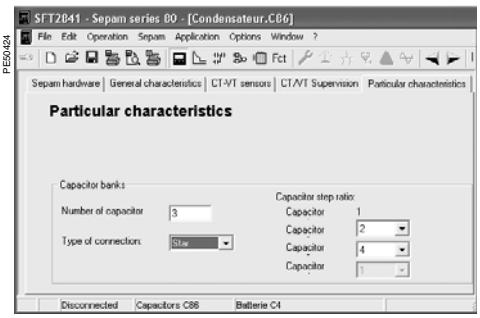
Settings				
Alarm Current Ialarm				
Setting range	1.05 to 1.70 IB			
Accuracy (1)	±2%			
Resolution	1 A			
Tripping Current Itrip				
Setting range	1.05 to 1.70 IB			
Accuracy (1)	±2%			
Resolution	1 A			
Setting Current Is				
Setting range	1.02 Itrip to 2 IB			
Accuracy (1)	±2%			
Resolution	1 A			
Setting Time Ts				
Setting range	1 to 2000 minutes (range varies depending on the tripping and setting currents)			
Resolution	1 mn			
Characteristic Times				
Operation time accuracy	±2% or ±2 s			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P49RMS_1_101	■	■	
Protection blocking	P49RMS_1_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Delayed output	P49RMS _1_3	■	■	■
Alarm	P49RMS _1_10	■	■	■
Block closing	P49RMS _1_11	■	■	■
Protection blocked	P49RMS _1_16	■	■	
Hot state	P49RMS _1_18	■	■	

(1) Under reference conditions (IEC 60255-6).

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Thermal Overload for Capacitors
ANSI Code 49RMS



PE50424

Parameter setting of capacitor bank step ratio.

3

Example

Given a 350 kVAR capacitor bank with three steps, and no harmonic filters, for a voltage of 2 kV. The capacitor step ratio is 1.2.2.

The rated current of the capacitor bank is:
IB = -31 °FQ /($\sqrt{3}$ V_{LLN})= 350000 ($\sqrt{3}$ x 2000) = 101 A

According to the manufacturer data, this capacitor bank can operate continuously with an overload current of 120% IB and for 20 minutes with an overload of 140% IB.

The protection settings are:
Itrip = 120% IB = 121 A
Is = 140% IB = 141 A
Ts = 20 min.

Steps 1 and 2 closed
Steps 1 and 2 are closed in the sequence in progress. The sequence current is:

$$IBseq = \frac{1+2+0}{1+2+2} \times IB = \mathbf{61\ A}$$

For a current of 125% IBseq = 76 A, and an initial heat rise of 100%, the value of k in the tripping curve tables is: k = 2.486.

The tripping time is:
t = k x Ts = 2.486 x 20 ≈ 50 mn

All the steps closed
When all the steps are closed, the sequence current is the rated current of the capacitor bank:

$$IBseq = \frac{1+2+2}{1+2+2} \times IB = \mathbf{101\ A}$$

For a current of 140% IBseq = 141 A, and an initial heat rise of 0%, the value of k in the tripping curve tables is: k = 2.164.

The tripping time is:
t = k x Ts = 2.164 x 20 ≈ 43 mn

The table below summarizes the rated sequence current, the tripping current and examples of tripping times for overload currents of 125% IB and 140% IB, for initial heat rises of 0% and 100%.

Closed Step Numbers			IBseq (A)	Itrip (A)	125% IBseq			140% IBseq		
					Iph (A)	Tripping time (mn)		Iph (A)	Tripping time (mn)	
1	2	3				0%	100%		0%	100%
■	-	-	$\frac{+0+0}{+2+2} \times IB = 20$	24	25	83	50	28	43	20
■	■	-	$\frac{+2+0}{+2+2} \times IB = 61$	73	76	83	50	85	43	20

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-	■	■	$\frac{+2+2}{+2+2} \times IB = 81$	97	101	83	50	113	43	20
■	■	■	$\frac{1+2+2}{1+2+2} \times IB = 101$	121	126	83	50	141	43	20

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Curves for Initial Heat Rise = 0%

Is = 1.2 IB

Iph/IBseq Itrip/IBseq	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
1.05	9.1282	6.7632	5.4705	4.6108	3.9841	3.5018	3.1171	2.8020	2.5389	2.3157	2.1239	1.9574	1.8115	1.6828	1.5683
1.10		3.7989	2.8277	2.2954	1.9404	1.6809	1.4809	1.3209	1.1896	1.0798	0.9865	0.9061	0.8362	0.7749	0.7207
1.15			1.8980	1.4189	1.1556	0.9796	0.8507	0.7510	0.6712	0.6056	0.5506	0.5037	0.4634	0.4282	0.3973

Is = 1.2 IB

Iph/IBseq Itrip/IBseq	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
1.05	1.4660	1.3741	1.2911	1.2158	0.9747	0.8011	0.6713	0.5714	0.4927	0.4295	0.3779	0.3352	0.2995	0.2692
1.10	0.6725	0.6293	0.5905	0.5554	0.4435	0.3635	0.3040	0.2584	0.2226	0.1939	0.1704	0.1511	0.1349	0.1212
1.15	0.3699	0.3456	0.3237	0.3040	0.2417	0.1976	0.1649	0.1399	0.1204	0.1047	0.0920	0.0815	0.0728	0.0653

Is = 1.3 IB

Iph/IBseq Itrip/IBseq	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
1.05	15.0540	11.1530	9.0217	7.6039	6.5703	5.7750	5.1405	4.6210	4.1871	3.8189	3.5027	3.2281	2.9875	2.7752	2.5864
1.10		6.7905	5.0545	4.1030	3.4684	3.0047	2.6470	2.3611	2.1265	1.9301	1.7633	1.6197	1.4948	1.3852	1.2883
1.15			3.9779	2.9738	2.4220	2.0530	1.7829	1.5740	1.4067	1.2692	1.1539	1.0557	0.9711	0.8974	0.8327
1.20				2.5077	1.8824	1.5378	1.3070	1.1375	1.0063	0.9010	0.8143	0.7415	0.6794	0.6257	0.5790
1.25					1.5305	1.1532	0.9449	0.8050	0.7021	0.6223	0.5582	0.5052	0.4607	0.4227	0.3898

Is = 1.3 IB

Iph/IBseq Itrip/IBseq	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
1.05	2.4177	2.2661	2.1292	2.0051	1.6074	1.3211	1.1071	0.9424	0.8126	0.7084	0.6233	0.5529	0.4939	0.4440
1.10	1.2021	1.1249	1.0555	0.9927	0.7927	0.6498	0.5435	0.4619	0.3979	0.3465	0.3047	0.2701	0.2412	0.2167
1.15	0.7753	0.7242	0.6785	0.6372	0.5066	0.4141	0.3456	0.2933	0.2523	0.2195	0.1929	0.1709	0.1525	0.1370
1.20	0.5378	0.5013	0.4688	0.4396	0.3478	0.2834	0.2360	0.1999	0.1717	0.1493	0.1310	0.1160	0.1035	0.0929
1.25	0.3611	0.3358	0.3134	0.2933	0.2309	0.1874	0.1557	0.1316	0.1129	0.0981	0.0860	0.0761	0.0678	0.0609

Is = 1.4 Ib

Iph/IBseq Itrip/IBseq	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
1.05	21.4400	15.8850	12.8490	10.8300	9.3578	8.2251	7.3214	6.5815	5.9634	5.4391	4.9887	4.5976	4.2550	3.9525	3.6837
1.10		9.9827	7.4306	6.0317	5.0988	4.4171	3.8914	3.4710	3.1261	2.8375	2.5922	2.3811	2.1975	2.0364	1.8939
1.15			6.1214	4.5762	3.7270	3.1593	2.7435	2.4222	2.1647	1.9531	1.7757	1.6246	1.4944	1.3810	1.2813
1.20				4.1525	3.1170	2.5464	2.1642	1.8836	1.6664	1.4920	1.3483	1.2278	1.1249	1.0361	0.9587
1.25					2.9310	2.2085	1.8095	1.5416	1.3446	1.1918	1.0689	0.9676	0.8823	0.8095	0.7466
1.30						2.0665	1.5627	1.2839	1.0964	0.9582	0.8508	0.7643	0.6929	0.6327	0.5813
1.35							1.3673	1.0375	0.8546	0.7314	0.6404	0.5696	0.5125	0.4653	0.4254

Is = 1.4 Ib

Iph/IBseq Itrip/IBseq	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
1.05	3.4434	3.2275	3.0325	2.8557	2.2894	1.8816	1.5768	1.3422	1.1573	1.0089	0.8877	0.7874	0.7034	0.6323
1.10	1.7672	1.6537	1.5516	1.4593	1.1654	0.9552	0.7989	0.6791	0.5849	0.5094	0.4479	0.3970	0.3545	0.3186
1.15	1.1931	1.1145	1.0440	0.9805	0.7796	0.6372	0.5318	0.4513	0.3882	0.3378	0.2968	0.2629	0.2346	0.2107
1.20	0.8906	0.8302	0.7763	0.7279	0.5760	0.4692	0.3907	0.3310	0.2844	0.2472	0.2170	0.1921	0.1714	0.1538
1.25	0.6916	0.6432	0.6002	0.5618	0.4421	0.3589	0.2981	0.2521	0.2163	0.1878	0.1647	0.1457	0.1299	0.1165
1.30	0.5367	0.4977	0.4634	0.4328	0.3386	0.2738	0.2268	0.1914	0.1640	0.1422	0.1246	0.1102	0.0981	0.0880
1.35	0.3913	0.3617	0.3358	0.3129	0.2431	0.1957	0.1617	0.1361	0.1164	0.1009	0.0883	0.0780	0.0694	0.0622

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Thermal Overload for Capacitors
ANSI Code 49RMS

Curves for Initial Heat Rise = 0%

Is = 2 IB

Iph/IBseq Itrip/IBseq	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
1.05	69.6380	51.5950	41.7340	35.1750	30.3940	26.7150	23.7800	21.3760	19.3690	17.6660	16.2030	14.9330	13.8200	12.8380	11.9650
1.10		33.9580	25.2760	20.5180	17.3440	15.0260	13.2370	11.8070	10.6340	9.6521	8.8176	8.0995	7.4750	6.9270	6.4425
1.15			22.0350	16.4730	13.4160	11.3720	9.8756	8.7189	7.7922	7.0303	6.3916	5.8479	5.3792	4.9710	4.6123
1.20				16.0520	12.0490	9.8435	8.3659	7.2814	6.4415	5.7674	5.2122	4.7460	4.3485	4.0053	3.7060
1.25					12.4460	9.3782	7.6840	6.5465	5.7100	5.0610	4.5392	4.1087	3.7467	3.4375	3.1703
1.30						10.0300	7.5843	6.2313	5.3211	4.6505	4.1294	3.7096	3.3629	3.0708	2.8210
1.35							8.2921	6.2917	5.1827	4.4353	3.8838	3.4544	3.1081	2.8215	2.5799
1.40								6.9790	5.3124	4.3868	3.7619	3.3000	2.9399	2.6491	2.4081
1.50										5.1152	3.9169	3.2491	2.7969	2.4617	2.1997
1.60												3.8403	2.9564	2.4625	2.1271
1.70														2.8932	2.2383

Is = 2 IB

Iph/IBseq Itrip/IBseq	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
1.05	11.1840	10.4830	9.8495	9.2753	7.4358	6.1115	5.1214	4.3594	3.7590	3.2768	2.8832	2.5574	2.2846	2.0537
1.10	6.0114	5.6254	5.2781	4.9642	3.9642	3.2494	2.7177	2.3099	1.9896	1.7328	1.5235	1.3506	1.2059	1.0836
1.15	4.2947	4.0117	3.7581	3.5295	2.8064	2.2936	1.9142	1.6245	1.3975	1.2159	1.0683	0.9464	0.8446	0.7586
1.20	3.4426	3.2091	3.0008	2.8138	2.2265	1.8138	1.5104	1.2795	1.0993	0.9555	0.8388	0.7426	0.6624	0.5946
1.25	2.9368	2.7311	2.5486	2.3855	1.8775	1.5240	1.2659	1.0704	0.9184	0.7974	0.6994	0.6187	0.5515	0.4949
1.30	2.6048	2.4157	2.2489	2.1007	1.6433	1.3288	1.1007	0.9289	0.7958	0.6901	0.6047	0.5346	0.4762	0.4271
1.35	2.3729	2.1935	2.0365	1.8978	1.4745	1.1871	0.9804	0.8257	0.7061	0.6116	0.5354	0.4730	0.4210	0.3774
1.40	2.2046	2.0301	1.8787	1.7459	1.3461	1.0785	0.8878	0.7459	0.6369	0.5509	0.4817	0.4252	0.3782	0.3388
1.50	1.9875	1.8112	1.6620	1.5337	1.1600	0.9190	0.7509	0.6276	0.5337	0.4603	0.4016	0.3538	0.3143	0.2812
1.60	1.8779	1.6825	1.5240	1.3920	1.0256	0.8008	0.6484	0.5386	0.4560	0.3920	0.3411	0.2998	0.2659	0.2376
1.70	1.8713	1.6215	1.4355	1.2893	0.9143	0.7007	0.5610	0.4625	0.3895	0.3335	0.2894	0.2538	0.2246	0.2004

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Thermal Overload for Capacitors
ANSI Code 49RMS

Curves for Initial Heat Rise = 100%

Is = 1.2 IB

Iph/IBseq Itrip/IBseq	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
1.05	2.5249	1.4422	1.0000	0.7585	0.6064	0.5019	0.4258	0.3679	0.3226	0.2862	0.2563	0.2313	0.2102	0.1922	0.1766
1.10		1.624	1.000	0.720	0.559	0.454	0.381	0.3257	0.2835	0.2501	0.2229	0.2004	0.1816	0.1655	0.1518
1.15			1.000	0.645	0.477	0.377	0.310	0.2621	0.2260	0.1979	0.1754	0.1570	0.1417	0.1288	0.1177

Is = 1.2 IB

Iph/IBseq Itrip/IBseq	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
1.05	0.1630	0.1511	0.1405	0.1311	0.1020	0.0821	0.0677	0.0569	0.0486	0.0421	0.0368	0.0325	0.0289	0.0259
1.10	0.1398	0.1293	0.1201	0.1119	0.0867	0.0696	0.0573	0.0481	0.0410	0.0354	0.0310	0.0273	0.0243	0.0217
1.15	0.1082	0.0999	0.0926	0.0861	0.0664	0.0531	0.0436	0.0366	0.0312	0.0269	0.0235	0.0207	0.0184	0.0165

Is = 1.3 IB

Iph/IBseq Itrip/IBseq	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
1.05	4.1639	2.3784	1.6492	1.2509	1.0000	0.8276	0.7021	0.6068	0.5320	0.4719	0.4226	0.3815	0.3467	0.3170	0.2913
1.10		2.9020	1.7875	1.2878	1.0000	0.8123	0.6802	0.5823	0.5068	0.4470	0.3984	0.3583	0.3246	0.2959	0.2713
1.15			2.0959	1.3521	1.0000	0.7901	0.6498	0.5493	0.4737	0.4148	0.3676	0.3291	0.2970	0.2699	0.2468
1.20				1.5014	1.0000	0.7541	0.6039	0.5017	0.4274	0.3708	0.3264	0.2905	0.2610	0.2364	0.2154
1.25					1.0000	0.6820	0.5222	0.4227	0.3541	0.3036	0.2648	0.2341	0.2092	0.1886	0.1713

Is = 1.3 IB

Iph/IBseq Itrip/IBseq	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
1.05	0.2688	0.2491	0.2317	0.2162	0.1682	0.1354	0.1117	0.0939	0.0802	0.0694	0.0607	0.0535	0.0476	0.0426
1.10	0.2499	0.2311	0.2146	0.2000	0.1550	0.1243	0.1023	0.0859	0.0733	0.0633	0.0554	0.0488	0.0434	0.0389
1.15	0.2268	0.2094	0.1941	0.1805	0.1393	0.1114	0.0915	0.0767	0.0653	0.0564	0.0492	0.0434	0.0386	0.0345
1.20	0.1974	0.1819	0.1682	0.1562	0.1199	0.0955	0.0783	0.0655	0.0557	0.0481	0.0419	0.0369	0.0328	0.0293
1.25	0.1565	0.1438	0.1327	0.1230	0.0938	0.0745	0.0609	0.0508	0.0432	0.0372	0.0324	0.0285	0.0253	0.0226

Is = 1.4 IB

Iph/IBseq Itrip/IBseq	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
1.05	5.9304	3.3874	2.3488	1.7816	1.4243	1.1788	1.0000	0.8642	0.7577	0.6721	0.6019	0.5434	0.4938	0.4515	0.4148
1.10		4.2662	2.6278	1.8931	1.4701	1.1942	1.0000	0.8560	0.7451	0.6571	0.5857	0.5267	0.4771	0.4350	0.3988
1.15			3.2252	2.0806	1.5388	1.2158	1.0000	0.8453	0.7289	0.6383	0.5657	0.5064	0.4570	0.4154	0.3797
1.20				2.4862	1.6559	1.2488	1.0000	0.8307	0.7077	0.6141	0.5405	0.4811	0.4323	0.3914	0.3567
1.25					1.9151	1.3061	1.0000	0.8095	0.6780	0.5814	0.5072	0.4484	0.4007	0.3612	0.3280
1.30						1.4393	1.0000	0.7750	0.6330	0.5339	0.4603	0.4035	0.3581	0.3211	0.2903
1.35							1.0000	0.7053	0.5521	0.4544	0.3855	0.3340	0.2940	0.2618	0.2355

Is = 1.4 IB

Iph/IBseq Itrip/IBseq	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
1.05	0.3829	0.3548	0.3300	0.3079	0.2396	0.1928	0.1590	0.1337	0.1142	0.0988	0.0864	0.0762	0.0678	0.0607
1.10	0.3673	0.3398	0.3155	0.2940	0.2278	0.1828	0.1505	0.1263	0.1078	0.0931	0.0814	0.0718	0.0638	0.0571
1.15	0.3490	0.3222	0.2986	0.2778	0.2143	0.1714	0.1408	0.1180	0.1005	0.0868	0.0758	0.0668	0.0593	0.0531
1.20	0.3269	0.3011	0.2786	0.2587	0.1985	0.1582	0.1296	0.1085	0.0923	0.0796	0.0694	0.0611	0.0543	0.0486
1.25	0.2997	0.2753	0.2541	0.2355	0.1796	0.1426	0.1165	0.0973	0.0827	0.0712	0.0621	0.0546	0.0485	0.0433
1.30	0.2643	0.2420	0.2228	0.2060	0.1561	0.1235	0.1006	0.0838	0.0711	0.0612	0.0533	0.0468	0.0415	0.0371
1.35	0.2135	0.1948	0.1788	0.1649	0.1240	0.0976	0.0793	0.0659	0.0558	0.0480	0.0417	0.0367	0.0325	0.0290

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Curves for Initial Heat Rise = 100%

Is = 2 IB

Iph/IBseq / Itrip/IBseq	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
1.05	19.2620	11.0020	7.6288	5.7866	4.6259	3.8286	3.2480	2.8069	2.4611	2.1831	1.9550	1.7648	1.6039	1.4663	1.3473
1.10		14.5120	8.9388	6.4398	5.0007	4.0622	3.4016	2.9118	2.5344	2.2351	1.9923	1.7915	1.6230	1.4797	1.3565
1.15			11.6100	7.4893	5.5392	4.3766	3.5996	3.0427	2.6238	2.2975	2.0364	1.8228	1.6451	1.4951	1.3669
1.20				9.6105	6.4010	4.8272	3.8656	3.2112	2.7355	2.3737	2.0892	1.8597	1.6709	1.5129	1.3788
1.25					8.1323	5.5465	4.2465	3.4375	2.8792	2.4688	2.1537	1.9041	1.7014	1.5337	1.3927
1.30						6.9855	4.8534	3.7614	3.0722	2.5911	2.2342	1.9582	1.7380	1.5583	1.4088
1.35							6.0646	4.2771	3.3484	2.7556	2.3380	2.0258	1.7828	1.5879	1.4280
1.40								5.3051	3.7883	2.9911	2.4776	2.1131	1.8388	1.6241	1.4511
1.50										4.1166	2.9979	2.3998	2.0090	1.7283	1.5149
1.60												3.2166	2.3778	1.9239	1.6242
1.70														2.4956	1.8670

Is = 2 IB

Iph/IBseq / Itrip/IBseq	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
1.05	1.2436	1.1525	1.0718	1.0000	0.7783	0.6262	0.5165	0.4343	0.3709	0.3209	0.2806	0.2476	0.2202	0.1972
1.10	1.2495	1.1559	1.0733	1.0000	0.7750	0.6217	0.5118	0.4297	0.3666	0.3168	0.2768	0.2441	0.2170	0.1943
1.15	1.2562	1.1597	1.0750	1.0000	0.7713	0.6169	0.5066	0.4247	0.3618	0.3124	0.2727	0.2404	0.2136	0.1911
1.20	1.2638	1.1640	1.0768	1.0000	0.7673	0.6115	0.5010	0.4192	0.3567	0.3076	0.2683	0.2363	0.2099	0.1877
1.25	1.2725	1.1690	1.0790	1.0000	0.7628	0.6057	0.4949	0.4133	0.3511	0.3025	0.2636	0.2320	0.2059	0.1841
1.30	1.2826	1.1747	1.0814	1.0000	0.7578	0.5992	0.4882	0.4069	0.3451	0.2969	0.2585	0.2274	0.2017	0.1802
1.35	1.2945	1.1813	1.0842	1.0000	0.7522	0.5920	0.4808	0.3998	0.3386	0.2910	0.2531	0.2224	0.1971	0.1760
1.40	1.3085	1.1891	1.0874	1.0000	0.7459	0.5841	0.4728	0.3921	0.3315	0.2844	0.2471	0.2170	0.1922	0.1715
1.50	1.3463	1.2094	1.0958	1.0000	0.7306	0.5652	0.4539	0.3744	0.3152	0.2697	0.2337	0.2048	0.1811	0.1614
1.60	1.4070	1.2406	1.1082	1.0000	0.7102	0.5410	0.4303	0.3527	0.2955	0.2520	0.2178	0.1904	0.1681	0.1496
1.70	1.5237	1.2953	1.1286	1.0000	0.6816	0.5089	0.4000	0.3253	0.2711	0.2302	0.1983	0.1730	0.1524	0.1355

$$\frac{t}{T} = \ln\frac{\left(\frac{Ieq}{IB}\right)^2}{\left(\frac{Ieq}{I_B}\right)^2 - Fs}$$

$$\frac{t}{T} = \ln\frac{\left(\frac{Ieq}{I_B}\right)^2}{\left(\frac{Ieq}{I_B}\right)^2 - 1.Fs}$$

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Thermal Overload for Machines
ANSI Code 49RMS

Protection of equipment against thermal damage caused by overloads.

Description

This function is used to protect equipment (motors, transformers, generators) against overloads, based on measurement of the current drawn.

Operation Curve

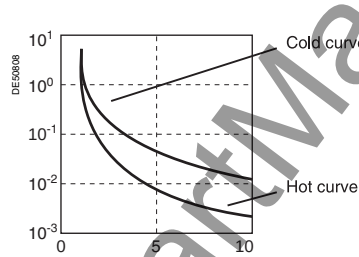
The protection issues a trip command when the heat rise E (calculated by measuring an equivalent current Ieq) is greater than the heat rise set point Es.

The greatest permissible continuous current is

$I = I_B\sqrt{Es}$

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

- the calculated heat rise depends on the current drawn and the previous heat rise
- the cold curve defines the protection tripping time based on zero heat rise
- the hot curve defines the protection tripping time based on 100% rated heat rise.



IN: natural logarithm.

Alarm Set Point, Tripping Set Point

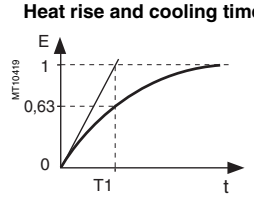
Two set points are available for heat rise:

- Es1: alarm
- Es2: tripping. = $(Imax/I_B)^2$ (if the max operating conditions are unknown use SF x FLA for Imax)

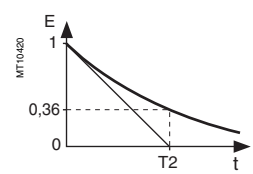
"Hot State" Set Point

When the function is used to protect a motor, this fixed set point is designed for detection of the hot state used by the number of starts function. The value of the fixed set point is 50%.

Heat rise and cooling time constants



Heat rise time constant



Cooling time constant

For self-ventilated rotating machines, cooling is more effective when the machine is running than when it is stopped. Running and stopping of the equipment are calculated based on the value of the current:

- running if I > 0.1 IB
- stopped if I < 0.1 IB

Two time constants may be set:

- T1: heat rise time constant: concerns equipment that is running
- T2: cooling time constant: concerns equipment that is stopped.

Taking into account harmonics

The current measured by the thermal protection is an RMS 3-phase current which takes into account 13th level harmonics.

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Considering Ambient Temperature
Most machines are designed to operate at a maximum ambient temperature of 104°F (40°C). The thermal overload function takes into account the ambient temperature (Sepam™ equipped with the temperature sensor option (1)) to increase the calculated heat rise value when the temperature measured exceeds 104°F (40°C).

Increase factor: $fa = \frac{Tmax - 40°C}{Tmax - Tambiant}$

where T max is the equipment maximum temperature (according to insulation class)
T ambient is the measured temperature.

Table of Insulation Classes

Class	Y	A	E	B	F	H	200	220	250
Tmax	90 °C	105 °C	120 °C	130 °C	155 °C	180 °C	200 °C	220 °C	250 °C
Tmax	194 °F	221 °F	248 °F	266 °F	311 °F	356 °F	392 °F	428 °F	482 °F

Reference IEC 60085 (1984).

Adaptation of the Protection to Motor Thermal Withstand
Motor thermal protection is often set based on the hot and cold curves supplied by the machine manufacturer.

To fully comply with these experimental curves, additional parameters must be set:
- initial heat rise, Es0, is used to reduce the cold tripping time.

modified cold curve: $\frac{t}{T} = \ln \frac{\left(\frac{Ieq}{I_B}\right)^2 - Es0}{\left(\frac{Ieq}{I_B}\right)^2 - Es}$ where ln: natural logarithm

- a second group of parameters (time constants and set points) is used for thermal withstand with locked rotors. This second set of parameters applies when the current is greater than an adjustable set point Is.

Taking the Negative Sequence Component into Account
For motors with wound rotors, the presence of a negative sequence component increases the heat rise in the motor. The current's negative sequence component is addressed in the protection function by the equation.

$Ieq = \sqrt{Iph^2 + K \times I2^2}$ where Iph is the largest phase current
I2 is the negative sequence current component
K is a adjustable coefficient

K may have the following values: 0 - 2.25 - 4.5 - 9
For an asynchronous motor, K is determined as follows:

$K = 2 \times \frac{Cd}{Cn} \times \frac{1}{g \times \left(\frac{I1}{IB}\right)^2} - 1$ where Cn, Cd: rated torque and starting torque
IB, I1: base current and starting current
g: rated slip

Learning the Cooling Time Constant T2
The time constant T2 may be "learned" from the temperatures measured in the equipment by temperature sensors connected to the MET1482 module number 1. T2 is estimated:
- after a heating/cooling sequence:
  - heating period detected by ES > 70%
  - followed by a shutdown detected by Ieq < 10% of Ib
- when the machine temperature is measured by RTDs connected to MET1482 module number 1:
  - RTD 1, 2, or 3 assigned to motor/generator stator temperature measurement
  - RTD 1, 3, or 5 assigned to transformer temperature measurement.

After each new heating/cooling sequence is detected, a new T2 value is estimated. Following estimation, T2 can be used in two manners:
- automatically, where each new calculated value updates the T2 constant used
- manually, by entering the value for the T2 parameter.

Measurement accuracy may be improved by using RTD 8 to measure the ambient temperature.

Because the function has two operating modes, a time constant is estimated for each mode.

For generator-transformer unit or motor-transformer unit applications, it is advised to connect the rotating machine RTDs to MET1482 module number 1 to take advantage of T2 learning on the rotating machine rather than on the transformer.

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Block Start
The thermal overload protection can block the closing of the motor control device until the heat rise drops back down below a value that allows restarting. This value addresses the heat rise produced by motor startup.

The block function is grouped together with the **starts per hour** protection function and the indication BLOCK START informs the user.

Saving the Heat Rise Information
The current heat rise is saved in the event of an auxiliary power failure.

Blocking Tripping
Tripping of the thermal overload protection can be blocked by the logic input "Block thermal overload" when required by the process.

Use of Two Operating Modes
The thermal overload protection function may be used to protect equipment with two operating modes, for example:
- transformers with two ventilation modes, with or without forced ventilation (ONAN / ONAF)
- two-speed motors.

The protection function comprises two groups of settings, and each group is suitable for equipment protection in one of the two operating modes.

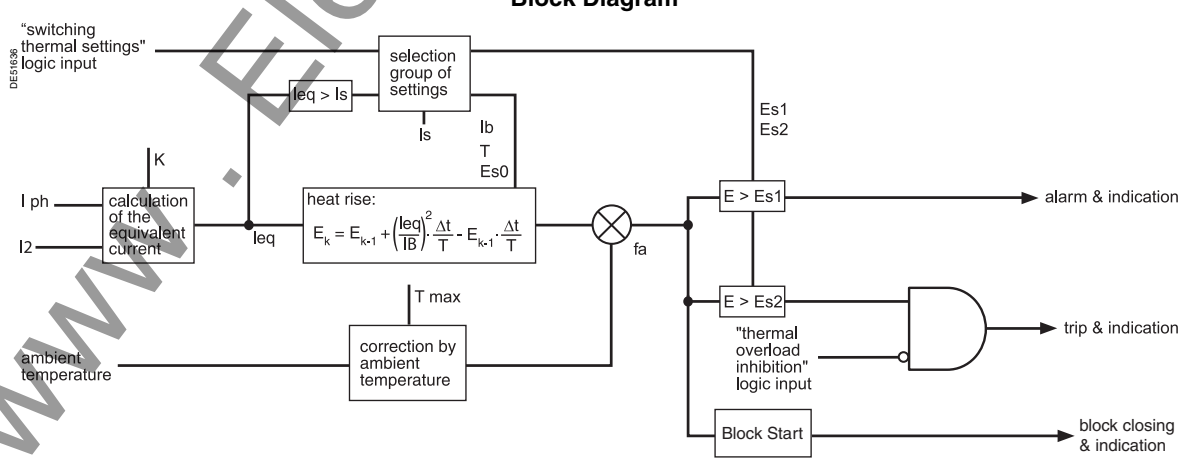
Switching from one group of thermal settings to the other is done without losing the heat rise information. It is controlled:
- either via a logic input, assigned to the "switching of thermal settings" function
- or when the phase current reaches an adjustable Is set point (to be used for switching of thermal settings of a motor with locked rotor).

The base current of the equipment, used to calculate heat rise, also depends on the operating mode:
- for logic input switching in mode 2, the base current IB-mode 2, a specific thermal overload protection setting, is used to calculate the heat rise in the equipment
- in all other cases, the base current IB, defined as a general Sepam™ parameter, is used to calculate the heat rise in the equipment.

User Information
The following information is available for the user:
- heat rise
- learned cooling time constant T2
- time before restart enabled (in case of blocking starting)
- time before tripping (with constant current).

See the section on measurement and machine operation assistance functions.

Block Diagram



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Characteristics

Settings	
Measurement Origin	
Setting range	Ia, Ib, Ic / I'a, I'b, I'c
Considering the Negative Sequence Component K	
Setting range	0 - 2.25 - 4.59
Considering Ambient Temperature	
Setting range	Yes / no
Using the Learned Cooling Time Constant T2	
Setting range	Yes / no
Maximum equipment temperature Tmax (according to insulation class)	
Setting range	140 °F to 392 °F or 60 °C to 200 °C
Resolution	1°F or 1°C
Thermal Mode 1	
Alarm Set Point Es1	
Setting range	0% to 300%
Accuracy (1)	±2%
Resolution	1%
Tripping Set Point Es2	
Setting range	0% to 300%
Accuracy (1)	±2%
Resolution	1%
Initial Heat Rise Set Point Es0	
Setting range	0% to 100%
Accuracy (1)	±2%
Resolution	1%
Heat Rise Time Constant T1	
Setting range	1 min. to 600 min.
Resolution	1 min.
Cooling Time Constant T2	
Setting range	5 min. to 600 min.
Resolution	1 min.
Thermal Mode 2	
Using Thermal Mode 2	
Setting range	Yes / no
Alarm Set Point Es1	
Setting range	0% to 300%
Accuracy (1)	±2%
Resolution	1%
Tripping Set Point Es2	
Setting range	0% to 300%
Accuracy (1)	±2%
Resolution	1%
Initial Heat Rise Set Point Es0	
Setting range	0% to 100%
Accuracy (1)	±2%
Resolution	1%
Heat Rise Time Constant T1	
Setting range	1 min. to 600 min.
Resolution	1 min.
Cooling Time Constant T2	
Setting range	5 min. to 600 min.
Resolution	1 min.
Switching Set Point for Thermal Mode 2	
Setting range	25% to 800% of IB
Accuracy (1)	±5%
Resolution	1%
Base Current IB - Mode 2	
Setting range	0.2 to 2.6 IN or I'N
Accuracy (1)	±5%
Resolution	1 A
Characteristic Times (1)	
Operation time accuracy	±2% or ±1 s

(1) Under reference conditions (IEC 60255-8).

Inputs			
Designation	**Syntax**	**Equations**	**Logipam**
Protection reset	P49RMS_1_101	■	■
Protection blocking	P49RMS_1_113	■	■

Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Delayed output	P49RMS_1_3	■	■	■
Alarm	P49RMS_1_10	■	■	■
Block closing	P49RMS_1_11	■	■	■
Protection blocked	P49RMS_1_16	■	■	
Hot state	P49RMS_1_18	■	■	
Block thermal overload	P49RMS_1_32	■	■	

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Thermal Overload for Machines
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Setting Examples

Example 1: Motor

The following data are available:
- time constants for on operation T1 and off operation T2:
  - T1 = 25 min.
  - T2 = 70 min.
- maximum steady state current:
  - Imax/IB = 1.05.

Setting the Tripping Set Point Es2
Es2 = $(Imax/IB)^2$ = 110%

Nota : *If the motor draws a current of 1.05 IB continuously, the heat rise calculated by the thermal overload protection will reach 110%.*

Setting Alarm Set Point Es1
Es1 = 90% (I/I_B = 0.95).
Knegative: 4.5 (usual value)

The other thermal overload parameters do not need to be set. They are not considered by default.

Example 2: Motor

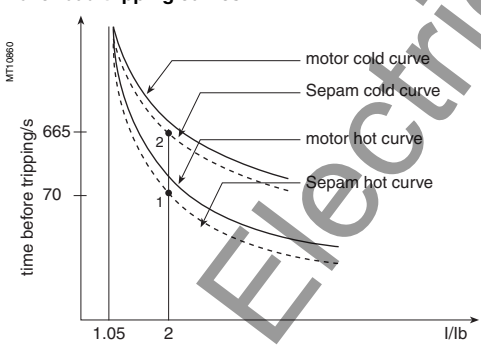
The following data are available:
- motor thermal withstand in the form of hot and cold curves (see solid line curves in Figure 1)
- cooling time constant T2
- maximum steady state current:
- Imax/IB = 1.05.

Setting the Tripping Set Point Es2
Es2 = $(Imax/IB)^2$ = 110%
Setting of alarm set point Es1:
Es1 = 90% (I/I_B = 0.95).

The manufacturer's hot/cold curves **(1)** may be used to determine the heating time constant T1.

The method consists of placing the Sepam™ hot/cold curves below those of the motor.

Figure 1. Motor thermal withstand and thermal overload tripping curves.



For an overload of 2 IB, the value t/T1 = 0.0339 **(2)**.
In order for Sepam™ to trip at point 1 (t = 70 s), T1 is equal to 2065 sec ≈ 34 min.

With a setting of T1 = 34 min., the tripping time is obtained based on a cold state (point 2). Here, it is equal to t/T1 = 0.3216 ⇒ t = 665 sec, that is,. ≈ 11 minutes, which is compatible with the motor thermal withstand when it is cold.

The negative sequence factor K is calculated using the equation defined on page 109.

The parameters of the second thermal overload relay do not need to be set. They are not considered by default.

Example 3: Motor

The following data are available:
- motor thermal withstand in the form of hot and cold curves (see solid line curves in Figure 2)
- cooling time constant T2
- maximum steady state current: Imax/Ib = 1.1.

The thermal overload parameters are determined as in the previous example.

Setting the Tripping Set Point Es2
Es2 = $(Imax/IB)^2$ = 120%

Setting the Alarm Set Point Es1
Es1 = 90% (I/IB = 0.95).
The time constant T1 is calculated so that the thermal overload protection trips after 100 seconds (point 1).
With t/T1 = 0.069 (I/IB = 2 and Es2 = 120%):
⇒ T1 = 100 sec / 0.069 = 1449 sec ≈ 24 min.

The tripping time starting from the cold state is equal to:
t/T1 = 0.3567 ⇒ t = 24 min. x 0.3567 = 513 sec (point 2').

This tripping time is too long since the limit for this overload current is 400 sec (point 2).

If the time constant T1 is lowered, the thermal overload protection will trip earlier, below point 2.

The risk that motor starting when hot will not be possible also exists in this case (see Figure 2 in which a lower Sepam™ hot curve would intersect the starting curve with V_{LL} = 0.9 V_{LL}).

The **Es0 parameter** is a setting that is used to solve these differences by lowering the Sepam™ cold curve without moving the hot curve. In this example, the thermal overload protection should trip after 400 sec starting from the cold state.

The following equation is used to obtain the Es0 value:

$$Es0 = \left[\frac{I_{processed}}{I_B}\right]^2 - e^{\frac{t_{necessary}}{T_1}} \times \left[\left[\frac{I_{processed}}{I_B}\right]^2 - Es2\right]$$

where:
$t_{necessary}$: tripping time necessary starting from a cold state.
$I_{processed}$: equipment current.

(1) *When the machine manufacturer provides both a time constant T1 and the machine hot/cold curves, the use of the curves is recommended since they are more accurate.*
(2) *It is possible to use the charts containing the numerical values of the Sepam™ hot curve or the equation of the curve which is given on page 108.*

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Setting Examples

In numerical values, the following is obtained:

$$Es0 = 4 - e^{\frac{400\ s}{24 \times 60\ s} \times [4 - (1.2)]} = 0.3035 \approx (31\ \%)$$

By setting Es0 = 31%, point 2' is moved downward to obtain a shorter tripping time that is compatible with the motor thermal withstand when cold (see Figure 3).

Nota : *A setting Es0 = 100% means that the hot and cold curves are the same.*

Figure 2. Hot/cold curves incompatible with the motor thermal withstand.

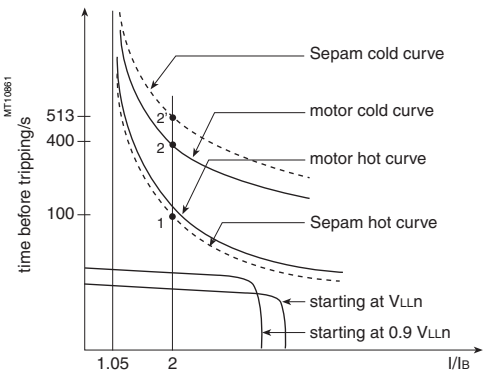
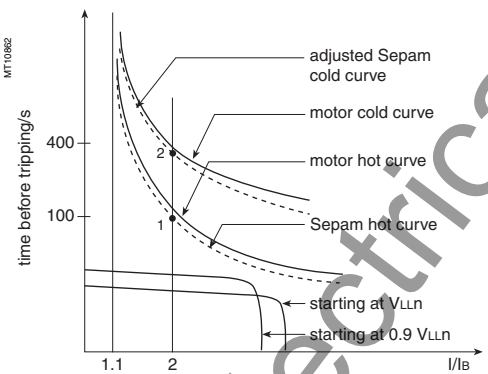


Figure 3. Hot/cold curves compatible with the motor thermal withstand via the setting of an initial heat rise Es0.



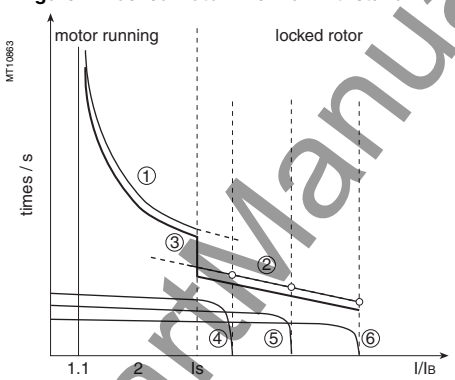
Using the Additional Setting Group

When a motor rotor is locked or turning very slowly, its thermal behavior differs from one with a rated load. In such conditions, the motor is damaged by overheating of the rotor or stator. For high power motors, rotor overheating is usually a limiting factor.

The thermal overload parameters selected to operate with a low overload are no longer valid. In order to protect the motor in this case, "excessive starting time" protection may be used.

However, motor manufacturers provide the thermal withstand curves when the rotor is locked, for different voltages at the time of starting.

Figure 4. Locked Rotor Thermal Withstand.



① : thermal withstand, motor running
② : thermal withstand, motor stopped
③ : Sepam™ tripping curve
④ : starting at 65% V_{LL}
⑤ : starting at 80% V_{LL}
⑥ : starting at 100% V_{LL}

In order to consider these curves, a second thermal overload relay can be used. The time constant in this case is theoretically shorter. It should, however, be determined in the same way as that of the first relay.

The thermal overload protection switches between the first and second relay if the equivalent current Ieq exceeds the Is value (set point current).

Example 4. Transformer with Two Ventilation Modes

The following data are available:

The rated current of a transformer with two ventilation modes is:

- IB = 200 A without forced ventilation (ONAN mode), the main operating mode of the transformer
- IB = 240 A with forced ventilation (ONAF mode), a temporary operating mode, to have 20% more power available

Setting the base current for ventilation operating mode 1: IB = 200 A (to be set in the Sepam™ general parameters).

Setting the base current for ventilation operating mode 2: IB2 = 240 A (to be set among the specific thermal overload protection settings).

Switching thermal settings by the logic input, to be assigned to "switching thermal settings" function and to be connected to the transformer ventilation control unit.

Settings related to each ventilation operating mode (Es set points, time constants, etc.) are determined according to transformer characteristics provided by the manufacturer.

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Trip Curves

Cold Curves for Es0 = 0%

I/IB Es (%)	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

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Trip Curves

Cold Curves for Es0 = 0%

I/IB Es (%)	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

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Thermal Overload for Machines
ANSI Code 49RMS
Trip Curves

Cold Curves for Es0 = 0%

I/IB Es (%)	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

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Thermal Overload for Machines
ANSI Code 49RMS
Trip Curves

Hot Curves

I/IB Es (%)	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	1.0213	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 Es (%)	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

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Thermal Overload for Machines
ANSI Code 49RMS
Trip Curves

Hot Curves

I/IB Es (%)	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

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Breaker Failure
ANSI Code 50BF

Backup protection if the circuit breaker does not trip.

Description

If a breaker fails to open after a tripping command (detected by the non-extinction of the fault current), this backup protection sends a tripping command to upstream or adjacent breakers.

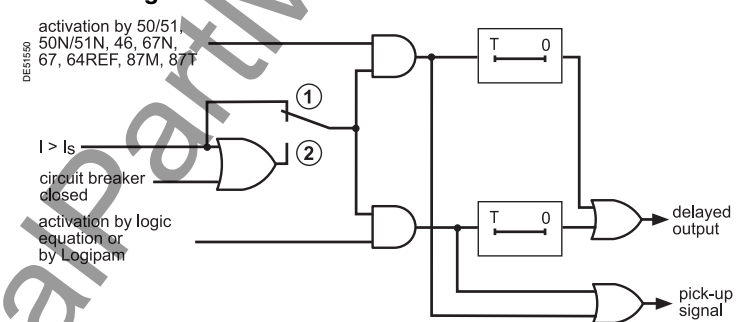
The "breaker failure" protection function is activated by an O1 output tripping command received from the overcurrent protection functions which trip the circuit breaker (50/51, 50N/51N, 46, 67N, 67, 64REF, 87M, 87T). It checks for the absence of current during the time interval specified by the time delay T. It may also take into account the position of the circuit breaker, read on the logic inputs to determine the actual opening of the breaker.

Automatic activation of this protection function requires the use of the circuit breaker control function in the control logic. A specific input can also be used to activate the protection by logic equation or by Logipam. That option is useful for adding special cases of activation (e.g. tripping by an external protection unit).

The time-delayed output of the protection function should be assigned to a logic output via the control matrix.

Starting and stopping of the time delay T counter are conditioned by the presence of a current above the set point (I > Is).

Block Diagram



Setting: (1) *without considering circuit breaker position*
(2) *considering circuit breaker position*

Characteristics

Settings				
Is Set Point				
Setting range	0.2 In to 2 In			
Accuracy (1)	±5%			
Resolution	0.1 A			
Drop out/pick up ratio	87.5% ±2%			
Time Delay T				
Setting range	50 ms to 3 s			
Accuracy (1)	±2% or -10 ms to +15 ms			
Resolution	10 ms or 1 digit			
Considering Circuit Breaker Position				
Setting range	With / without			
Characteristic Times				
Overshoot time	< 35 ms at 2 Is			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P50BF_1_101	■	■	
Start 50BF	P50BF_1_107	■	■	
Protection blocking	P50BF_1_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P50BF_1_1	■	■	
Delayed output	P50BF_1_3	■	■	■
Protection blocked	P50BF_1_16	■	■	

(1) *Under reference conditions (IEC 60255-6).*

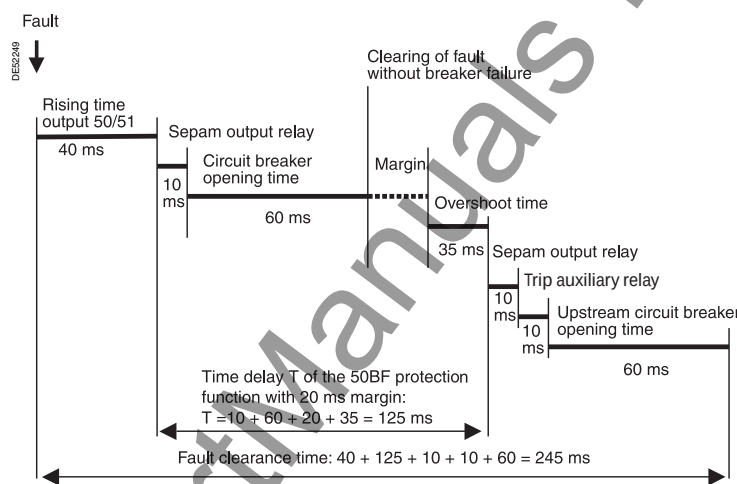
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Breaker Failure
ANSI Code 50BF

Example

Below is an example for determining the time-delay setting of the breaker failure function. The following parameters are for the illustration:

- overcurrent protection setting: T = inst
- circuit breaker operating time: 60 ms
- auxiliary relay operating time to open the upstream breaker(s): 10 ms.



The breaker failure function time delay is the sum of the following times:

- Sepam™ O1 output relay pick-up time = 10 ms
- circuit breaker opening time = 60 ms
- Breaker failure function overshoot time = 35 ms.

To avoid unwanted tripping of the upstream breakers, add a margin of approximately 20 ms.

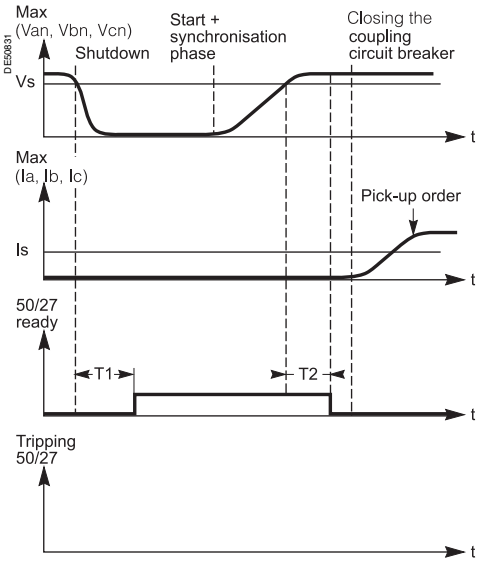
The time delay is 125 ms minimum, set at 130 ms.

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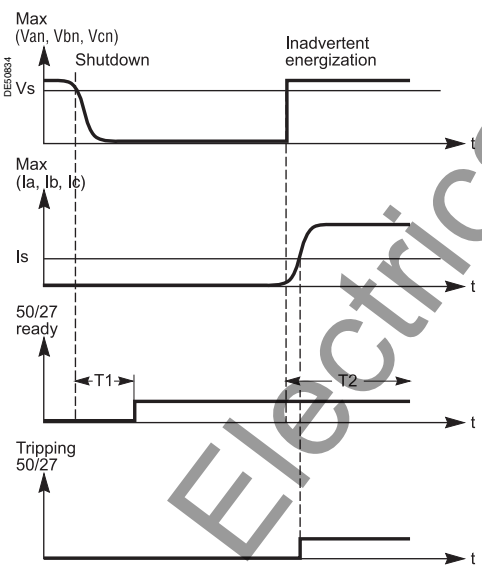
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Inadvertent Energization
ANSI Code 50/27

Protection against inadvertent energization of generators that are shut down.



Example: Generator shutdown and normal starting.



Example: Generator shutdown and inadvertent starting.

Description

The protection function checks the generator starting sequence to detect inadvertent energization of generators that are shut down.
A generator which is energized when shut down operates like a motor. A starting current occurs and produces significant heat rise that can damage machine windings.

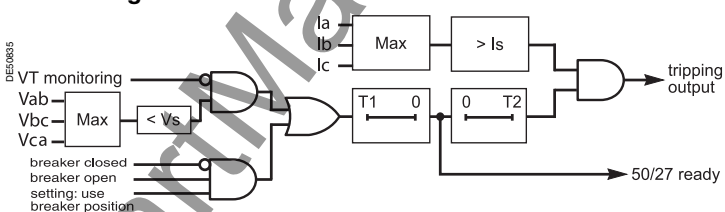
The check on the generator starting sequence is carried out by an instantaneous phase overcurrent protection function, confirmed by an undervoltage protection function. The undervoltage protection function is set up with:

- an on time delay T1 to make the function insensitive to voltage sags
- a timer hold T2 during which the function detects a generator starting current caused by inadvertent energization.

By taking into account the circuit-breaker position, it is possible to check the quality of synchronization. If the voltage and frequency differences are too high when the circuit breaker closes, a current immediately appears that the element detects.

When the VT monitoring detects a measurement problem on the voltage channels, the part concerning the voltages is blocked.

Block Diagram



Characteristics

Settings				
Current Set Point				
Setting range	0.5 to 4 I_N			
Accuracy (1)	±5% or 0.02 I_N			
Resolution	1 A			
Drop out/pick up ratio	95.5% or 0.015 I_N			
Voltage Set Point				
Setting range	10% to 100% of V_{LL}			
Accuracy (1)	±2% or 0.005 V_{LL}p			
Resolution	1%			
Drop out/pick up ratio	103%			
Advanced Settings				
Use of Breaker Position				
Setting range	Used / not used			
T1 Time				
Setting range	0 to 10 s			
Accuracy (1)	±2% or from -10 ms to +25 ms			
Resolution	10 ms or 1 digit			
T2 Time				
Setting range	0 to 10 s			
Accuracy (1)	±2% or from -10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Characteristic times (1)				
Operation time	< 40 ms at 2 Is (typically 30 ms)			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P50/27_1_101	■	■	
Protection blocking	P50/27_1_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Tripping output	P50/27_1_3	■	■	■
Protection blocked	P50/27_1_16	■	■	
Protection ready	P50/27_1_35	■	■	

(1) *Under reference conditions (IEC 60255-6).*

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Inadvertent Energization
ANSI Code 50/27

Example

Synchronous generator data

- S = 3.15 MVA
- $V_{LLN}1$ = 6.3 kV
- Xd = 233%
- X'd = 21%
- X''d = 15%
- the generator is connected to a network with a Psc = 10 MVA
- the maximum admissible duration of a voltage sag is 2.5 seconds.

To set the protection function, it is necessary to calculate the rated generator impedance:

- IB = S/($\sqrt{3}$ $V_{LLN}1$) = 289 A
- Z_N = $V_{LLN}1$/ ($\sqrt{3}$ IB) = 12.59 Ω.

The network impedance is:
Zpsc = $(V_{LLN}1)^2$/Psc = 3.97 Ω.

The Istart starting current is approximately:

$$\text{Istart} = \frac{V_{LLN}1}{\sqrt{3}\left(\text{Zpsc} + \frac{X'd}{100} \times Z_N\right)} = 621\ \text{A}$$

The current set point is set between 20% and 50% of the starting current.

$$\text{Is} = 0.5 \times \text{Istart} \approx 311\ \text{A}$$

The voltage set point is often set between 80% and 85% of V_{LLN}. In this example, the selected set point is $V_{LL}s$ = 85%.

The T1 time is set longer than the maximum admissible duration of a voltage sag, e.g. T1 = 4 sec.

T2 is set to detect the appearance of a current during starting.
For example, T2 = 250 ms.

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Phase Overcurrent
ANSI Code 50/51

Protection against overcurrents and overloads.

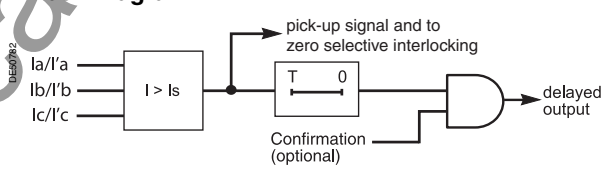
Description

Protection against overcurrents and overloads:

- the protection function is three-phase and has a definite or IDMT time delay
- each of the eight units has two groups of settings. Switching to setting group A or B can be carried out by a logic input or a remote control command, depending on the settings
- for better detection of distant faults, the protection function can be confirmed by:
  - undervoltage protection unit 1 or
  - negative sequence overvoltage protection unit 1
- the customized curve, defined point by point, may be used with this protection function
- an adjustable timer hold, definite time or IDMT, can be used for coordination with electromagnetic relays and to detect restriking faults.
- Set IDMT Trip Curves by Time delay T (at $I/I_{set} = 10$) or TMS Factor (like Time Dial Setting) - refer to topic "General Trip Curves at the end of this section

Tripping Curve	Timer Hold
Definite time (DT)	Definite time
Standard inverse time (SIT)	Definite time
Very inverse time (VIT or LTI)	Definite time
Extremely inverse time (EIT)	Definite time
Ultra inverse time (UIT)	Definite time
RI curve	Definite time
IEC inverse time SIT / A	Definite time or IDMT
IEC very inverse time VIT or LTI / B	Definite time or IDMT
IEC extremely inverse time EIT / C	Definite time or IDMT
IEEE moderately inverse (IEC / D)	Definite time or IDMT
IEEE very inverse (IEC / E)	Definite time or IDMT
IEEE extremely inverse (IEC / F)	Definite time or IDMT
IAC inverse	Definite time or IDMT
IAC very inverse	Definite time or IDMT
IAC extremely inverse	Definite time or IDMT
Customized	Definite time

Block Diagram



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Phase Overcurrent
ANSI Code 50/51

Characteristics

Settings		
Measurement Origin		
Setting range	Main channels (I) / Additional channels (I')	
Tripping Curve		
Setting range	See previous page	
Is Set Point		
Setting range	Definite time	0.05 I_N ≤ Is ≤ 24 I_N expressed in amperes
	IDMT	0.05 I_N ≤ Is ≤ 2.4 I_N expressed in amperes
Accuracy (1)	±5% or ±0.01 I_N	
Resolution	1 A or 1 digit	
Drop out/pick up ratio	93.5% ±5% or > (1 - 0.015 I_N/Is) x 100%	
Time Delay T (Operation Time at 10 Is)		
Setting range	Definite time	Inst, 50 ms ≤ T ≤ 300 s
	IDMT	100 ms ≤ T ≤ 12.5 s or TMS (2)
Accuracy (1)	Definite time	±2% or from –10 ms to +25 ms
	IDMT	Class 5 or from –10 ms to +25 ms
Resolution	10 ms or 1 digit	
Advanced Settings		
Confirmation		
Setting range	By undervoltage (unit 1) By negative sequence overvoltage (unit 1) None, no confirmation	
Timer Hold T1		
Setting range	Definite time	0; 0.05 to 300 s
	IDMT (3)	0.5 to 20 s
Resolution	10 ms or 1 digit	
Characteristic Times		
Operation time	pick-up < 35 ms at 2 Is (typically 25 ms) Inst. < 50 ms at 2 Is (confirmed instantaneous) (typically 35 ms)	
Overshoot time	< 50 ms at 2 Is	
Reset time	< 50 ms at 2 Is (for T1 = 0)	

Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P50/51_x_101	■	■	
Protection blocking	P50/51_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P50/51_x_1	■	■	
Delayed output	P50/51_x_3	■	■	■
Drop out	P50/51_x_4	■	■	
Phase "a" fault	P50/51_x_7	■	■	
Phase "b" fault	P50/51_x_8	■	■	
Phase "c" fault	P50/51_x_9	■	■	
Protection blocked	P50/51_x_16	■	■	

x: unit number.
***(1)** Under reference conditions (IEC 60255-6).*
***(2)** Setting ranges in TMS (Time Multiplier Setting) mode*
- *Inverse (SIT) and IEC SIT/A: 0.04 to 4.20*
- *Very inverse (VIT) and IEC VIT/B: 0.07 to 8.33*
- *Very inverse (LTI) and IEC LTI/B: 0.01 to 0.93*
- *Ext. inverse (EIT) and IEC EIT/C: 0.13 to 15.47*
- *IEEE moderately inverse: 0.42 to 51.86*
- *IEEE very inverse: 0.73 to 90.57*
- *IEEE extremely inverse: 1.24 to 154.32*
- *IAC inverse: 0.34 to 42.08*
- *IAC very inverse: 0.61 to 75.75*
- *IAC extremely inverse: 1.08 to 134.4.*

***(3)** Only for standardized tripping curves of the IEC, IEEE and IAC types.*

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Ground Fault
ANSI Code 50N/51N or 50G/51G

Protection against ground faults.

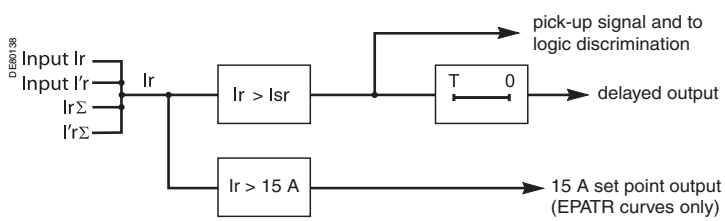
Description

Ground fault protection based on measured neutral, zero sequence or ground fault (tank ground leakage protection) current:

- the protection function has a definite or IDMT time delay
- each of the eight units has two groups of settings. Switching to setting group A or B can be carried out by a logic input or a remote control command, depending on the settings
- The protection function includes settable second harmonic restraint which provides greater stability when transformers are energized.
- the customized curve, defined point by point, may be used with this protection function
- an adjustable timer hold, definite or IDMT, can be used for coordination with electromagnetic relays and to detect restriking faults
- each unit can be independently set to one of the two measurement channels Ir or I'r or to the sum of the phase currents on the main or additional channels. By mixing the possibilities on the different units, it is possible to have:
  - different dynamic set points
  - different applications, like zero sequence and tank ground leakage protection.
- Set IDMT Trip Curves by Time delay T (at $I/I_{set} = 10$) or TMS Factor (like Time Dial Setting) - refer to topic "General Trip Curves at the end of this section

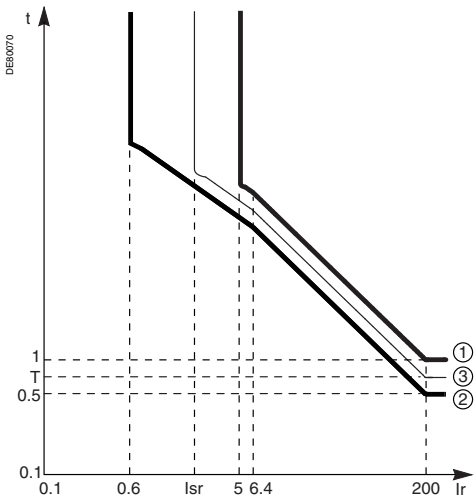
Tripping Curve	Timer Hold Curve
Definite time (DT)	Definite time
Standard inverse time (SIT)	Definite time
Very inverse time (VIT or LTI)	Definite time
Extremely inverse time (EIT)	Definite time
Ultra inverse time (UIT)	Definite time
RI curve	Definite time
IEC inverse time SIT / A	Definite time or IDMT
IEC very inverse time VIT or LTI / B	Definite time or IDMT
IEC extremely inverse time EIT / C	Definite time or IDMT
IEEE moderately inverse (IEC / D)	Definite time or IDMT
IEEE very inverse (IEC / E)	Definite time or IDMT
IEEE extremely inverse (IEC / F)	Definite time or IDMT
IAC inverse	Definite time or IDMT
IAC very inverse	Definite time or IDMT
IAC extremely inverse	Definite time or IDMT
EPATR-B	Definite time
EPATR-C	Definite time
Customized	Definite time

Block Diagram



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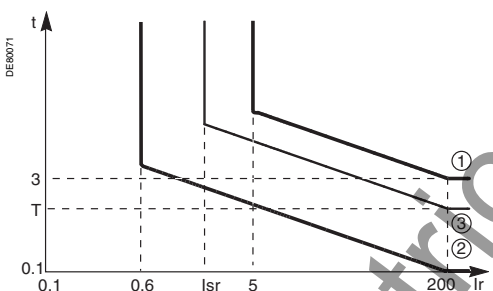
EPATR-B standard curve (log scales)

Curve ① : Isr = 5 A and T = 1 s
Curve ② : Isr = 0.6 A and T = 0.5 s
Curve ③ : Isr and T

EPATR-B curves

EPATR-B tripping curves are defined from the following equations:

- for Isr ≤ Ir ≤ 6.4 A $t = \frac{85.386}{I0^{0.708}} \times \frac{T}{0.8}$
- if 6.4A ≤ Ir ≤ 200A $= \frac{140.213}{I0^{0.975}} \times \frac{T}{0.8}$
- for Ir > 200 A $t = T$



EPATR-C standard curve (log scales)

Curve ① : Isr = 5 A and T = 3 s
Curve ② : Isr = 0.6 A and T = 0.1 s
Curve ③ : Isr and T

EPATR-C Curves

EPATR-C tripping curves are defined from the following equations:

- for Isr ≤ Ir ≤ 200 A $t = \frac{72}{I0^{2/3}} \times \frac{T}{2.10}$
- for Ir > 200 A $t = T$

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Ground Fault
ANSI Code 50N/51N or 50G/51G

Characteristics

Settings		
Measurement Origin		
Setting range	Ir I'r IrΣ (sum of the main phase channels) I'rΣ (sum of the additional phase channels)	
Tripping Curve		
Setting range	See previous page	
Isr Setting		
Definite time Setting range	0.01 Inr ≤ Isr ≤ 15 Inr (min. 0.1 A) expressed in amperes	
	Sum of CTs	0.01 In ≤ Isr ≤ 15 In (min. 0.1 A)
	With CSH sensor 2 A rating 20 A rating	 0.1 to 30 A 0.2 to 300 A
	CT	0.01 Inr ≤ Isr ≤ 15 Inr (min. 0.1 A)
	Zero sequence CT + ACE990	0.01 Inr ≤ Isr ≤ 15 Inr (min. 0.1 A)
IDMT Setting range	0.01 Inr ≤ Isr ≤ Inr (min. 0.1 A) expressed in amperes	
	Sum of CTs	0.01 In ≤ Isr ≤ In (min. 0.1 A)
	With CSH sensor 2 A rating 20 A rating	 0.1 to 2 A 0.2 to 20 A
	CT	0.01 Inr ≤ Isr ≤ Inr (min. 0.1 A)
	Zero sequence CT + ACE990	0.01 Inr ≤ Isr ≤ Inr (min. 0.1 A)
EPATR Setting range	CSH sensor 20 A rating	0.6 to 5 A
	Zero sequence CT with ACE990 and 15 A ≤ Inr ≤ 50 A	0.6 to 5 A
Accuracy (1)	±5% or ±0.004 In0	
Resolution	1 A or 1 digit	
Drop out/pick up ratio	93.5% ±5% or > (1 - 0.005 Inr/Isr) x 100%	
Time Delay T (Operation Time at 10 Isr)		
Setting range	Definite time	Inst, 50 ms ≤ T ≤ 300 s
	IDMT	100 ms ≤ T ≤ 12.5 s or TMS (2)
	EPATR-B	0.5 to 1 s
	EPATR-C	0.1 to 3 s
Accuracy (1)	Definite time	±2% or from –10 ms to +25 ms
	IDMT	Class 5 or from –10 ms to +25 ms
Resolution	10 ms or 1 digit	
Advanced Settings		
2nd Harmonic Restraint		
Fixed threshold	17% ±3%	
Timer Hold T1		
Setting range	Definite time	0; 0.05 to 300 s
	IDMT (3)	0.5 to 20 s
Resolution	10 ms or 1 digit	
Characteristic Times		
Operation time	Pick-up < 40 ms at 2 Isr (typically 25 ms) Confirmed instantaneous: ■ inst < 55 ms at 2 Isr for Is ≥ 0.3 Inr (typically 35 ms) ■ inst < 70 ms at 2 Isr for Is < 0.3 Inr (typically 50 ms)	
Overshoot time	< 40 ms at 2 Isr	
Reset time	< 50 ms at 2 Isr (for T1 = 0)	

Inputs			
Designation	**Syntax**	**Equations**	**Logipam**
Protection reset	P50N/51N_x_101	■	■
Protection blocking	P50N/51N_x_113	■	■

Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P50N/51N_x_1	■	■	
Delayed output	P50N/51N_x_3	■	■	■
Drop out	P50N/51N_x_4	■	■	
Protection blocked	P50N/51N_x_16	■	■	
15 A set point output	P50N/51N_x_56	■	■	

x: unit number.
***(1)** Under reference conditions (IEC 60255-6).*
***(2)** Setting ranges in TMS (Time Multiplier Setting) mode*
- *Inverse (SIT) and IEC SIT/A: 0.04 to 4.20*
- *Very inverse (VIT) and IEC VIT/B: 0.07 to 8.33*
- *Very inverse (LTI) and IEC LTI/B: 0.01 to 0.93*
- *Ext. inverse (EIT) and IEC EIT/C: 0.13 to 15.47*
- *IEEE moderately inverse: 0.42 to 51.86*
- *IEEE very inverse: 0.73 to 90.57*
- *IEEE extremely inverse: 1.24 to 154.32*
- *IAC inverse: 0.34 to 42.08*
- *IAC very inverse: 0.61 to 75.75*
- *IAC extremely inverse: 1.08 to 134.4.*

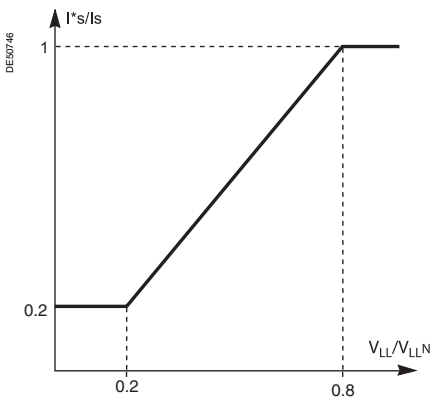
***(3)** Only for standardized tripping curves of the IEC, IEEE and IAC types.*

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Voltage-Restrained Overcurrent
ANSI Code 50V/51V

Generator protection against close short-circuits.



Set point adjustment.

Description

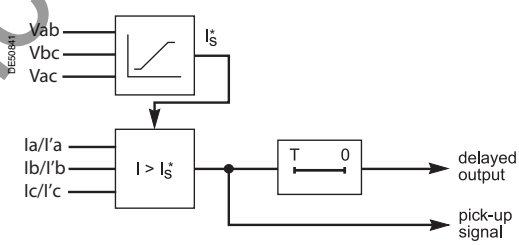
The voltage-restrained overcurrent protection function is used to protect generators. The operation set point is adjusted according to the voltage to take into account cases of faults close to the generator which cause voltage dips and short-circuit current:

- the protection function is three-phase and has a definite or IDMT time delay
- the customized curve, defined point by point, may be used with this protection function
- an adjustable timer hold, definite time or IDMT, can be used for coordination with electromagnetic relays and to detect restriking faults
- the set point is adjusted according to the lowest of the phase-to-phase voltages measured. The adjusted set point I'_s is defined by the following equation:
- Set IDMT Trip Curves by Time delay T (at $I/I_{set} = 10$) or TMS Factor (like Time Dial Setting) - refer to topic "General Trip Curves at the end of this section

$$\mathbf{I'_s = \frac{Is}{3} \times \left(4\frac{V_{LL}}{V_{LLN}} - 0.2\right)}$$

Trip Curve	Timer Hold
Definite time (DT)	Definite time
Standard inverse time (SIT)	Definite time
Very inverse time (VIT or LTI)	Definite time
Extremely inverse time (EIT)	Definite time
Ultra inverse time (UIT)	Definite time
RI curve	Definite time
IEC inverse time SIT / A	Definite time or IDMT
IEC very inverse time VIT or LTI / B	Definite time or IDMT
IEC extremely inverse time EIT / C	Definite time or IDMT
IEEE moderately inverse (IEC / D)	Definite time or IDMT
IEEE very inverse (IEC / E)	Definite time or IDMT
IEEE extremely inverse (IEC / F)	Definite time or IDMT
IAC inverse	Definite time or IDMT
IAC very inverse	Definite time or IDMT
IAC extremely inverse	Definite time or IDMT
Customized	Definite time

Block Diagram



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Voltage-Restrained Overcurrent
ANSI Code 50V/51V

Characteristics

Settings		
Measurement Origin		
Setting range	Main channels (I) / Additional channels (I')	
Tripping Curve		
Setting range	See previous page	
Is Set Point		
Setting range	Definite time	0.5 $I_N \leq I_s \leq 24\ I_N$ expressed in amperes
	IDMT	0.5 $I_N \leq I_s \leq 2.4\ I_N$ expressed in amperes
Accuracy (1)	±5%	
Resolution	1 A or 1 digit	
Drop out/pick up ratio	93.5% (with min. reset variance of 0.015 I_N)	
Time Delay T (Operation Time at 10 Is)		
Setting range	Definite time	Inst, 50 ms ≤ T ≤ 300 s
	IDMT	100 ms ≤ T ≤ 12.5 s or TMS (2)
Accuracy (1)	Definite time	±2% or from –10 ms to +25 ms
	IDMT	Class 5 or from –10 ms to +25 ms
Resolution	10 ms or 1 digit	
Advanced Settings		
Timer Hold T1		
Setting range	Definite time	0; 0.05 to 300 s
	IDMT time (3)	0.5 to 20 s
Resolution	10 ms or 1 digit	
Characteristic Times		
Operation time	pick-up < 35 ms at 2 Is (typically 25 ms) Inst. < 50 ms at 2 Is (confirmed instantaneous) (typically 35 ms)	
Overshoot time	< 50 ms	
Reset time	< 50 ms (for T1 = 0)	

Inputs

Designation	Syntax	Equations	Logipam
Protection reset	P50V/51V_x_101	■	■
Protection blocking	P50V/51V_x_113	■	■

Outputs

Designation	Syntax	Equations	Logipam	Matrix
Instantaneous output (pick-up)	P50V/51V_x_1	■	■	
Delayed output	P50V/51V_x_3	■	■	■
Drop out	P50V/51V_x_4	■	■	
Phase a fault	P50V/51V_x_7	■	■	
Phase b fault	P50V/51V_x_8	■	■	
Phase c fault	P50V/51V_x_9	■	■	
Protection blocked	P50V/51V_x_16	■	■	

x: unit number.

***(1)** Under reference conditions (IEC 60255-6).*

***(2)** Setting ranges in TMS (Time Multiplier Setting) mode*

- *Inverse (SIT) and IEC SIT/A: 0.04 to 4.20*
- Very inverse (VIT) and IEC VIT/B: 0.07 to 8.33
- Very inverse (LTI) and IEC LTI/B: 0.01 to 0.93
- *Ext. inverse (EIT) and IEC EIT/C: 0.13 to 15.47*
- IEEE moderately inverse: 0.42 to 51.86
- *IEEE very inverse: 0.73 to 90.57*
- IEEE extremely inverse: 1.24 to 154.32
- *IAC inverse: 0.34 to 42.08*
- *IAC very inverse: 0.61 to 75.75*
- *IAC extremely inverse: 1.08 to 134.4.*

***(3)** Only for standardized tripping curves of the IEC, IEEE and IAC types.*

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Capacitor Bank Unbalance
ANSI Code 51C

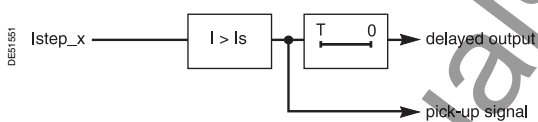
Detection of capacitor bank internal faults by measurement of the unbalance current flowing between the two neutral points of a double-wye connected capacitor bank.

Description

The capacitor bank unbalance function detects unbalance current flowing between the two neutral points of double-wye connected capacitor banks.

The protection function is activated when the unbalance current is higher than the current set point (Is) during tripping time T.

Block Diagram



Characteristics

Settings				
Set Point Is				
Setting range	0.02 I'_N to 2 I'_N with a minimum value of 0.05 A			
Accuracy (1)	±5%			
Resolution	0.01 A			
Drop out/pick up ratio	93.5%			
Time Delay				
Setting range	0.1 to 300 s			
Accuracy (1)	±2% or ±25 ms			
Resolution	10 ms or 1 digit			
Characteristic Times (1)				
Operation time	Pick-up < 35 ms			
Overshoot time	< 35 ms			
Reset time	< 50 ms			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P51C_x_101	■	■	
Protection blocking	P51C_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output	P51C_x_1	■	■	
Tripping output	P51C_x_3	■	■	■
Protection blocked	P51C_x_16	■	■	

x: unit number.
***(1)** Under reference conditions (IEC 60255-6).*

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Overvoltage (L-L or L-N)
ANSI Code 59

Protection against phase-to-neutral or phase-to-phase overvoltages.

Description

Protection against overvoltages or checking for sufficient voltage to enable source transfer.

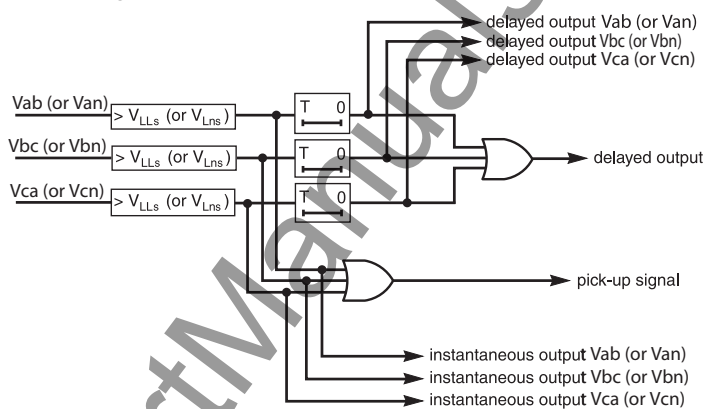
- the protection function is single-phase and operates with phase-to-neutral or phase-to-phase voltage
- it includes a definite time delay, T
- in phase-to-neutral operation, it indicates the faulty phase in the alarm associated with the fault

Operation with phase-to-neutral or phase-to-phase voltage depends on the connection selected for the voltage inputs.

Connection conditions					
Type of connection	Van, Vbn, Vcn (1)	Vab, Vbc + Vr	Vab, Vbc	Vab (1)	Van (1)
Phase-to-neutral operation	YES	YES	NO	NO	On Van only
Phase-to-phase operation	YES	YES	YES	On Vab only	NO

(1) With or without Vr.

Block Diagram



Characteristics

Settings	
Measurement Origin	
Setting range	Main channels (V_{LL}) / Additional channels (V_{LL}')
Voltage Mode	
Setting range	Phase-to-phase voltage / Phase-to-neutral voltage
V_{LL}s (or V_{Ln}s) Set Point	
Setting range	50% of V_{LL}p (or V_{Ln}p) to 150% of V_{LL}p (or V_{Ln}p)
Accuracy (1)	±2%
Resolution	1%
Drop out/pick up ratio	97% ±1%
Time Delay T	
Setting range	50 ms to 300 s
Accuracy (1)	±2% or ±25 ms
Resolution	10 ms or 1 digit
Characteristic Times	
Operation time	Pick-up < 40 ms from 0.9 V_{LL}s (V_{Ln}s) to 1.1 V_{LL}s (V_{Ln}s) (typically 25 ms)
Overshoot time	< 40 ms from 0.9 V_{LL}s (V_{Ln}s) to 1.1 V_{LL}s (V_{Ln}s)
Reset time	< 50 ms from 1.1 V_{LL}s (V_{Ln}s) to 0.9 V_{LL}s (V_{Ln}s)

Inputs			
Designation	**Syntax**	**Equations**	**Logipam**
Protection reset	P59_x_101	■	■
Protection blocking	P59_x_113	■	■

Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P59_x_1	■	■	
Delayed output	P59_x_3	■	■	■
Fault phase a (2)	P59_x_7	■	■	
Fault phase b(2)	P59_x_8	■	■	
Fault phase c(2)	P59_x_9	■	■	
Protection blocked	P59_x_16	■	■	
Instantaneous output Van or Vab	P59_x_23	■	■	
Instantaneous output Vbn or Vbc	P59_x_24	■	■	
Instantaneous output Vcn or Vca	P59_x_25	■	■	
Delayed output Van or Vab	P59_x_26	■	■	
Delayed output Vbn or Vbc	P59_x_27	■	■	
Delayed output Vcn or Vca	P59_x_28	■	■	

x: unit number.
***(1)** Under reference conditions (IEC 60255-6).*
***(2)**When the protection function is used for phase-to-neutral voltage.*

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Neutral Voltage Displacement
ANSI Code 59N

Protection against insulation faults

Description

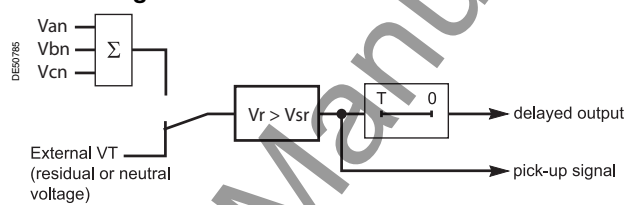
This function provides protection against insulation faults by measuring the residual voltage Vr or the neutral point voltage $V_{Ln}t$ for generators and motors.

The residual voltage is obtained by the vector sum of the phase voltages or by measurements using delta connected VTs. The neutral point voltage is measured by a VT inserted in the neutral point of the generator or the motor.

The protection function includes a time delay T, either definite or IDMT (dependent on the residual voltage Vr) (see tripping curve equation on page 173).

It operates only when a residual or neutral point voltage is available, by connecting VanVbnVcn, Vr, or $V_{Ln}t$.

Block Diagram



Characteristics

Settings				
Measurement Origin				
Setting range	Main channels (Vr) Additional channels (V'r) Neutral-point voltage ($V_{Ln}t$)			
Tripping Curve				
Setting range	Definite time IDMT (dependent on the residual voltage Vr)			
Vsr Set Point				
Definite time setting range	2% to 80% $V_{LL}p$ (for residual voltage Vr) 2% to 80% Vntp (for neutral point voltage Vnt)			
IDMT setting range	2% to 10 % $V_{LL}p$ (for residual voltage Vr) 2% to 10 % Vntp (for neutral point voltage $V_{Ln}t$)			
Accuracy (1)	±2% or 0.005 $V_{LL}p$			
Resolution	1%			
Drop out/pick up ratio	97% ±2% or > (1 - 0.006 $V_{LL}p$/Vsr) x 100%			
Time Delay T (Tripping Time at 2 Vsr)				
Definite time setting range	50 ms to 300 s			
IDMT setting range	100 ms to 10 s			
Accuracy (1)	±2% or ±25 ms			
Resolution	10 ms or 1 digit			
Characteristic Times				
Operation time	pick-up < 45 ms (typically 25 ms) at 2 Vsr			
Overshoot time	< 40 ms at 2 Vsr			
Reset time	< 40 ms at 2 Vsr			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P59N_x_101	■	■	
Protection blocking	P59N_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P59N_x_1	■	■	
Delayed output	P59N_x_3	■	■	■
Protection blocked	P59N_x_16	■	■	

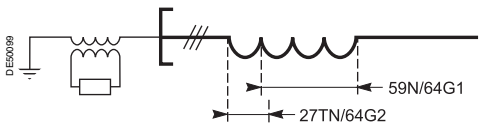
x: unit number.
***(1)** Under reference conditions (IEC 60255-6).*

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100% Stator Ground Fault
ANSI Code 64G

Protection against internal faults in generators.



Description

The 64G protection function is made of the two independent functions:

- protection function 64G1 which commonly corresponds to a neutral voltage displacement function at the fundamental frequency (ANSI code 59N). It may be implemented by a ground fault protection function (ANSI code 51N) when the ground fault current is sufficient.
- protection function 64G2 which corresponds to a third harmonic undervoltage function (ANSI code 27TN) whose operating principle depends on the type of connection of the generator terminal VTs.

When a single-phase fault occurs, the flow of the zero sequence current increases the potential of the neutral point, detected by protection function 59N. However, given the natural unbalance of the three network phases, the sensitivity set point for 59N cannot be set under 10% to 15% of the phase-to-neutral voltage.

If the single-phase fault occurs on a stator winding near the neutral point, the increase in the potential at the neutral point may be insufficient to trip protection function 59N.

The combination of functions 59N and 27TN is the means to protect 100% of the stator winding. Depending on the settings:

- protection function 59N protects 85 to 95% of the stator winding on the terminal side and
- protection function 27TN protects 10 to 20% of the stator winding on the neutral point side.

To create a 100% stator ground fault protection function, it is necessary to implement the 64G1 (59N or 51N) and the 64G2 (27TN) protection functions (see each of these functions for more information).

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Restricted Ground Fault Differential
ANSI Code 64REF

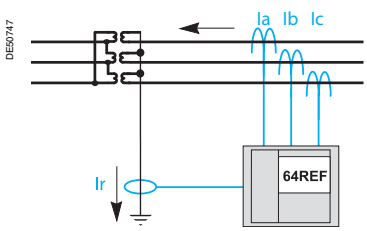
Protection of 3-phase windings against phase-to-ground faults.

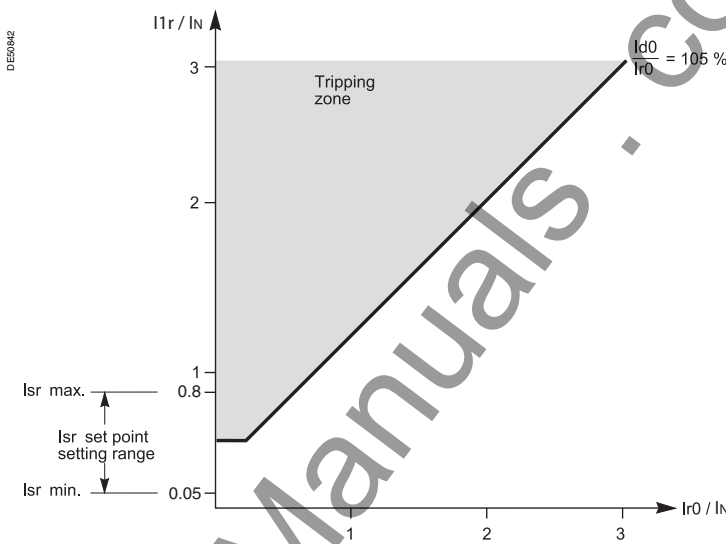
Description

The restricted ground fault protection function detects phase-to-ground faults on three-phase windings with grounded neutral. This function protects generators and transformers.

The protected zone, depending on the measurement origin and the set parameters, is between:

- the Ia, Ib, Ic CTs and the neutral point current measurement Ir
- the I'a, I'b, I'c CTs and the neutral point current measurement I'r.





The function is based on the comparison of the residual current calculated using the sum of the three phase currents and the neutral point current. These two currents define the differential residual current and the restrained current:

- differential residual current: $I1r = |\vec{I}r\Sigma - \vec{I}r|$
- restrained current or through residual current: the value of the restrained current depends on detection of a fault outside the protected zone:
  - without detection of an external fault

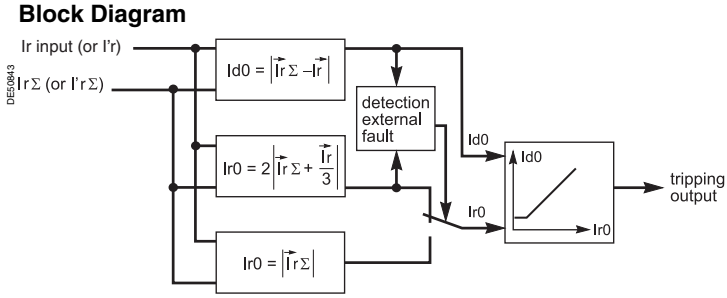
    $Ir0 = |\vec{I}r\Sigma|$
  - with detection of an external fault: the protection function is insensitive to saturation of the CTs, but its operation is not blocked.

    $Ir0 = 2 \times \left|\vec{I}r\Sigma + \frac{\vec{I}r}{3}\right|$

The function picks up if the differential residual current is greater than the operating set point. The set point is defined by:

- the minimum set point Is0
- a tripping characteristic with a slope of 1.05 (differential residual current vs. restrained current).

Block Diagram



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Restricted Ground Fault Differential
ANSI Code 64REF

Sizing Current Transformers

The primary currents of the current transformers used must comply with the following rule:

0.1 $I_N \leq I_{Nr} \leq$ 2 I_N

with I_N = primary current of phase CTs
and I_{Nr} = primary current of the neutral point CT.

The current transformer should be defined by which equation produces the highest knee point voltage:

a. $Vk \geq (RCT + Rw) \times 20\ I_N$
b. $Vk \geq (RCT + Rw)\ (1.6\ I3P / I_N) \times I_N$
c. $Vk \geq (RCT + Rw)\ (2.4\ I1P / I_N) \times I_N$

The equations apply to the phase current transformers and the neutral-point current transformer.
I_N is the CT rated secondary current.
R_{CT} is the CT internal resistance.
Rw is the resistance of the CT load and wiring.
I_{3P} is the maximum current value for a three-phase short-circuit.
I_{1P} is the maximum current value for a phase-to-ground short-circuit.

Characteristics

Settings				
Measurement Origin				
Setting range	Main channels (I, Ir) Additional channels (I', I'r)			
Isr				
Setting range	0.05 I_N to 0.8 I_N for $I_N \geq$ 20 A 0.1 I_N to 0.8 I_N for $I_N <$ 20 A			
Accuracy (1)	5%			
Resolution	1 A or 1 digit			
Drop out/pick up ratio	93% ±2%			
Characteristic Times				
Operation time	< 55 ms at I1r = 2.1 Ir0			
Overshoot time	< 35 ms at I1r = 2.1 Ir0			
Reset time	< 45 ms at I1r = 2.1 Ir0			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P64REF_x_101	■	■	
Protection blocking	P64REF_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Protection output	P64REF_x_3	■	■	■
Protection blocked	P64REF_x_16	■	■	

x: unit number.
***(1)** Under reference conditions (IEC 60255-6).*

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Starts per Hour
ANSI Code 66

Motor protection against heat rise caused overly frequent starts.

Description

Protection against motor overheating caused by:
- overly frequent starts: motor energizing is blocked when the maximum permissible number of starts is reached
- starts occur too close to one another: motor re-energizing after a shutdown is allowed only after an adjustable time delay.

Starting is detected when the current drawn rises above 5% of current IB.
The number of starts is limited by:
- the number of starts (Nt) allowed per period of time (P)
- the permissible number of consecutive hot starts (Nh)
- the permissible number of consecutive cold starts (Nc).

The number of consecutive starts is the number starts counted during the last P/Nt minutes.

The motor hot state corresponds to the overshooting of the fixed set point (50% heat rise) of the thermal overload function. During re-acceleration, the motor is subjected to a stress similar to that of starting without the current first passing through a value less than 5% of IB. In this case, the number of starts is not incremented. It is however possible to increment the number of starts for a re-acceleration using a logic input or information from a logic equation or Logipam program ("motor re-acceleration" input).

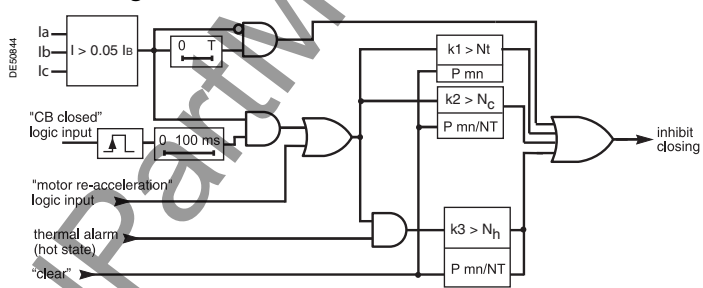
The "stop/start" time delay T may be used to block starting after a stop until the delay has elapsed and thus impose a minimum stop time before each restart.

Use of Circuit Breaker Closed Data
In synchronous motor applications, it is advisable to connect the "circuit breaker closed" data to a logic input in order to enable more precise detection of starts.

User Information
The following information is available for the user:
- the time before a start is allowed
- the number of starts still allowed.

See the section on machine diagnosis.

Block Diagram



where **k1** = counter #1 for total starts
k2 = counter #2 for cold starts
Nc = number of cold starts
Nh = number of hot starts
Nt = total number of starts allowed per period of time.
k3 = counter #3 for hot starts
P = period of time

Characteristics

Settings				
Period of Time (P)				
Setting range	1 to 6 hours			
Resolution	1 h			
Total Number of Starts (Nt) Allowed per Period of Time (P)				
Setting range	1 to 60			
Resolution	1			
Number of Consecutive Hot Starts (Nh)				
Setting range	1 to Nf			
Resolution	1			
Number of Consecutive Cold Starts (Nc)				
Setting range	1 to Nt			
Resolution	1			
Stop/start Time Delay				
Setting range	0 to 90 min. (0 = no delay)			
Resolution	1 min.			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P66_1_101	■	■	
Motor re-acceleration	P66_1_102	■	■	
Protection blocking	P66_1_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Protection output	P66_1_3	■	■	■
Protection blocked	P66_1_16	■	■	
Stop/start block	P66_1_29	■	■	
Total number starts reached	P66_1_30	■	■	
Total consecutive starts reached	P66_1_31	■	■	

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Directional Phase Overcurrent
ANSI Code 67

Phase-to-phase short-circuit protection, with selective tripping according to fault current direction.

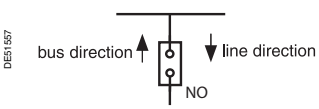
Description

This function comprises a phase overcurrent function associated with direction detection and picks up if the phase overcurrent function in the chosen direction (line or bus) is activated for at least one of the three phases (or two of the three, depending on the settings).

- the protection function is 3-phase and has a definite or IDMT time delay.
- each of the two units has two groups of settings. Switching to setting group A or B can be carried out by a logic input or remote control command, depending on the settings.
- the customized curve, defined point by point, may be used with this protection function.
- an adjustable timer hold, definite time or IDMT, can be used for coordination with electromagnetic relays and to detect restriking faults.
- the alarm linked to the protection function indicates the faulty phase or phases.

Tripping Direction

Current flow direction is determined by measuring the phase in relation to a polarization value. It is qualified as either bus or line direction, as shown below:



Tripping can be set to occur in either zone. The zone in which tripping does not occur is used for indication.

Polarization Value

The polarization value is the phase-to-phase value in quadrature with the current for cosθ = 1 (90° connection angle). A phase current vector plane is divided into two half-planes that correspond to the line zone and bus zone. The characteristic angle θ is the angle of the perpendicular to the boundary line between the two zones and the polarization value.

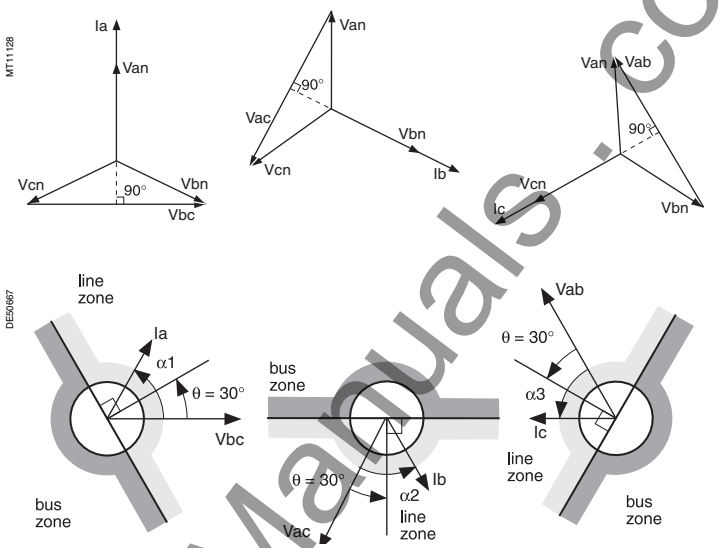
Voltage Memory

Should all the voltages disappear during a 3-phase fault near the bus, the voltage level may be insufficient for the fault direction to be detected (< 1.5 % $V_{LL}p$). The protection function therefore uses a voltage memory to reliably determine the direction. The fault direction is saved as long as the voltage level is too low and the current is above the Is set point.

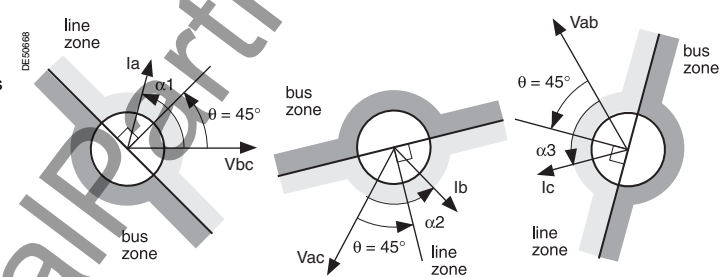
Closing on a Pre-Existing Fault

If the circuit breaker is closed when there is a pre-existing 3-phase fault on the bus, the voltage memory is blank. As a result, the direction cannot be determined and the protection does not trip.

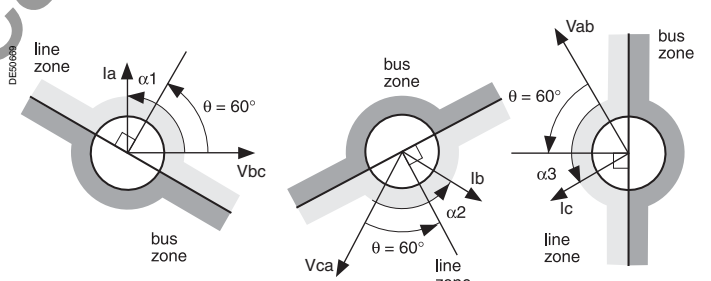
In such cases, a backup 50/51 protection function should be used.



Fault tripping in line zone with θ = 30°



Fault tripping in line zone with θ = 45°



Fault tripping in line zone with θ = 60°

Tripping Logic

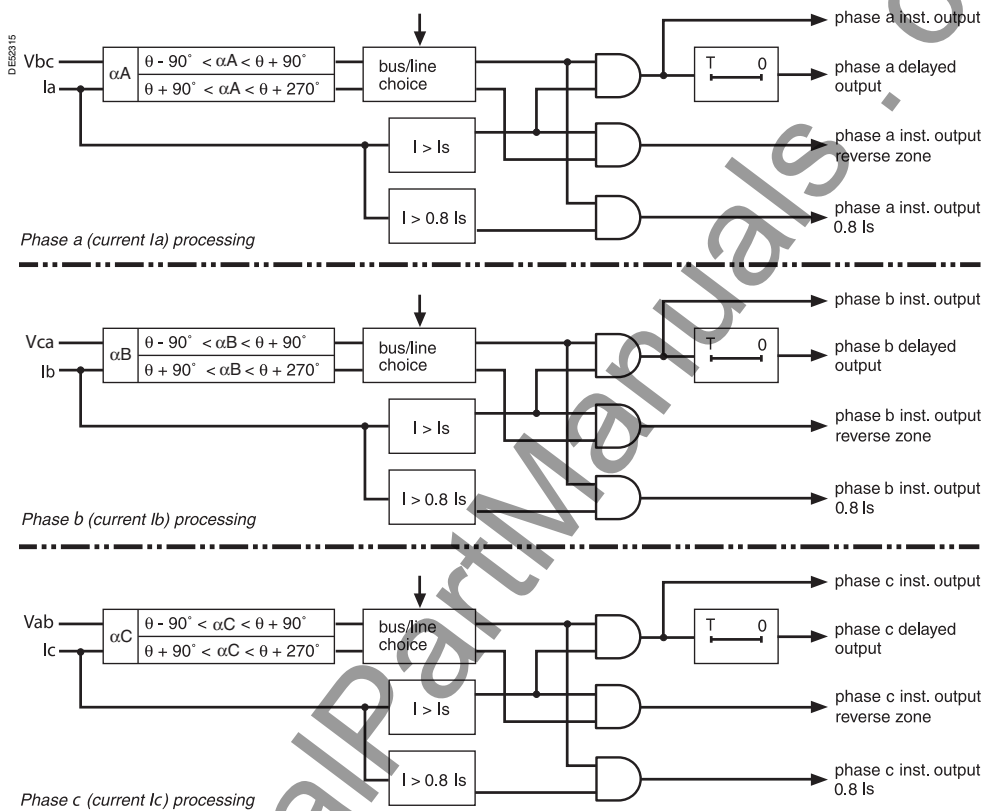
In certain cases, it is wise to select the "two out of three phases" tripping logic. Such cases may occur when two parallel transformers (Dy) must be protected. For a 2-phase fault on a transformer primary winding, there is a 2-1-1 current distribution at the secondary end. The highest current is in the expected zone (operation zone for the faulty main, no operation zone for the fault-free main).

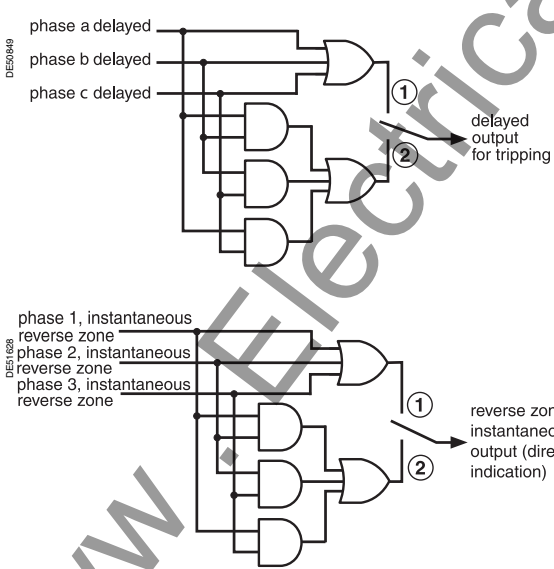
One of the lowest currents is at the edge of the zone. According to the line parameters, it may even be in the wrong zone. There is therefore a risk of tripping both mains.

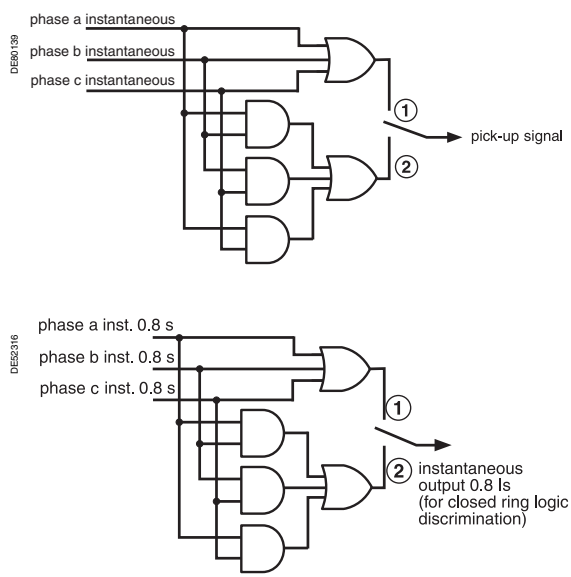
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Directional Phase Overcurrent
ANSI Code 67

Block Diagram







Grouping output data.

Tripping logic parameter setting:

(1) *one out of three*

(2) *two out of three*

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Directional Phase Overcurrent
ANSI Code 67

Tripping Curve	TimerHhold
Definite time (DT)	Definite time
Standard inverse time (SIT)	Definite time
Very inverse time (VIT or LTI)	Definite time
Extremely inverse time (EIT)	Definite time
Ultra inverse time (UIT)	Definite time
RI curve	Definite time
IEC inverse time SIT / A	Definite time or IDMT
IEC very inverse time VIT or LTI / B	Definite time or IDMT
IEC extremely inverse time EIT / C	Definite time or IDMT
IEEE moderately inverse (IEC / D)	Definite time or IDMT
IEEE very inverse (IEC / E)	Definite time or IDMT
IEEE extremely inverse (IEC / F)	Definite time or IDMT
IAC inverse	Definite time or IDMT
IAC very inverse	Definite time or IDMT
IAC extremely inverse	Definite time or IDMT
Customized	Definite time

Characteristics

Settings		
Characteristic Angle θ		
Setting range		30°, 45°, 60°
Accuracy (1)		±2%
Tripping Curve		
Setting range		See list above
Is Set Point		
Setting range	definite time	0.1 I_N ≤ Is ≤ 24 I_N in amperes
	IDMT	0.1 I_N ≤ Is ≤ 2.4 I_N in amperes
Accuracy (1)		±5% or ±0.01 I_N
Resolution		1 A or 1 digit
Drop out/pick up ratio		93.5% ±5% or > (1 - 0.015 I_N/Is) x 100%
Time Delay T (Operation Time at 10 Is)		
Setting range	definite time	Inst, 50 ms ≤ T ≤ 300 s
	IDMT	100 ms ≤ T ≤ 12.5 s or TMS (2)
Accuracy (1)	definite time (4)	±2% or from –10 ms to +25 ms
	IDMT	Class 5 or from –10 ms to +25 ms
Resolution		10 ms or 1 digit
Advanced Settings		
Tripping Direction		
Setting range		Bus / line
Tripping Logic		
Setting range		One out of three / two out of three
Timer Hold T1		
Setting range	definite time	0; 0.05 to 300 s
	IDMT (3)	0.5 to 20 s
Resolution		10 ms or 1 digit
Characteristic Times		
Operation time		pick-up < 75 ms at 2 Is (typically 65 ms) Inst. < 90 ms at 2 Is (confirmed instantaneous) (typically 75 ms)
Overshoot time		< 45 ms at 2 Is
Reset time		< 55 ms at 2 Is (for T1 = 0)

Inputs			
Designation	**Syntax**	**Equations**	**Logipam**
Protection reset	P67_x_101	■	■
Protection blocking	P67_x_113	■	■

Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P67_x_1	■	■	
Delayed output	P67_x_3	■	■	■
Drop out	P67_x_4	■	■	
Instantaneous output (reverse zone)	P67_x_6	■	■	
Phase a fault	P67_x_7	■	■	
Phase b fault	P67_x_8	■	■	
Phase c fault	P67_x_9	■	■	
Protection blocked	P67_x_16	■	■	
Instantaneous output at 0.8 Is	P67_x_21	■	■	
1 out of 3 delayed output	P67_x_36	■	■	
2 out of 3 delayed output	P67_x_37	■	■	

x: unit number.
(1) *Under reference conditions (IEC 60255-6).*
(2) *Setting ranges in TMS (Time Multiplier Setting) mode*
Inverse (SIT) and IEC SIT/A: 0.04 to 4.20
Very inverse (VIT) and IEC VIT/B: 0.07 to 8.33
Very inverse (LTI) and IEC LTI/B: 0.01 to 0.93
Ext. inverse (EIT) and IEC EIT/C: 0.13 to 15.47
IEEE moderately inverse: 0.42 to 51.86
IEEE very inverse: 0.73 to 90.57
IEEE extremely inverse: 1.24 to 154.32
IAC inverse: 0.34 to 42.08
IAC very inverse: 0.61 to 75.75
IAC extremely inverse: 1.08 to 134.4.
(3) *Only for standardized tripping curves of the IEC, IEEE and IAC types.*

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Directional Ground Fault - Type 1
ANSI Code 67N/67NC

Ground fault protection, with selective tripping according to fault current direction.

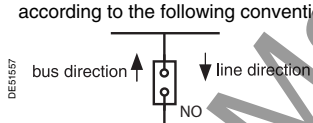
Description

In order to adapt to all types of applications and all grounding systems, the protection function operates according to three different types of characteristics:

- **type 1:** the protection function uses Ir vector projection. This projection method is suitable for radial feeders in resistive, effectively ungrounded, or compensated neutral systems (designed to compensate for system capacitance using a tuned inductor in the neutral. This is not common in North America).
- **type 2:** the protection function uses the Ir vector magnitude and operates like a ground fault protection function with an added direction criterion. This projection method is used with closed ring distribution networks with directly grounded neutral.
- **type 3:** the protection function uses the Ir vector magnitude and complies with Italian specification ENEL DK5600. It operates like a ground fault protection function with an added angular direction criterion {*Lim.1*, *Lim.2*}. This protection method is suitable for distribution networks in which the neutral grounding system varies according to the operational mode.

Tripping direction

The direction of the residual current is qualified as bus direction or line direction according to the following convention:



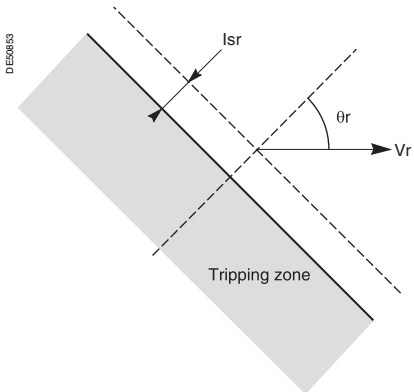
The tripping zone is set for tripping in the bus zone or in the line zone.
The reverse zone is the zone for which the protection function does not trip. The detection of current in the reverse zone is used for indication.

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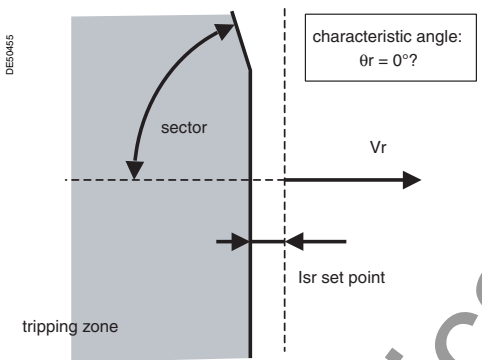
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Directional Ground Fault - Type 1
ANSI Code 67N/67NC

Ground fault protection for impedant or compensated neutral systems.



Tripping characteristic of ANSI 67N/67NC type 1 protection (characteristic angle θ0 ≠ 0°).



Tripping characteristic of ANSI 67N/67NC type 1 protection (characteristic angle θ0 = 0°).

Description

The function determines the projection of the residual current Ir on the characteristic line, the position of which is determined by the setting of characteristic angle θr in relation to the residual voltage. The projection value is compared to the Isr set point. This protection function is suitable for radial feeders in resistive, effectively ungrounded or compensated neutral systems (designed to compensate for system capacitance using a tuned inductor in the neutral. This is not common in North America).

With compensated neutral systems, it is characterized by its capacity to detect very brief, repetitive faults (recurrent faults). In the case of Petersen coils with no additional resistance, fault detection under steady state conditions is not possible due to the absence of active zero sequence current. The protection function uses the transient current at the beginning of the fault to ensure tripping.

The θr = 0° setting is suitable for compensated or resistance grounded systems. When this setting is selected, the parameter setting of the sector is used to reduce the protection tripping zone to ensure its stability on fault-free feeders.

The protection function operates with the residual current measured at one of the relay Ir inputs (operation with sum of three currents impossible). The protection function is blocked for residual voltages below the Vsr set point.

It implements a definite time (DT) delay.

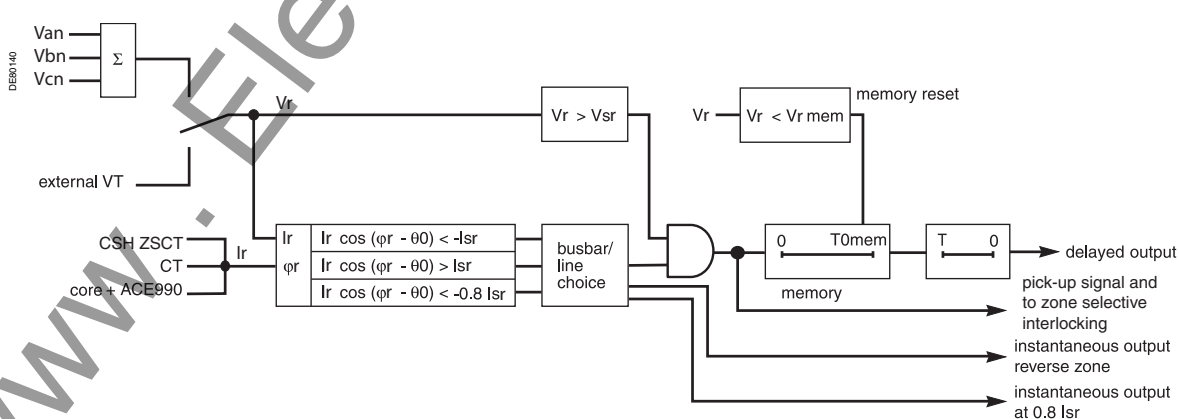
The tripping direction may be set at the bus end or line end.

Each of the two units has two groups of settings. Switching to setting group A or B can be carried out by a logic input or a remote control command, depending on the settings.

Memory

The detection of recurrent faults is controlled by the time delay T0mem which extends the transient pick-up information, thereby enabling the operation of the definite time delay even with faults that are rapidly extinguished (≈ 2 ms) and restrike periodically. Even when a Petersen coil with no additional resistance is used, tripping is ensured due to fault detection during the transient fault appearance. Detection is extended throughout the duration of the fault based on the criterion Vr ≥ Vr mem, within the limit of T0mem. With this type of application, T0mem must be greater than T (definite time delay).

Block Diagram



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Directional Ground Fault - Type 1
ANSI Code 67N/67NC

Characteristics

Settings			
Measurement Origin			
Setting range			Ir / I'r
Characteristic Angle θ			
Setting range			-45°, 0°, 15°, 30°, 45°, 60°, 90°
Accuracy (1)			±2°
Isr Setting			
Setting range			0.01 INr ≤ Isr ≤ 15 INr (min. 0.1 A) in amperes
	Sum of CTs		0.01 IN ≤ Isr ≤ 15 In (min. 0.1 A)
	With CSH sensor	2 A rating	0.1 to 30 A
		20 A rating	0.2 to 300 A
	CT		0.01 INr ≤ Isr ≤ 15 INr (min. 0.1 A)
	Zero sequence CT with ACE990		0.01 INr ≤ Isr ≤ 15 INr (min. 0.1 A)
Accuracy (1)			±5% (at φr = 180°)
Resolution			1 A or 1 digit
Drop out/pick up ratio			93.5% ±5%
Time Delay T (Definite Time (DT) Tripping Curve)			
Setting range			Inst, 50 ms ≤ T ≤ 300 s
Accuracy (1)			±2% or from -10 ms to +25 ms
Resolution			10 ms or 1 digit
Advanced Settings			
Tripping Direction			
Setting range			Bus / line
Vsr Set Point			
Setting range			2% to 80% $V_{LL}p$
Accuracy (1)			±5% or ±0.005 $V_{LL}p$
Resolution			1%
Drop out/pick up ratio			93.5% ±5% or > (1 - 0.006 $V_{LL}p$/Vsr) x 100%
Sector			
Setting range			86°, 83°, 76°
Accuracy (1)			±2°
Memory Time Tr mem			
Setting range			0; 0.05 to 300 s
Resolution			10 ms or 1 digit
Memory Voltage Vr mem			
Setting range			0; 2 to 80% of $V_{LL}p$
Resolution			1%
Characteristic Times			
Operation time			Pick-up < 55 ms at 2 Isr
Overshoot time			< 45 ms at 2 Isr
Reset time			< 50 ms (at Tr mem = 0)

Inputs			
Designation	**Syntax**	**Equations**	**Logipam**
Protection reset	P67N_x_101	■	■
Protection blocking	P67N_x_113	■	■

Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P67N_x_1	■	■	
Delayed output	P67N_x_3	■	■	■
Drop-out	P67N_x_4	■	■	
Instantaneous output (reverse zone)	P67N_x_6	■	■	
Protection blocked	P67N_x_16	■	■	
Instantaneous output at 0.8 Isr	P67N_x_21	■	■	

x: unit number.
***(1)** Under reference conditions (IEC 60255-6).*

Standard Setting

The settings below are given for usual applications in different grounding systems. The shaded boxes represent default settings.

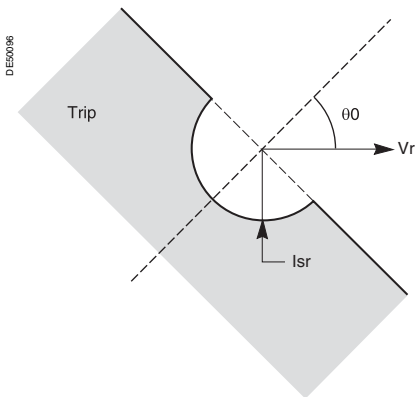
	Isolated neutral	**Impedant neutral**	**Compensated neutral**
Isr setting	Set according to coordination study	Set according to coordination study	Set according to coordination study
Characteristic angle θ0	90°	0°	0°
Time delay T	Set according to coordination study	Set according to coordination study	Set according to coordination study
Direction	Line	Line	Line
Vsr set point	2% of $V_{LL}s$	2% of $V_{LL}s$	2% of $V_{LL}s$
Sector	N/A	86°	86°
Memory time T0mem	0	0	200 ms
Memory voltage V0mem	0	0	0

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Directional Ground Fault - Type 2
ANSI Code 67N/67NC

Ground fault protection for impedant or solidly grounded systems.



Tripping characteristic of ANSI 67N/67NC - type 2 protection function.

Description

The protection function operates like a ground fault protection function with an added direction criterion. It is suitable for closed ring distribution networks with solidly grounded neutral. It has all the characteristics of a ground fault protection function (50N/51N) and can therefore be easily coordinated with that function.

Residual current is the current measured at one of the Sepam™ Ir inputs or calculated using the sum of the main phase currents (I), according to the parameter setting.

The tripping direction may be set at the bus end or line end.

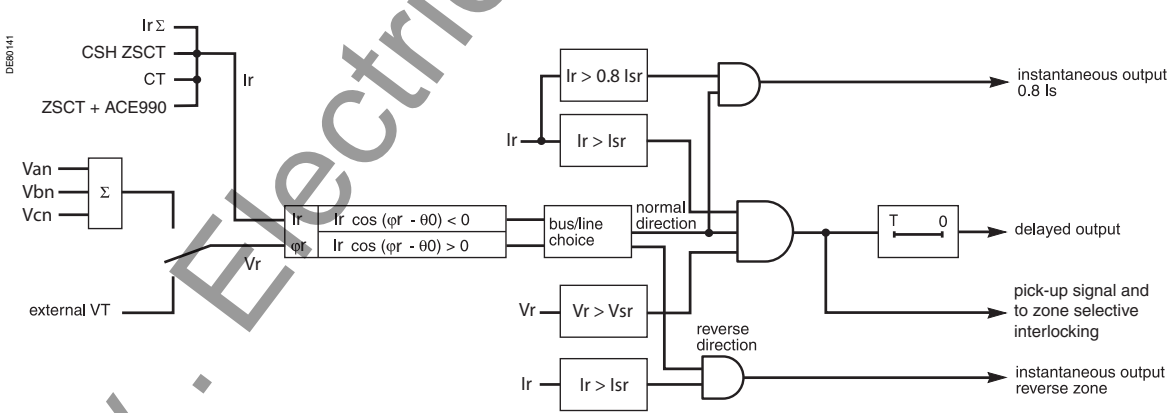
The protection function has a definite or IDMT time delay.

Each unit has two groups of settings. Switching to setting group A or B is carried out by a logic input or a remote control command, depending on the settings.

The customized curve, defined point by point, may be used with this protection function. An adjustable timer hold, definite time or IDMT, can be used for coordination with electromagnetic relays and to detect restriking faults.

Tripping Curve	Timer Hold
Definite time (DT)	Definite time
Standard inverse time (SIT)	Definite time
Very inverse time (VIT or LTI)	Definite time
Extremely inverse time (EIT)	Definite time
Ultra inverse time (UIT)	Definite time
RI curve	Definite time
IEC inverse time SIT / A	Definite time or IDMT
IEC very inverse time VIT or LTI / B	Definite time or IDMT
IEC extremely inverse time EIT / C	Definite time or IDMT
IEEE moderately inverse (IEC / D)	Definite time or IDMT
IEEE very inverse (IEC / E)	Definite time or IDMT
IEEE extremely inverse (IEC / F)	Definite time or IDMT
IAC inverse	Definite time or IDMT
IAC very inverse	Definite time or IDMT
IAC extremely inverse	Definite time or IDMT
Customized	Definite time

Block Diagram



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Directional Ground Fault - Type 2
ANSI Code 67N/67NC

Characteristics

Settings			
Measurement Origin			
Setting range			Ir I'r IrΣ (sum of the main phase channels)
Characteristic Angle θ			
Setting range			-45°, 0°, 15°, 30°, 45°, 60°, 90°
Accuracy (1)			±2°
Tripping Curve			
Setting range			See previous page
Isr Setting			
Definite time setting range			0.01 I_{Nr} ≤ Isr ≤ 15 I_{Nr} (min. 0.1 A) in amperes
	Sum of CTs		0.01 I_N ≤ Isr ≤ 15 I_N (min. 0.1 A)
	With CSH sensor	2 A rating	0.1 to 30 A
		20 A rating	0.2 to 300 A
	CT		0.01 I_{Nr} ≤ Isr ≤ 15 I_{Nr} (min. 0.1 A)
	Zero sequence CT with ACE990		0.01 I_{Nr} ≤ Isr ≤ 15 I_{Nr} (min. 0.1 A)
IDMT setting range			0.01 I_{Nr} ≤ Isr ≤ I_{Nr} (min. 0.1 A) in amperes
	Sum of CTs		0.01 I_N ≤ Isr ≤ I_N (min. 0.1 A)
	With CSH sensor	2 A rating	0.1 to 2 A
		20 A rating	0.2 to 20 A
	CT		0.01 I_{Nr} ≤ Isr ≤ I_{Nr} (min. 0.1 A)
	Zero sequence CT with ACE990		0.01 I_{Nr} ≤ Isr ≤ I_{Nr} (min. 0.1 A)
Accuracy (1)			±5% or ±0.004 In0
Resolution			0.1 A or 1 digit
Drop out/pick up ratio			93.5% ±5% or > (1 - 0.005 I_{Nr}/Isr) x 100%
Time Delay T (Operation Time at 10 Isr)			
Setting range	definite time		Inst, 50 ms ≤ T ≤ 300 s
	IDMT		100 ms ≤ T ≤ 12.5 s or TMS (2)
Accuracy (1)	definite time		±2% or from -10 ms to +25 ms
	IDMT		Class 5 or from -10 ms to +25 ms
Resolution			10 ms or 1 digit
Advanced Settings			
Tripping Direction			
Setting range			Bus / line
Vsr Set Point			
Setting range			2% to 80% $V_{LL}p$
Accuracy (1)			±5% or ±0.005 $V_{LL}p$
Resolution			1%
Drop out/pick up ratio			93% ±5% or > (1 - 0.006 $V_{LL}p$/Vsr) x 100%
Timer Hold T1			
Setting range	definite time		0; 0.05 to 300 s
	IDMT (3)		0.5 to 20 s
Resolution			10 ms or 1 digit
Characteristic Times			
Operation time			Pick-up < 40 ms at 2 Isr (typically 25 ms) Inst. < 55 ms at 2 Isr (confirmed instantaneous) (typically 35 ms)
Overshoot time			< 35 ms at 2 Isr
Reset time			< 50 ms at 2 Isr (for T1 = 0)

Inputs

Designation	Syntax	Equations	Logipam
Protection reset	P67N_x_101	■	■
Protection blocking	P67N_x_113	■	■

Outputs

Designation	Syntax	Equations	Logipam	Matrix
Instantaneous output (pick-up)	P67N_x_1	■	■	
Delayed output	P67N_x_3	■	■	■
Drop out	P67N_x_4	■	■	
Instantaneous output (reverse zone)	P67N_x_6	■	■	
Protection blocked	P67N_x_16	■	■	
Instantaneous output at 0.8 Is0	P67N_x_21	■	■	

x: unit number.

(1) *Under reference conditions (IEC 60255-6).*

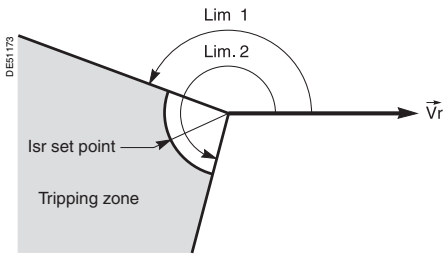
(2) *Setting ranges in TMS (Time Multiplier Setting) mode*
Inverse (SIT) and IEC SIT/A: 0.04 to 4.20
Very inverse (VIT) and IEC VIT/B: 0.07 to 8.33
Very inverse (LTI) and IEC LTI/B: 0.01 to 0.93
Ext. inverse (EIT) and IEC EIT/C: 0.13 to 15.47
IEEE moderately inverse: 0.42 to 51.86
IEEE very inverse: 0.73 to 90.57
IEEE extremely inverse: 1.24 to 154.32
IAC inverse: 0.34 to 42.08
IAC very inverse: 0.61 to 75.75
IAC extremely inverse: 1.08 to 134.4.

(3) *Only for standardized tripping curves of the IEC, IEEE and IAC types.*

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Directional Ground Fault - Type 3
ANSI Code 67N/67NC



Type 3 Operation

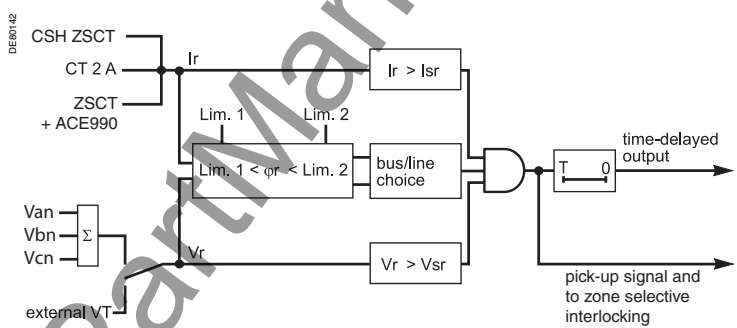
This protection operates like a ground fault protection function (ANSI 50N/51N) with an added angular direction criterion {*Lim.1*, *Lim.2*}. It is suitable for distribution networks in which the neutral grounding system varies according to the operational mode.

The tripping direction may be set at the bus end or line end.

Residual current is the current measured at the Sepam™ Ir input. It has a definite time delay (DT constant).

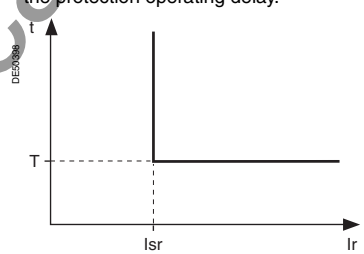
By choosing "0" as an Isr set point, the protection function behaves like a neutral voltage displacement protection function (ANSI 59N).

Simplified Schematic



Definite Time Operation

Isr corresponds to the operating set point expressed in amps, and T corresponds to the protection operating delay.



Definite time protection principle.

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Directional Ground Fault - Type 3
ANSI Code 67N/67NC

Type 3 Characteristics

Measurement Origin		
Setting range		Ir I'r IrΣ (sum of the main phase channels)
Tripping Zone Start Angle *Lim.1*		
Setting		0° to 359°
Resolution		1°
Accuracy		±3°
Tripping Zone End Angle *Lim.2*		
Setting		0° to 359° (1)
Resolution		1°
Accuracy		±3°
Tripping Direction		
Setting		Line/bus
Isr Set Point		
Setting (2)	With CSH zero sequence CT (2 A rating)	0.1 A to 30 A
	With 1 A CT	0.005 I_{Nr} ≤ Isr ≤ 15 I_{Nr} (min. 0.1 A)
	With zero sequence CT + ACE990 (range 1)	0.01 I_{Nr} ≤ Isr ≤ 15 I_{Nr} (min. 0.1 A) (3)
Resolution		0.1 A or 1 digit
Accuracy		±5%
Drop-out/pick-up ratio		≥ 95%
Vsr Set Point		
Setting	On sum of 3 Vs	2% $V_{LL}p$ ≤ Vsr ≤ 80% $V_{LL}p$
	On external VT	0.6% $V_{LL}p$ ≤ Vsr ≤ 80% $V_{LL}p$
Resolution		0.1% for Vsr < 10% 1% for Vsr ≥ 10%
Accuracy		±5%
Drop-out/pick-up ratio		≥ 95%
Time Delay T		
Setting		instantaneous, 50 ms ≤ T ≤ 300 s
Resolution		10 ms or 1 digit
Accuracy		≤ 3% or ±20 ms at 2 Isr
Characteristic Times		
Operation time		pick-up < 40 ms at 2 Isr instantaneous < 55 ms at 2 Isr
Overshoot time		< 40 ms
Reset time		< 50 ms

Inputs			
Designation	**Syntax**	**Equations**	**Logipam**
Reset protection	P67N_x_101	■	■
Block protection	P67N_x_113	■	■

Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P67N_x_1	■	■	
Delayed output	P67N_x_3	■	■	■
Drop-out	P67N_x_4	■	■	
Instantaneous output (reverse zone)	P67N_x_6	■	■	
Protection blocked	P67N_x_16	■	■	
Instantaneous output at 0.8 Is0	P67N_x_21	■	■	

(1) *Tripping zone Lim.2-Lim.1 should be 10° or more.*
(2) *For Isr = 0, the protection function behaves like a neutral voltage displacement protection function (59N).*
(3) *I_{Nr} = k n where n = the zero sequence CT ratio and k = coefficient to be determined according to the wiring of the ACE990 (0.00578 ≤ k ≤ 0.04).*

Standard Tripping Zone Setting (Line End)

The settings below are given for the usual applications in different types of neutral grounding system. The shaded boxes represent default settings.

	Isolated Neutral	**Impedant Neutral**	**Directly Grounded Neutral**
Lim.1 angle	190°	100°	100°
Lim.2 angle	350°	280°	280°

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Pole Slip
ANSI Code 78PS

Protecting synchronous generators and motors against loss of synchronism

Description

This function provides protection against synchronization loss on synchronous machines. It is based on calculated active power.

The function is composed of two independent protection modules, based on:

- the equal-area criterion
- the power-swing criterion.

The tripping command can be issued by one or both criteria, depending on the parameter settings.

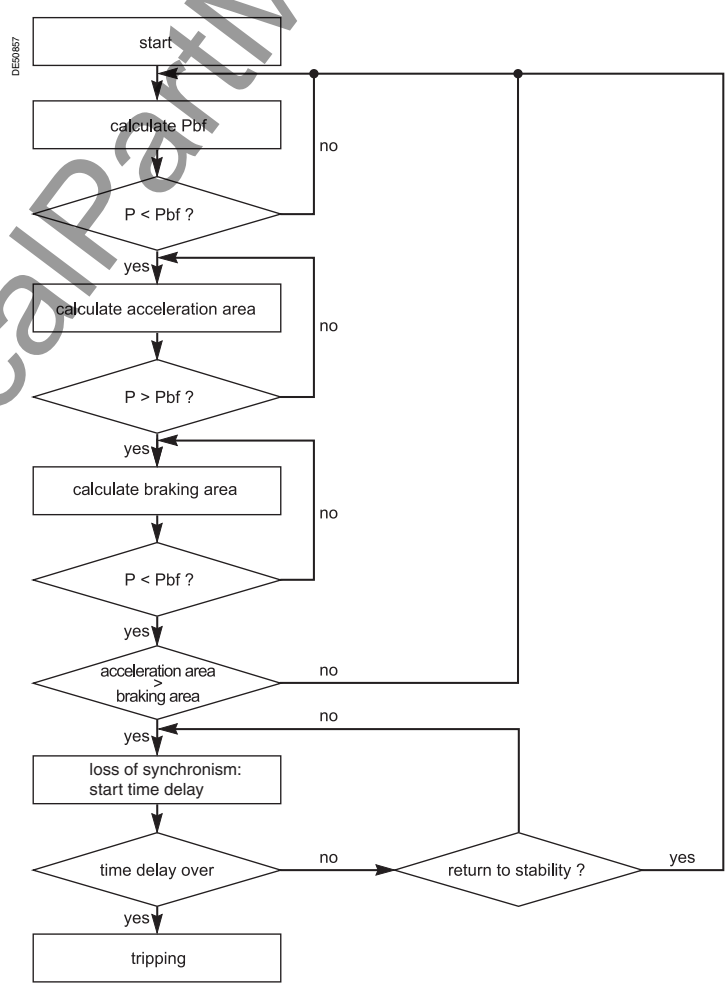
Equal-Area Criterion

This function calculates the acceleration area when a fault appears and the braking area when the fault disappears. The tripping command is issued if the braking area is smaller than the acceleration area.

The function calculates an average power over four seconds (under steady state conditions). This is called power before fault (**Pbf**) and corresponds to the electrical power supplied by a generator or drawn by a motor. The function picks up when the instantaneous power is different than Pbf.

A time delay is available to delay tripping. If a "return to stability" is detected during the time delay, the function is reinitialized without tripping.

Equal-Area Criterion Block Diagram



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Pole Slip
ANSI Code 78PS

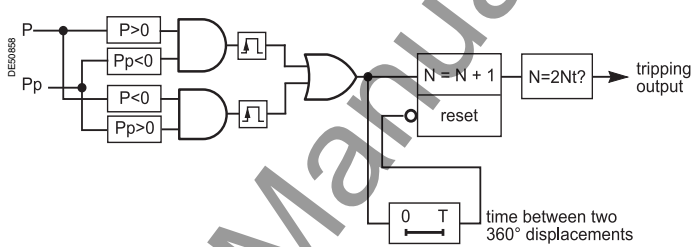
Power-Swing Criterion

This function detects a change in the active power sign.

Two power swings are counted for each 360° of phase displacement between the electromotive force of the machine and the network. Power swings are detected by comparing the sign of the instantaneous power with that of the power 14 ms before, Pp. If the signs are different, a swing is counted.

The trip command is issued if the number of 360° displacements measured is equal to the set number. A time delay may be used to set a maximum time between two swings. This makes the function insensitive to low-frequency power oscillations.

Power-Swing Criterion Block Diagram



Current Transformers

Current transformers should be defined by a knee-point voltage

$Vk \geq (R_{CT} + R_W)\ 20\ I_{NS}$

where R_{CT}: CT internal resistance

R_W: wiring resistance CT rated secondary current

Characteristics

Settings				
Tripping Type Selection				
Setting range	Equal-area criterion Power-swing criterion Equal-area criterion and power-swing criterion			
Equal-Area Criterion Time Delay				
Setting range	100 ms ≤ T ≤ 300 s			
Accuracy (1)	±2% or from –10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Number of 360° Displacements				
Setting range	1 ≤ number of 360° displacements ≤ 30			
Accuracy (1)	–			
Resolution	1 360° displacement			
Maximum Time Between Two 360° Displacements				
Setting range	1 s ≤ T ≤ 300 s			
Accuracy (1)	±2% or from –10 ms to +25 ms			
Resolution	1 s or 1 digit			
Characteristic Times				
Operation time	38 ms to 2 Ps (2)			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P78PS_1_101	■	■	
Protection blocking	P78PS_1_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P78PS_1_1	■	■	
Delayed output	P78PS_1_3	■	■	■
Protection blocked	P78PS_1_16	■	■	

(1) *Under reference conditions (IEC 60255-6).*

(2) *Ps = the maximum number of Poles slipped.*

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Pole Slip
ANSI Code 78PS

Example of Setting

Consider a 3.15 MVA generator in an industrial installation, connected to a network with a high short-circuit. Protection against losing synchronization is set up to trip according to the equal-area criterion and the power-swing criterion.

- tripping according to the equal-area criterion: 300 ms
- number of 360° displacements allowed: 2
- the maximum time between two swings is 10 seconds.

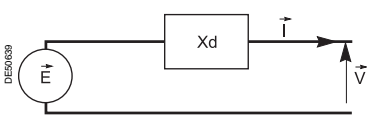
Principle of Transient Stability

There are three types of stability in an electrical network:

- *steady state stability* concerns small variations in load and power. It is monitored by the power regulation functions
- *dynamic stability* concerns larger variations. It is ensured by the network regulation functions
- *transient stability* concerns major variations in power, such as during faults. It is monitored by action on the network, such as load shedding, source disconnection or independent operation of certain zones in the network.

Protection against synchronism loss can be used to detect cases of transient instability.

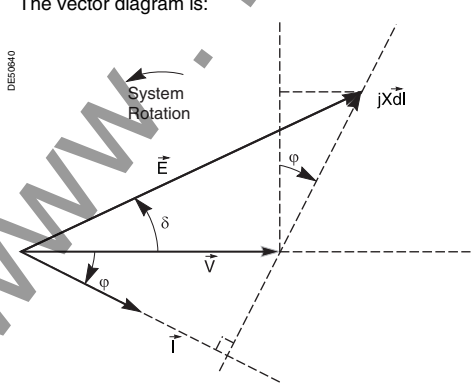
When a generator is connected to a network that has infinite power, the voltage across its terminals is imposed by the network. For a turbo-generator under steady state conditions, the internal impedance is equal to its longitudinal synchronous reactance Xd (the resistance and possible saturation of the magnetic circuit are not factors).



$$\vec{V} = \vec{E} - jX_d\vec{I}$$

where E is the electromotive force of the machine
Xd: the synchronous reactance
V: the network voltage
I: the current supplied by the generator

If the generator supplies a current, the network voltage and the electromotive force of the machine are not in phase because of the synchronous reactance. This displacement is commonly called the internal angle of the machine or the *load angle,* β. When the electromotive force leads the network voltage, the internal angle is positive. When the electromotive force lags the network voltage, the internal angle is negative. The vector diagram is:



The electrical power supplied by the machine to the network is: $P_e = 3VI\cos\varphi$.

On the vector diagram: $E\sin\delta = X_d(I\cos\varphi) = X_d\left(\frac{P_e}{3V}\right)$.

As a function of the electromotive force, the internal angle and the synchronous reactance, the active power is: $P_e = \frac{3VE\sin\delta}{X_d}$.

This equation can be used to determine the electrical power supplied by the generator to the network, as a function of the internal angle and assuming that V, E and Xd are constant.

If losses are neglected (efficiency is close to 0.99), the relation between the mechanical power P_m and the electrical power supplied P_e is:

$$P_m = P_e + J\Omega\frac{d\Omega}{dt}$$

where J is the moment of inertia of the machine
Ω is the angular velocity of the rotating masses
P_m is the mechanical power supplied by the driving machine

The velocity of the electric field is related to the mechanical velocity by the equation:

$$\Omega = \frac{\omega}{p}$$

where ω is the angular velocity of the electrical field
p is the number of pole pairs in the machine

In the remainder of this example, we will consider a machine with a single pair of poles, i.e. p = 1.

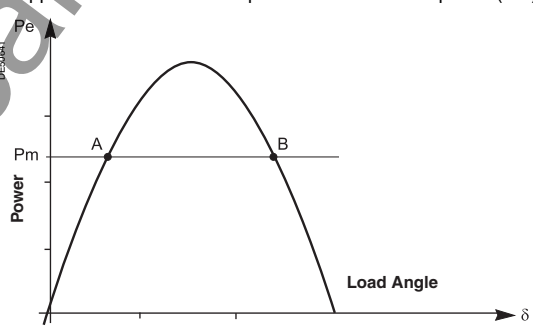
The relation between electrical and mechanical power becomes:

$$P_m = P_e + J\omega\frac{d\omega}{dt}.$$

Variations in speed are directly related to unbalances between the mechanical power and the electrical power supplied to the network.

$$\frac{d\omega}{dt} = \frac{P_m - P_e}{J\omega}.$$

Under steady state conditions (with no increase in speed), the electrical power (Pe) supplied to the network is equal to the mechanical power (Pm).



The electrical power curve intersects the constant mechanical power line at two points (A and B).

- point A (stable operation):
  - if δ increases slightly with respect to its value at point A (the electromotive force leads the network voltage), the electrical power supplied to the network increases slightly. At a constant level of mechanical power:

$$\frac{d\omega}{dt} = \frac{P_m - P_e}{J\omega} < 0 .$$

The machine slows as long as the electrical power supplied is not equal to the mechanical power, because the derivative of the velocity is negative. Electrically speaking, the electromotive force reduces its lead and consequently the angle δ.

  - if δ decreases slightly with respect to its value at point A (the electromotive force reduces its lead on the network voltage), the electrical power supplied to the network decreases slightly. At a constant level of mechanical power:

$$\frac{d\omega}{dt} = \frac{P_m - P_e}{J\omega} > 0 .$$

The machine accelerates as long as the electrical power supplied is not equal to the mechanical power, because the derivative of the velocity is positive. Electrically speaking, the electromotive force increases its lead and consequently the angle δ.

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- point B (unstable operation)
  - if δ increases slightly with respect to its value at point B (the electromotive force leads the network voltage), the electrical power supplied to the network decreases slightly. At a constant level of mechanical power:

$$\frac{d\omega}{dt} = \frac{P_m - P_e}{J\omega} > 0 .$$

The machine accelerates because the derivative of the velocity is positive. Electrically speaking, the electromotive force increases its lead and consequently the angle δ.

  - if δ decreases slightly with respect to its value at point B (the electromotive force reduces its lead on the network voltage), the electrical power supplied to the network increases slightly. At a constant level of mechanical power:

$$\frac{d\omega}{dt} = \frac{P_m - P_e}{J\omega} < 0 .$$

The machine slows because the derivative of the velocity is negative. Electrically speaking, the electromotive force reduces its lead and consequently the angle δ until it returns to point A.

When the machine passes point B, racing occurs. When a fault occurs, assuming it is a three-phase dead short across the generator terminals, the voltage across the machine terminals is equal to zero. Consequently, the electrical power supplied to the network is zero:

$$P_e = \frac{3VE\sin\delta}{X_d} = \frac{3\times 0\times E\sin\delta}{X_d} = 0 .$$

The regulation systems do not have enough time to react and the mechanical power across the machine terminals remain constant.

The fault results in an unbalance between the electrical power supplied to the network and the mechanical power:

$$\frac{d\omega}{dt} = \frac{P_m - P_e}{J\omega} > 0 .$$

If the derivative of the velocity is positive, the machine accelerates and the electromotive force begins to lead with respect to the voltage of the network. As long as the fault continues, the machine accelerates.
The variation in velocity is:

$$\int_{\omega_0}^{\omega_1} \omega d\omega = \frac{1}{J}\int_{t_0}^{t_1} P_m dt \quad \text{where}$$

the steady state conditions before the fault: t_0, ω_0, δ_0
the fault clearing conditions: t_1, ω_1, δ_1.

The integral $\int_{t_0}^{t_1} P_m dt$ is proportional to the acceleration of the machine.

It is commonly called the *acceleration area*.

When the fault is cleared, the voltage across the machine terminals is no longer zero. It is assumed that the network voltage, the load and the electromotive force are the same. In that the internal angle increased, the electrical power is $P_e(t)$.
Depending on the sign of $P_m - P_e(t)$, the machine slows or continues to accelerate.

$$\int_{\omega_1}^{\omega_2} \omega d\omega = \frac{1}{J}\int_{t_1}^{t_2} (P_m - P_e(t))\, dt$$

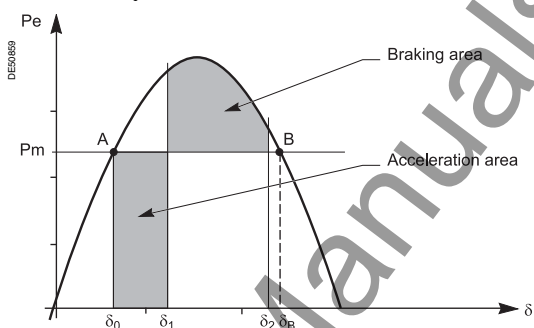
Generally, $P_m - P_e(t) < 0$. This condition is not sufficient to recover stability.

- fault clearing with return to stability

the machine returns to its operating mode prior to the fault if the two integrals are equal:

$$\int_{t_1}^{t_2} (P_m - P_e(t))dt = \int_{t_0}^{t_1} P_m dt .$$

The integral $\int_{t_1}^{t_2} (P_m - P_e(t))dt$ is called the braking area.

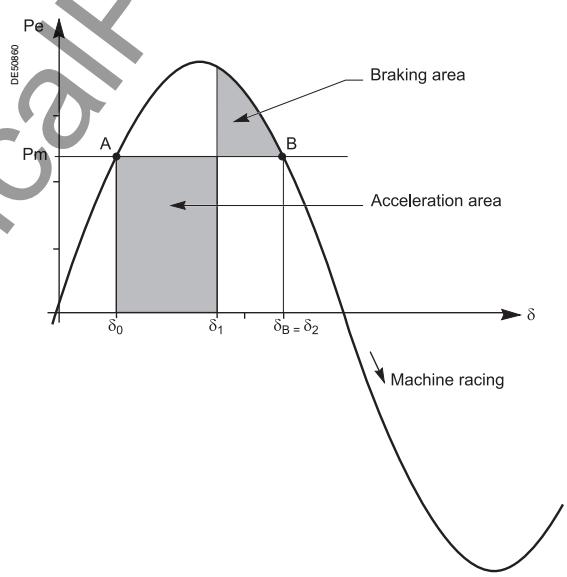


- fault clearing and loss of synchronization

During slowing, the machine passes point B and begins to accelerate again because beyond this point, $Pm - Pe(t) > 0$.

The braking area $\int_{t_1}^{t_2} (P_m - P_e(t))dt$ is not sufficient.

The machine starts to race and stability is lost. The machine alternates between phases during which it supplies electrical power and others where it draws power.



The situation presented here is also true for machines other than turbo-generators. In this case, the shape of P_e as a function of the internal angle is different. The same is true when the voltage across the machine terminals does not drop to zero, or when there is a change in the load due to load shedding when the fault is cleared.
The situation for synchronous motors is identical to that of synchronous generators, except that instead of supplying power, they draw power. The network voltage leads the electromotive force. In this case, the above relationships must be inverted.

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Recloser
ANSI Code 79

Recloser with 1 to 4 shots to clear transients or semi-permanent faults on overhead lines.

Definition

Reclaim Time
The reclaim time is activated by a circuit breaker closing command given by the recloser. If no faults are detected before the end of the reclaim time, the initial fault is considered to be cleared. Otherwise a new reclosing step is initiated.

The delay must be longer than the longest reclosing step activation condition.

Safety Time until Ready
The safety time is activated by a manual circuit breaker closing command. The recloser is blocked for the duration of the time. If a fault occurs during this time, no reclosing steps are initiated and the circuit breaker remains permanently open.

Dead Time
Step *n* dead time is launched by breaking device tripping command given by the recloser during step n. The breaking device remains open throughout the time. At the end of the step n dead time, the n+1 step begins, and the recloser commands the circuit breaker closed.

Description

An automation device is used to limit down time after tripping due to transient or temporary faults on overhead lines. The recloser automatically recloses the breaking device after a settable time delay. Recloser operation is easy to adapt for different operating modes by parameter setting.

The recloser is ready to operate if all of the following conditions are met:
- "switchgear control" function activated and recloser in service (not blocked by the recloser blocking logic input)
- circuit breaker closed
- the safety time is not running
- none of the recloser blocking conditions is true (trip circuit fault, control fault, SF6 pressure drop)

Recloser Steps
The recloser will step under any of the following conditions:
- **case of a fault that is not cleared**: following instantaneous or time-delayed tripping by the protection unit, activation of the dead time associated with the first active cycle. At the end of the dead time, a closing command is given, which activates the reclaim time. If the protection unit detects the fault before the end of the time delay, a tripping command is given and the following reclosing step is activated. After all the active shots have run, a final trip command is given if the fault still persists and a message will appear on the display
- **case of a cleared fault**: Following a reclosing command, if the fault does not appear after the reclaim time has run out, the recloser reinitializes and a message appears on the display (see example 1)
- **closing on a fault**. If the circuit breaker closes on a fault, or if the fault appears before the end of the safety time delay, the recloser is blocked. A final trip message is issued

Recloser Block Conditions
The recloser is blocked according to the following conditions:
- voluntary open or close command
- recloser put out of service
- receipt of a block command on the logic input
- activation of the breaker failure, such as trip circuit fault, control fault, SF6 pressure drop
- opening of the circuit breaker by a protection unit that does not run reclosing cycles (such as frequency protection), by external tripping or by a function set up not to activate reclosing cycles.

In such cases, a final trip message appears.

Extending the dead time
If, during a reclosing step, it is impossible to reclose the circuit breaker because recharging is not finished(1), the dead time can be extended up to the time the circuit breaker is ready to carry out an "Open-Close-Open" cycle. The maximum time added to the dead time is adjustable (Twait_max). If, at the end of the maximum waiting time, the circuit breaker is still not ready, the recloser is blocked (see example 5).

(1) *Following a drop in auxiliary voltage, recharging time is longer*

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Recloser
ANSI Code 79

Characteristics

Settings		
Number of Steps		
Setting range		1 to 4
Activation of Shot 1		
Protection 50/51 units 1 to 4		inst. / delayed / no activation
Protection 50N/51N units 1 to 4		inst. / delayed / no activation
Protection 67 units 1 to 2		inst. / delayed / no activation
Protection 67N/67NC units 1 to 2		inst. / delayed / no activation
Logic equations or Logipam outputs V_TRIPCB		active/inactive
Activation of Shots 2, 3, and 4		
Protection 50/51 units 1 to 4		inst. / delayed / no activation
Protection 50N/51N units 1 to 4		inst. / delayed / no activation
Protection 67 units 1 to 2		inst. / delayed / no activation
Protection 67N/67NC units 1 to 2		inst. / delayed / no activation
Logic equations or Logipam outputs V_TRIPCB		active/inactive
Time Delays		
Reclaim time		0.1 to 300 s
Dead time	Shot 1	0.1 to 300 s
	Shot 2	0.1 to 300 s
	Shot 3	0.1 to 300 s
	Shot 4	0.1 to 300 s
Safety time until ready		0 to 60 s
Maximum additional dead time		0.1 to 60 s
Accuracy (2)		±2% or ±25 ms
Resolution		10 ms

Inputs			
Designation	**Syntax**	**Equations**	**Logipam**
Protection blocking	P79_1_113	■	■

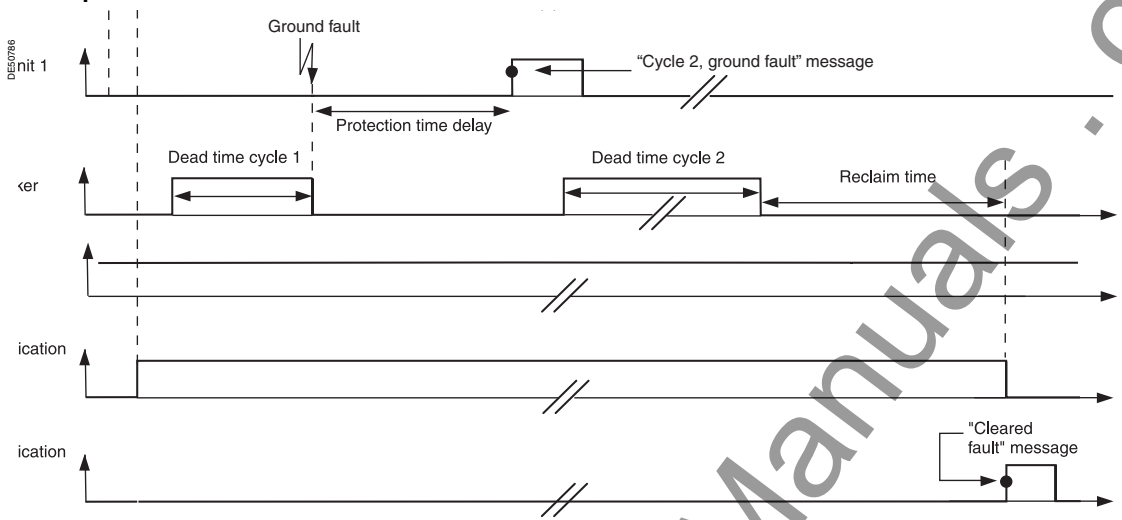
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Recloser in service	P79 _1_201	■	■	■
Recloser ready	P79 _1_202	■	■	■
Cleared fault	P79 _1_203	■	■	■
Final trip	P79 _1_204	■	■	■
Closing by recloser	P79 _1_205	■	■	
Reclosing step 1	P79 _1_211	■	■	■
Reclosing step 2	P79 _1_212	■	■	■
Reclosing step 3	P79 _1_213	■	■	■
Reclosing step 4	P79 _1_214	■	■	■

(1) *Under reference conditions (IEC 60255-6).*

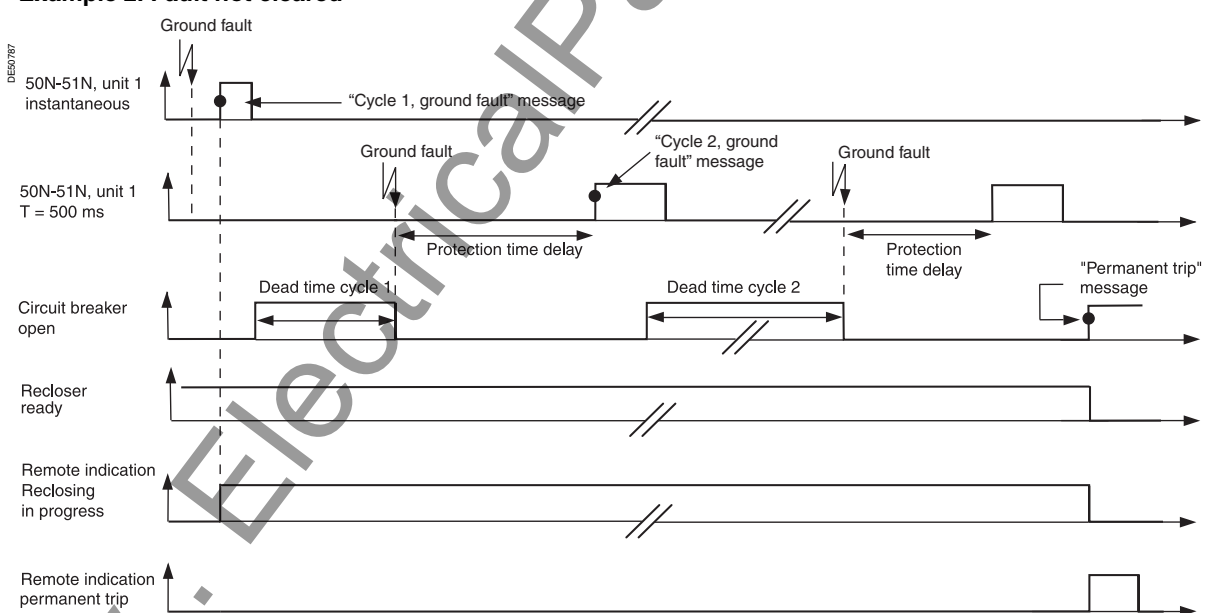
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Example 1. Fault cleared after the second shot



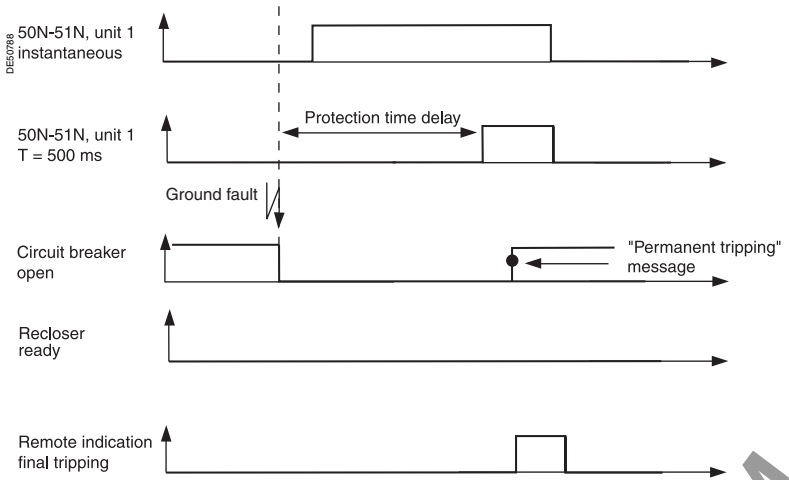
Example 2. Fault not cleared



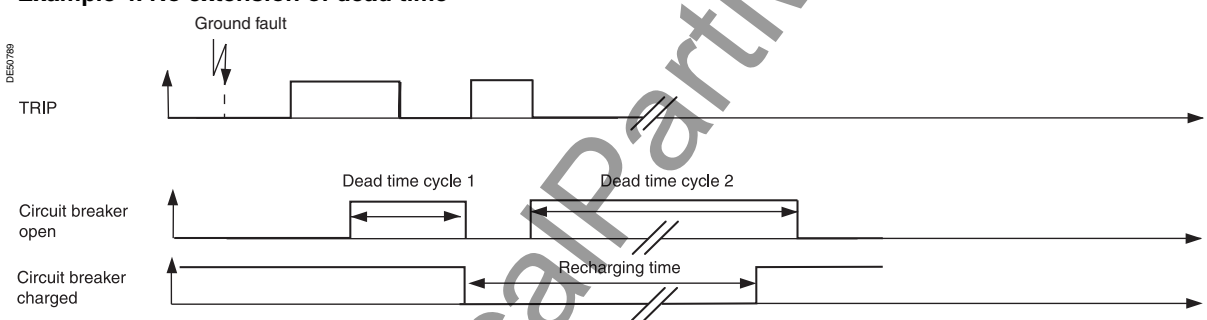
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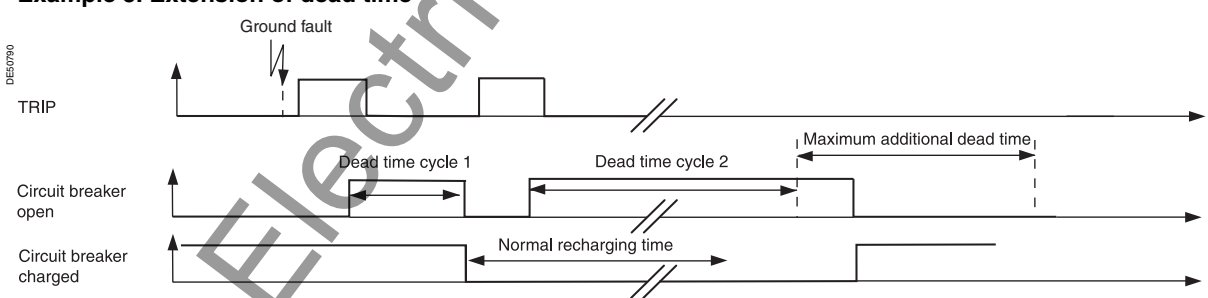
Example 3. Closing on a fault



Example 4. No extension of dead time



Example 5. Extension of dead time



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Overfrequency
ANSI Code 81H

Detection of abnormally high frequencies.

Description

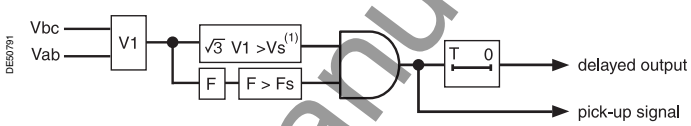
Detection of abnormally high frequency compared to the rated frequency, to monitor power supply quality or protect a generator against overspeeds.

The frequency is calculated using voltage Van or Vab when only one voltage is connected. Otherwise the positive sequence voltage V1 is used to procure greater stability. It is compared to the Fs set point.

The protection function is blocked if the voltage used for calculations is under the adjustable set point Vs.

The protection includes a definite time delay T.

Block Diagram



Characteristics

Settings				
Measurement Origin				
Setting range	Main channels (V_{LL}) / Additional channels (V_{LL}')			
Fs Set Point				
Setting range	50 to 55 Hz or 60 to 65 Hz			
Accuracy (1)	±0.01 Hz			
Resolution	0.1			
Pick up / drop out difference	0.25 Hz			
Time Delay T				
Setting range	100 ms to 300 s			
Accuracy (1)	±2% or ±25 ms			
Resolution	10 ms or 1 digit			
Advanced Settings				
Vs Set Point				
Setting range	20% to 50% V_{LLN}			
Accuracy (1)	2%			
Resolution	1%			
Characteristic Times				
Operation time	Pick-up < 90 ms from Fs -0.5 Hz to Fs +0.5 Hz			
Overshoot time	< 50 ms from Fs -0.5 Hz to Fs +0.5 Hz			
Reset time	< 55 ms from Fs +0.5 Hz to Fs -0.5 Hz			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P81H_x_101	■	■	
Protection blockingblock	P81H_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P81H_x_1	■	■	
Delayed output	P81H_x_3	■	■	■
Protection blockblocked	P81H_x_16	■	■	

x: unit number.
***(1)** Under reference conditions (IEC 60255-6) and df/dt < 3 Hz/s.*

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Underfrequency
ANSI Code 81L

Detecting abnormally low frequency for load shedding using a metric frequency criterion.

Description

This function detects abnormally low frequency and compares it to the rated frequency in order to monitor power supply quality. The protection can be used for overall tripping or load shedding.

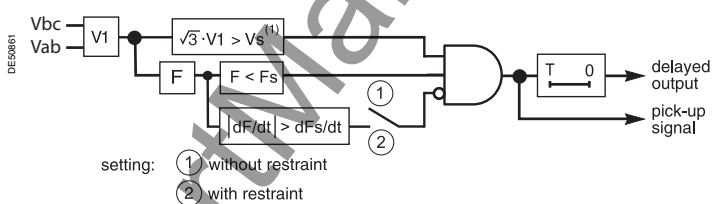
The frequency is calculated using voltage Van or Vab when only one voltage is connected. Otherwise the positive sequence voltage V1 is used to provide greater stability. It is compared to the frequency set point, Fs.

The protection function is blocked if the value of voltage used for calculations is below the adjustable set point Vs.

Protection stability is provided in the event of the loss of the main source and presence of remnant voltage by a restraint in the event of a continuous decrease of the frequency.

The protection includes a definite (DT) time delay T.

Block Diagram



Characteristics

Settings				
Measurement Origin				
Setting range	Main channels (V_{LL}) / Additional channels (V_{LL}')			
Fs Set Point				
Setting range	40 to 50 Hz or 50 to 60 Hz			
Accuracy (1)	±0.01 Hz			
Resolution	0.1			
Pick up / drop out difference	0.25 Hz			
Time Delay T				
Setting range	100 ms to 300 s			
Accuracy (1)	±2% or ±25 ms			
Resolution	10 ms or 1 digit			
Advanced Settings				
Vs Set Point				
Setting range	20% to 50% V_{LLN}			
Accuracy (1)	2%			
Resolution	1%			
Restraint on Frequency Variation				
Setting	With / without			
dFs/dt set point	1 Hz/s to 15 Hz/s			
Accuracy (1)	±1 Hz/s			
Resolution	±1 Hz/s			
Characteristic Times				
Operation time	Pick-up < 90 ms from Fs +0.5 Hz to Fs -0.5 Hz			
Overshoot time	< 50 ms from Fs +0.5 Hz to Fs -0.5 Hz			
Reset time	< 55 ms from Fs -0.5 Hz to Fs +0.5 Hz			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P81L_x_101	■	■	
Protection blockingblock	P81L_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P81L_x_1	■	■	
Delayed output	P81L_x_3	■	■	■
Protection blocked	P81L_x_16	■	■	

x: unit number.

***(1)** Under reference conditions (IEC 60255-6) and df/dt < 3 Hz/s.*

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Rate of Change of Frequency (df/dt)
ANSI Code 81R

Protection function based on the calculation of the frequency variation, used to rapidly disconnect a source supplying a network or to control load shedding.

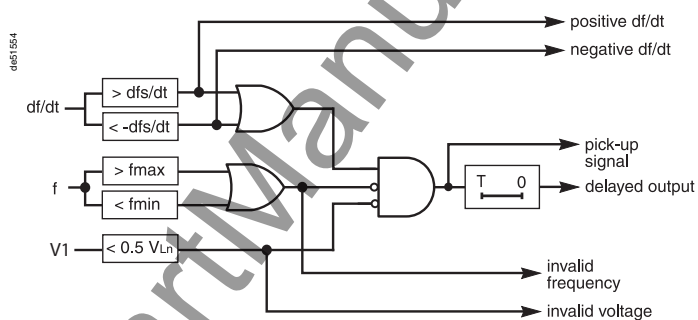
Operation

The rate of change of frequency protection function is complementary to the under and overfrequency protection functions in detecting network configurations that require load shedding or disconnection.

The function is activated when the "rate of change of frequency" df/dt of the positive sequence voltage is higher than a set point. It includes a definite time (DT) delay.

The protection function operates if:
- the positive sequence voltage is greater than 50% of the rated phase-to-neutral voltage
- the network frequency is between 42.2 Hz and 56.2 Hz for 50 Hz networks and between 51.3 Hz and 65 Hz for 60 Hz networks.

Block Diagram



Characteristics

Settings				
dfs/dt Set Point				
Setting range	0.1 to 10 Hz/s			
Accuracy (1)	±5% or ±0.1 Hz			
Resolution	0.01 Hz			
Drop out/pick up ratio	93%			
Temporization				
Setting range	0.15 to 300 s			
Accuracy (1)	±2% or -10% +25 ms			
Resolution	10 ms or 1 digit			
Characteristic Times (1)				
Operation time	Pick-up < 150 ms (typically 130 ms)			
Overshoot time	< 100 ms			
Reset time	< 100 ms			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P81R_x_101	■	■	
Protection blockingblock	P81R_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Instantaneous output (pick-up)	P81R_x_1	■	■	
Tripping output	P81R_x_3	■	■	■
Protection blocked	P81R_x_16	■	■	
Invalid voltage	P81R_x_42	■	■	
Invalid frequency	P81R_x_43	■	■	
Positive df/dt	P81R_x_44	■	■	
Negative df/dt	P81R_x_45	■	■	

x: unit number.
***(1)** Under reference conditions (IEC 60255-6) and df/dt < 3 Hz/s.*

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Rate of Change of Frequency (df/dt)
ANSI Code 81R

Disconnection Application

The rate of change of frequency (df/dt) function can be used on service entrance mains that include generators that operate in parallel with the utility grid. If, under these conditions, the utility experiences an outage, the co-gen will temporarily try to back feed the utility system. If the power flow from the utility prior to the service switchgear main was not a zero value, the generator frequency changes.

The df/dt protection function detects an islanded generator operation more rapidly than conventional frequency Protection Functions.

Other disturbances such as short-circuits, load fluctuations and switching may cause changes of frequency. The low set point may be reached temporarily due to these disturbances and a time delay is necessary. In order to maintain the advantage of the speed of the df/dt protection (compared to conventional frequency protection functions), a second, higher set point with a short time delay may be added.

The actual rate of change of frequency is not constant. Often, the rate is highest at the beginning of the disturbance and decreases afterward. This extends the tripping time of frequency protection functions but does not affect the tripping time of the rate of change of frequency protection function.

Low Set Point

- Follow the utility's instructions, if there are any.
- If there are no utility instructions, proceed as follows:
  - if the maximum rate of change of frequency on the network under normal conditions is known, dfs/dt should be set above it.
  - if no information on the network is available, the low set point may be set according to generator data.
    A good approximation of the rate of change of frequency after a utility failure resulting in a load variation ΔP is:

$$\frac{df}{dt} = \frac{\Delta P \times fn}{2 \times Sn \times H}$$

where Sn: rated power
fn: rated frequency
H: inertia constant

Typical value of the inertia constant (in MWs/MVA):
0.5 ≤ H ≤ 1.5 for diesel and low-power generators (≤ 2 MVA)
2 ≤ H ≤ 5 for gas turbines and medium-power generators (≤ 40 MVA)

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

where J: moment of inertia
Ω: machine speed

Examples

Rated power	2 MVA	20 MVA
Inertia constant	0.5 MWs/MVA	2 MWs/MVA
Power variation	0.1 MVA	1 MVA
df/dt	–2.5 Hz/s	–0.6 Hz/s

Low Set Point Delay Setting

For good protection stability during short-circuits or transient disturbances, the recommended time delay is 300 ms or more. If an automatic recloser is in service upstream of the installation, the detection of an islanded generator operation and the opening of the inter-tie circuit breaker 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 under and overfrequency protection curves.
If the frequency protection units are set to fn±0.5Hz and the low set point of the rate of change of frequency is T, the high set point may be set to 0.5/T.

High Set Point Delay Setting

No particular recommendantions.

Setting recommendations when no other information is available

Settings	Generator Power	2 to 10 MVA	> 10 MVA
Low set point	dfs/dt	0.5 Hz/s	0.2 Hz/s
	T	500 ms	500 ms
High set point	dfs/dt	2.5 Hz/s	1 Hz/s
	T	150 ms	150 ms

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Rate of Change of Frequency (df/dt)
ANSI Code 81R

Operating Precautions:
When the generator connects to the network, power oscillations may occur until the generator becomes fully synchronized. The df/dt protection function senses this phenomenon, so it is advisable to block the protection unit for a few seconds after circuit breaker closing.

Load Shedding Application

The df/dt protection function may also be used for load shedding in combination with underfrequency protection. In such cases, it is used on the installation bus. Only negative frequency derivatives are to be used.

Two principles are available:

- **Acceleration of load shedding**: The rate of change of frequency protection functions controls load shedding. It acts faster than underfrequency protection functions and the value measured (df/dt) is directly proportional to the load to be shed
- **Load shedding block**: This principle is included in underfrequency protection functions. It consists of activating the frequency variation restraint and does not call for implementation of the rate of change of frequency protection function.

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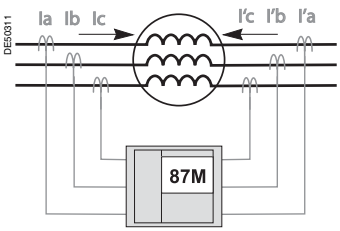
Machine Differential
ANSI Code 87M

Phase-to-phase short-circuit protection for generators and motors.

Description
This is phase-to-phase short-circuit protection and is based on phase by phase comparison of the currents on motor and generator windings.

This function enables if the difference in current is greater than the set point defined by:
- a percentage-based curve
- a differential curve (high set point).

Tripping restraint ensures stability due to:
- detection of an external fault or machine starting
- detection of CT saturation
- fast detection of CT loss
- detection of transformer energizing.



Percentage-Based Differential
The percentage-based tripping characteristic compares the through current to the differential current.

According to the current measurement convention, shown in the diagram and respecting the recommended wiring system, the differential and through currents are calculated by:
- differential current:

$$Idx = \left|\vec{I}_x + \vec{I'}_x\right| \quad \text{where x = a, b, c}$$

- through current

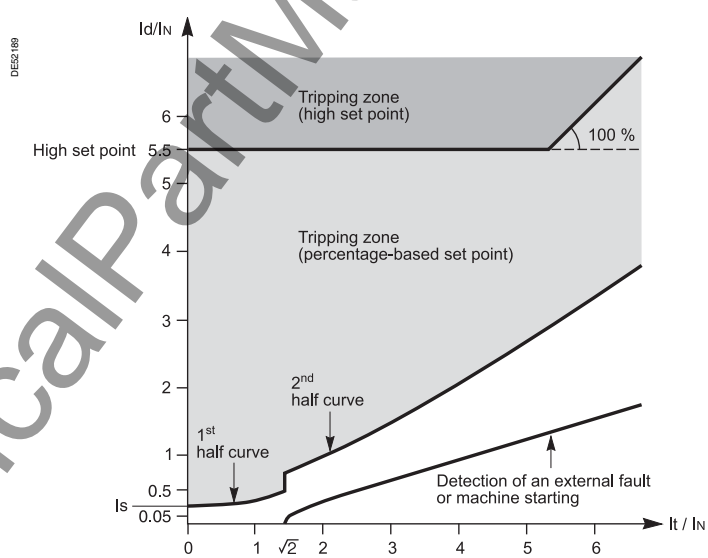
$$Itx = \frac{\left|\vec{I}_x - \vec{I'}_x\right|}{2} \quad \text{where x = a, b, c}$$

The percentage-based characteristic is made up to two half curves defined according to the following formulas:
- 1st half curve depending on the Is set point

$$Idx^2 - \frac{Itx^2}{32} > Is^2 \quad \text{where } 0 \le Itx \le \sqrt{2}\, I_N \text{ and x = a, b, c}$$

- 2nd half curve

$$\frac{Idx^2}{8} - \frac{Itx^2}{32} > (0.005\ I_N)^2 \quad \text{where } \sqrt{2}\, I_N < Itx \text{ and x = a, b, c.}$$



Differential High Set Point.
To avoid any delay for major asymmetrical faults, a differential high set point, without restraint, is used.

The characteristic of this set point is:

$$Idx > 5.5\ I_N \quad \text{and} \quad \frac{Idx}{Itx} > 1 \quad \text{where x = a, b, c}$$

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Machine Differential
ANSI Code 87M

Tripping Restraints
The following are applications for machine differential restraint:

1 Restraint for external faults or machine starting
During starting or an external fault, the through current is much higher than 1.5 I_N. As long as the CTs do not saturate, the differential current is low. This transient state is detected by the following characteristic:

$$\frac{Idx^2}{2} - \frac{Itx^2}{32} < -(0.25\ I_N)^2 \quad \text{where x = a, b, c}$$

An external fault can be followed by a short, but high differential current, that is why a 200 ms restraint is used to ensure protection stability for this type of fault.

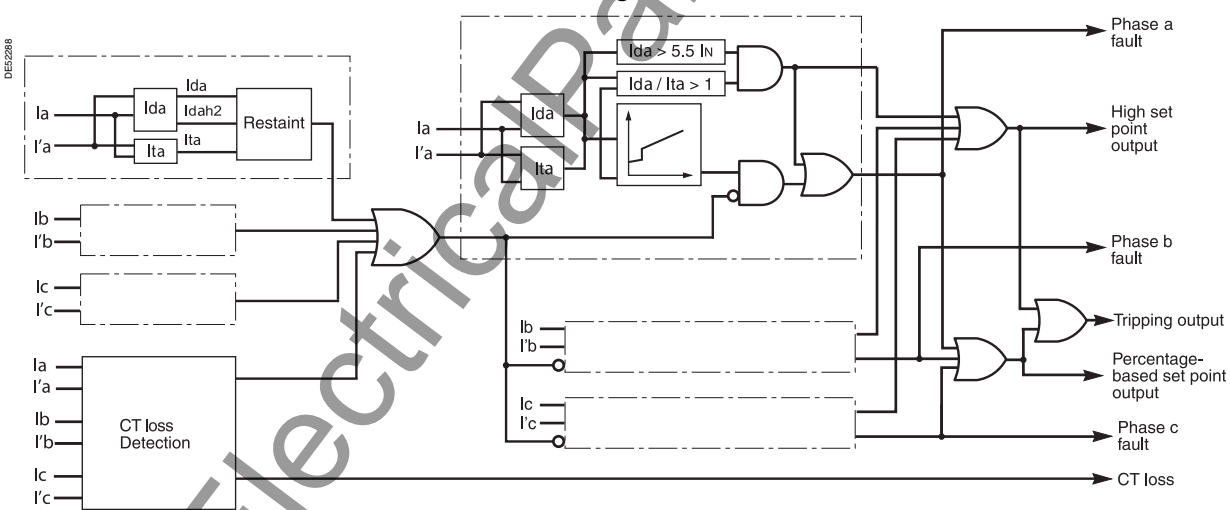
2 Restraint on CT saturation
CT saturation can result in a false differential current and nuisance tripping. The restraint analyses the asymmetry of the signals and restrains the tripping command if a CT is saturated.

3 Restraint on CT loss
CT loss can result in a false differential current and nuisance tripping. This restraint is the means to detect a measurement that abnormally drops to zero (sample analysis).

4 Restraint on transformer energizing
- this restraint ensures that the second harmonic level of the differential current is greater than 15 %:

$$\frac{Idxh2}{Idx} > 0.15 \quad \text{where x = a, b, c.}$$

Block Diagram



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Machine Differential
ANSI Code 87M

Sizing Phase-Current Transformers

Current transformers should be defined by a knee-point voltage $Vk \geq (R_{CT} + Rw).20.I_{N2}$.

Generators are characterized by large X/R ratio's. The rule of thumb is to use the highest possible accuracy class. A completely offset short circuit current requires the ct to support (1+X/R) times the calculated voltage. In many applications it is not possible to completely avoid saturation. Under these conditions it is helpful to have machine differential ct's with the same knee point voltage.

The equations apply to the phase current transformers placed on either side of the machine.

I_{N2} is the CT rated secondary current.
R_{CT} is the CT internal resistance.
Rw is the resistance of the CT load and wiring.

The setting range of the Is set point depends on the rated values of the CTs on the main channels Ia, Ib, Ic and the additional channels I'a, I'b, I'c. The setting range is the intersection of [0.05 I_N 0.5 I_N] with [0.05 I'_N 0.5 I'_N]. When the rated values are identical, the setting range is optimum. If there is no intersection, the function cannot be used.

Characteristics

Settings				
Is Set Point				
Setting range	max (0.05 I_{NA}; 0.05 I_{NB}) ≤ Is ≤ min (0.5 I_{NA}; 0.5 I_{NB})			
Accuracy (1)	5% Is or 0.4% I_N			
Resolution	1 A or 1 digit			
Drop out/pick up ratio	93.5%			
Advanced Settings				
Pick-up of restraint on CT loss				
Setting range	On / off			
Characteristic Times				
Operation time	Operation time of differential current function			
Overshoot time	< 40 ms			
Reset time	< 35 ms			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Protection reset	P81L_x_101	■	■	
Protection blockingblock	P81L_x_113	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Protection output	P87M_1_3	■	■	■
Phase a fault	P87M_1_7	■	■	
Phase b fault	P87M _1_8	■	■	
Phase c fault	P87M _1_9	■	■	
Protection blocked	P87M_1_16	■	■	
High set point	P87M_1_33	■	■	
Percentage-based set point	P87M_1_34	■	■	
CT loss	P87M_1_39	■	■	

(1) *Under reference conditions (IEC 60255-6).*

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Transformer Differential
ANSI Code 87T

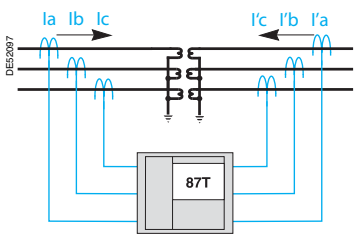
Phase-to-phase short-circuit protection for transformers and transformer-machine units (2 windings)

Operation

This protection function protects the zone between the CTs for the main currents Ia, Ib, Ic on the one hand and the CTs for the additional currents I'a, I'b, I'c on the other.

It adjusts both the amplitude and phase of the currents in each winding according to the vector shift and the transformer rated power, as well as the set voltage and current values.

It then compares the matched currents phase by phase.



According to the current measurement convention shown in the diagram and respecting the recommended wiring system, the differential currents Id and through currents It are calculated using the matched currents Im and I'm.

- Differential current: $\mathbf{Idx} = |\vec{I}\,\mathbf{xm} + \vec{I}'\mathbf{xm}|$ where x = a, b, or c
- Through current: $\mathbf{Itx} = \mathbf{max}(|\vec{I}\,\mathbf{xm}|, |\vec{I}'\mathbf{xm}|)$ where x = a, b, or c

The function picks up if the differential current of at least one phase is greater than the operating threshold defined by:

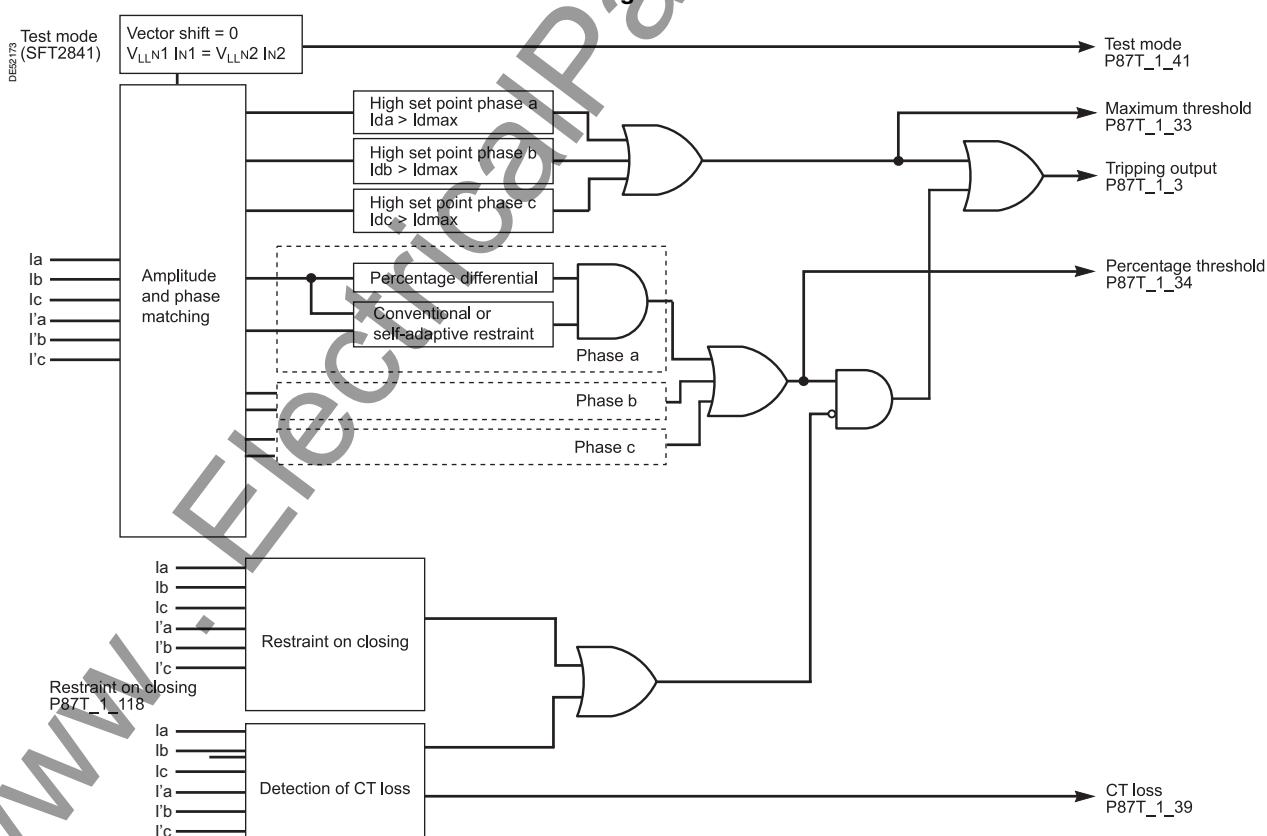
- a high adjustable differential current set point, without tripping restraint
- an adjustable percentage-based characteristic with two slopes
- a low adjustable differential current set point.

Stability is ensured by the following tripping restraints:

- a self-adaptive or conventional harmonic restraint
- a transfomer-energization restraint
- a CT-loss restraint.

The high tripping set point is not restrained.

Block Diagram



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Transformer Differential
ANSI Code 87T

Definitions

The terms winding 1 and winding 2 are used in the following manner:

- winding 1: corresponds to the circuit to which the main currents Ia, Ib, Ic, and the voltage measurements Van, Vbn, Vcn, Vab, or Vbc are connected
- winding 2: corresponds to the circuit to which the additional currents I'a, I'b, I'c are connected.

The transformer electrical parameters must be set on the "Particular characteristics" screen in the SFT2841 software:

- winding 1 voltage: $V_{LLN}1$
- winding 2 voltage: $V_{LLN}2$
- vector shift
- transformer rated power S.

To assist during the setup procedure, the screen shows:

- the transformer rated current value for windings 1 and 2: $I_{N}1$, $I_{N}2$
- the value set on the "CT-VT" screen for the base current IB of winding 1
- the value calculated using the transformation ratio for the base current I'B of winding 2.

Matching

Principle

The currents in windings 1 and 2 cannot be compared directly due to the transformation ratio and the phase displacement introduced by the power transformer.

Sepam™ does not use matching CTs. It uses the rated power and winding voltage data to calculate the transformation ratio and, therefore, to match current amplitude. The vector shift is used to match the phase currents.

Winding 1 Current Matching

Winding 1 is always matched in the same way, whatever the vector shift of the transformer. The matching is made by clearing the zero-sequence current in order to make the protection function immune to external ground faults.

$$\vec{I}1m = \frac{\vec{I}a}{I_{N}1} - \frac{\vec{I}a + \vec{I}b + \vec{I}c}{3I_{N}1}$$

$$\vec{I}2m = \frac{\vec{I}2}{I_{N}1} - \frac{\vec{I}a + \vec{I}b + \vec{I}c}{3I_{N}1}$$

$$\vec{I}3m = \frac{\vec{I}c}{I_{N}1} - \frac{\vec{I}a + \vec{I}b + \vec{I}c}{3I_{N}1}$$

Winding 2 Current Matching and Vector Shift

The matching of winding 2 affects the amplitude and phase and takes account of the vector shift of the transformer.

Standard IEC 60076-1 assumes the vector shift is given for a transformer connected to a power source with a phase-rotation sequence of a-b-c. Sepam™ uses this vector shift value for both a-b-c and a-c-b type networks.

Therefore, it is unnecessary to complement this value by a-b for an a-c-b type network. When the current transformer connections are correct. The vector shift matching is the result of the phase-displacement measurement taken by Sepam™ between the currents in winding 1 and winding 2, divided by 30°.

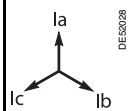
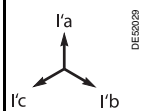
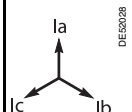
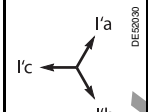
The table on the next page contains vectorial diagrams and matching formulae based on the vector shift of the transformer for networks with type a-b-c phase-rotation sequences.

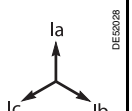
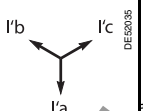
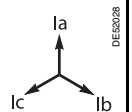
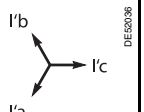
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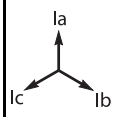
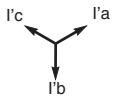
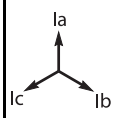
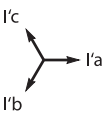
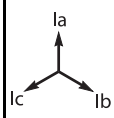
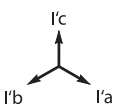
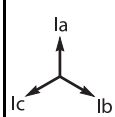
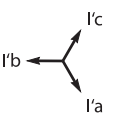
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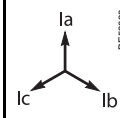
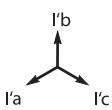
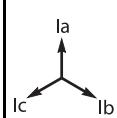
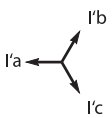
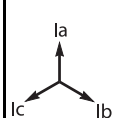
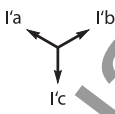
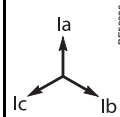
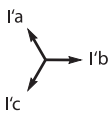
Calculating Matched Currents for Winding 2

Vector shift	Winding 1	Winding 2	Matching
0			$\frac{\vec{I}a}{I_{N2}} - \frac{\vec{I}a + \vec{I}b}{3I_{N2}}$ $\frac{\vec{I}b}{I_{N2}} - \frac{\vec{I}a + \vec{I}b}{3I_{N2}}$ $\frac{\vec{I}c}{I_{N2}} - \frac{\vec{I}a + \vec{I}b}{3I_{N2}}$
1			$\vec{I}'am = \frac{\vec{I}a - \vec{I}b}{\sqrt{3}I_{N2}}$ $\vec{I}'bm = \frac{\vec{I}b - \vec{I}c}{\sqrt{3}I_{N2}}$ $\vec{I}'cm = \frac{\vec{I}c - \vec{I}a}{\sqrt{3}I_{N2}}$

Vector shift	Winding 1	Winding 2	Matching
6			$\vec{I}'am = -\frac{\vec{I}a}{I_{N2}} + \frac{\vec{I}a + \vec{I}b + \vec{I}c}{3I_{N2}}$ $\vec{I}'bm = -\frac{\vec{I}b}{I_{N2}} + \frac{\vec{I}a + \vec{I}b + \vec{I}c}{3I_{N2}}$ $\vec{I}'cm = -\frac{\vec{I}c}{I_{N2}} + \frac{\vec{I}a + \vec{I}b + \vec{I}c}{3I_{N2}}$
7			$\vec{I}'am = \frac{\vec{I}b - \vec{I}a}{\sqrt{3}I_{N2}}$ $\vec{I}'bm = \frac{\vec{I}c - \vec{I}b}{\sqrt{3}I_{N2}}$ $\vec{I}'cm = \frac{\vec{I}a - \vec{I}c}{\sqrt{3}I_{N2}}$

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			$-\frac{\vec{I}'b}{I_{N2}} + \frac{\vec{I}'a + \vec{I}'b}{3I_{N2}}$
3 2			$\vec{I}'am = \frac{\vec{I}'c - \vec{I}'b}{\sqrt{3}I_{N2}}$ $\vec{I}'bm = \frac{\vec{I}'a - \vec{I}'c}{\sqrt{3}I_{N2}}$ $\vec{I}'cm = \frac{\vec{I}'b - \vec{I}'a}{\sqrt{3}I_{N2}}$ $\frac{\vec{I}'c}{I_{N2}} + \frac{\vec{I}'a + \vec{I}'b}{3I_{N2}}$
4			$\frac{\vec{I}'c}{I_{N2}} - \frac{\vec{I}'a + \vec{I}'b}{3I_{N2}}$ $-\frac{\vec{I}'a}{I_{N2}} + \frac{\vec{I}'a + \vec{I}'b}{3I_{N2}}$ $\vec{I}'bm = \frac{\vec{I}'a}{I_{N2}} - \frac{\vec{I}'a + \vec{I}'b + \vec{I}'c}{3I_{N2}}$
			$\frac{\vec{I}'b}{I_{N2}} - \frac{\vec{I}'a + \vec{I}'b}{3I_{N2}}$
5			$\vec{I}'am = \frac{\vec{I}'c - \vec{I}'a}{\sqrt{3}I_{N2}}$ $\vec{I}'bm = \frac{\vec{I}'a - \vec{I}'b}{\sqrt{3}I_{N2}}$ $\vec{I}'cm = \frac{\vec{I}'b - \vec{I}'c}{\sqrt{3}I_{N2}}$

			$\vec{I}'am = \frac{\vec{I}'b}{I_{N2}} - \frac{\vec{I}'a + \vec{I}'b + \vec{I}'c}{3I_{N2}}$
9 8			$\vec{I}'am = \frac{\vec{I}'b - \vec{I}'c}{\sqrt{3}I_{N2}}$ $\vec{I}'bm = \frac{\vec{I}'c - \vec{I}'a}{\sqrt{3}I_{N2}}$ $\vec{I}'cm = \frac{\vec{I}'a - \vec{I}'b}{\sqrt{3}I_{N2}}$ $\frac{\vec{I}'c}{I_{N2}} + \frac{\vec{I}'a + \vec{I}'b + \vec{I}'c}{3I_{N2}}$
10			$\vec{I}'am = -\frac{\vec{I}'c}{I_{N2}} + \frac{\vec{I}'a + \vec{I}'b + \vec{I}'c}{3I_{N2}}$ $\vec{I}'cm = \frac{\vec{I}'a}{I_{N2}} - \frac{\vec{I}'a + \vec{I}'b + \vec{I}'c}{3I_{N2}}$
			$\vec{I}'bm = -\frac{\vec{I}'a}{I_{N2}} + \frac{\vec{I}'a + \vec{I}'b + \vec{I}'c}{3I_{N2}}$ $\vec{I}'cm = -\frac{\vec{I}'b}{I_{N2}} + \frac{\vec{I}'a + \vec{I}'b + \vec{I}'c}{3I_{N2}}$
11			$\vec{I}'am = \frac{\vec{I}'a - \vec{I}'c}{\sqrt{3}I_{N2}}$ $\vec{I}'bm = \frac{\vec{I}'b - \vec{I}'a}{\sqrt{3}I_{N2}}$ $\vec{I}'cm = \frac{\vec{I}'c - \vec{I}'b}{\sqrt{3}I_{N2}}$

Test Mode

Two operating modes facilitate maintenance and startup operations:

- *normal mode*: the protection function controls the tripping and indication outputs based on the settings. This is the standard operating mode
- *test mode*: the protection function controls tripping and indication outputs based on test mode settings. This mode is accessed only by the SFT2841 software, once it is connected and the Protection setting password entered. The system returns to normal mode when the software is disconnected

Note : Transfer from normal mode to test mode can result in nuisance tripping if the protected transformer is energized.

Test mode settings:

- $V_{LLN1} = \frac{S}{I_N \times 3}$
- $V_{LLN2} = \frac{S}{I'_N \times 3}$
- vector shift = 0

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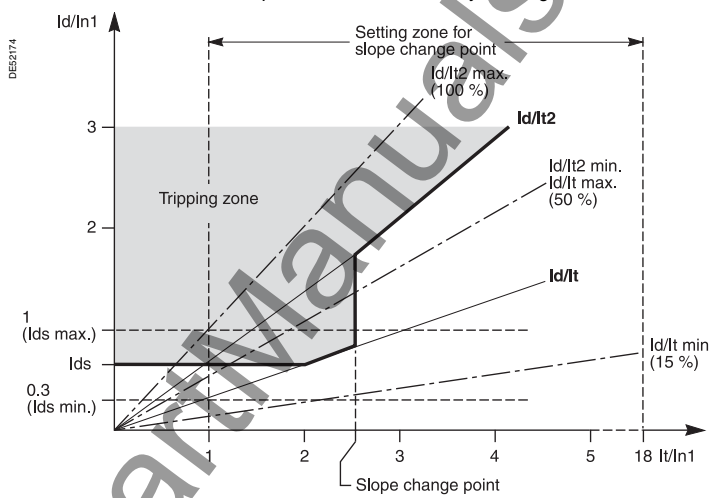
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Transformer Differential
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High Set Point
A non-restrained differential current set point will ensure fast tripping in the event of significant fault currents. This threshold must be set to a value higher than that of the inrush current.

Percentage-Based Curve
The percentage-based curve is made up of the following:
- a low set point (Ids)
- two straight lines crossing zero and with adjustable slopes (Id/It and Id/It2)
- the slope change point.

The curve must be set to protect itself against current-transformer measurement errors and transformation errors attributable to the tap changer. Also, the protection function must be immune to power shunts on auxiliary windings.



Self-Adaptive Restraint
The self-adaptive restraint is particularly suitable for transformers, where:

$$\hat{I}_{inr} < \frac{8}{2}\hat{I}_{2N} = 8I_N$$

where $\hat{I}_{inr}$ is the peak tripping current
$\hat{I}_N$ is the rated peak current
I_N is the rated transformer current

This neutral network restraint ensures stability in the event of an external fault by analyzing the second- and fifth-harmonic factors, the differential currents and the through currents. It ensures stability in the event of the following:
- transformer closing
- an asymmetrical fault outside the zone that saturates the CTs
- the transformer operating on a voltage supply that is too high (overexcitation).

Detecting the presence of harmonics and monitoring the through and differential currents, the restraint automatically increases the low set point and the percentage-based slopes. It is also more sensitive than the high set point.

Using the high set point is unecesseary when this restraint is active. Also, as the restraint integrates the stabilization slope for high through currents (which can saturate the CTs), slope Id/It2 does not have to be activated.

Conventional Restraint
The conventional restraint comprises a second-harmonic set point for each phase and a fifth-harmonic set point for each phase.

The second-harmonic set point ensures that the protection function will not pick up if the transformer closes or the CTs become saturated. The restraint can be global (cross-blocking: all three phases are restrained as soon as the harmonic in one phase exceeds the set point) or phase-specific (no cross-blocking: only the phase with a harmonic exceeding the set point is restrained). Cross-blocking is recommended for transformers used in three-phase mode.

The fifth-harmonic set point ensures that the protection function will not pick up if the transformer is connected to a voltage supply that is too high. The restraint can be global (all three phases are restrained) or phase-specific (only the phase with a harmonic exceeding the set point is restrained). Restraint without cross-blocking is recommended for normal operation.

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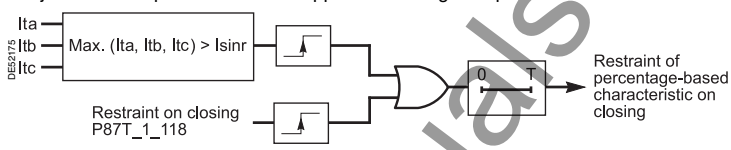
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Restraint on Closing

In some cases, the harmonic content of the transformer inrush current is not sufficient to activate harmonic restraints. An additional restraint can be activated:

- when the through current exceeds an adjustable set point Isinr
- by an internal variable, P87T_1_118, controlled by logic equations or Logipam.

This restraint is applied to the percentage-based differential elements for an adjustable time period T. It is not applied to the high set point.



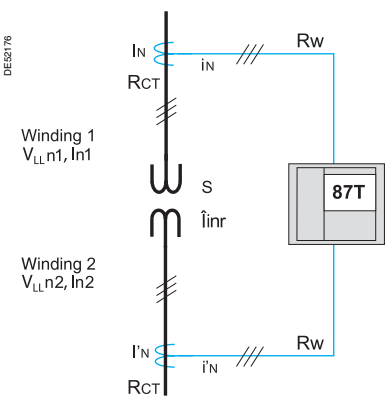
Restraint on CT Loss

CT loss can distort the differential current and cause nuisance tripping. This restraint detects a measurement dropping to zero abnormally by analyzing sampled differential and through currents.

Sizing Phase-Current Transformers

The primary rated current of the current transformers is governed by the following rule:

- for winding 1: $0.1 \times \frac{S}{V_{LLn1} \times \sqrt{3}} \leq I_N \leq 2.5 \times \frac{S}{V_{LLn1} \times \sqrt{3}}$
- for winding 2: $0.1 \times \frac{S}{V_{LLn2} \times \sqrt{3}} \leq I'_N \leq 2.5 \times \frac{S}{V_{LLn2} \times \sqrt{3}}$



where:

IN is the primary rated current of the CT.
IN is the secondary rated current of the CT.
RCT is the internal resistance of the CT.
Rw is the resistance of the wiring and the CT load.

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Characteristics

Settings				
Low Set Point Ids				
Setting range		30% to 100% of IN1		
Accuracy (1)		±2%		
Resolution		1%		
Drop-out/pick-up ratio		93.5% ±5%		
Percentage-Based Characteristic Id/It				
Setting range		15% to 50%		
Accuracy (1)		±2%		
Resolution		1%		
Drop-out/pick-up ratio		93.5% ±5%		
Percentage-Based Characteristic Id/It2				
Setting range		None, 50% to 100%		
Accuracy (1)		±2%		
Resolution		1%		
Drop-out/pick-up ratio		93.5% ±5%		
Slope Change Point				
Setting range		None, IN1 to 18 IN1		
Accuracy (1)		±5%		
Resolution		0.1 INa		
Drop-out/pick-up ratio		93.5% ±5%		
Test Mode				
Setting range		Active/Not active		
Advanced Settings				
Selection of restraint		Conventional/Self-adaptive		
Restraint on CT Loss				
Setting range		Active/Not active		
Restraint on Closing				
Setting range		Active/Not active		
Magnetization current set point Isinr	Setting range	1% to 10%		
	Accuracy (1)	±5%		
	Resolution	1%		
	Drop-out/pick-up ratio	90% ±5% or 0.5% IN1		
Time delay	Setting range	0 to 300 s		
	Accuracy (1)	±2% or -10 ms to +25 ms		
	Resolution	10 ms		
High Set Point Idmax				
Setting range	Conventional restraint	3 to 18 IN1		
	Self-adaptive restraint	None, 3 to 18 IN1		
Accuracy (1)		±2%		
Resolution		1%		
Drop-out/pick-up ratio		93.5% ±5%		
Second-Harmonic Set Point for Conventional Restraint				
Setting range		None, 5 to 40%		
Accuracy (1)		±5%		
Resolution		1%		
Drop-out/pick-up ratio		90% ±5%		
Second-Harmonic Restraint for Conventional Restraint				
Setting range		Phase-specific/Global		
Fifth-Harmonic Set Point for Conventional Restraint				
Setting range		None, 5 to 40%		
Accuracy (1)		±5%		
Resolution		1%		
Drop-out/pick-up ratio		90% ±5%		
Fifth-Harmonic Restraint for Conventional Restraint				
Setting range		Phase-specific/Global		
Characteristic Times				
Operating time high set point		< 45 ms at 2 Id		
Operating time percentage-based curve		< 45 ms at 2 Id		
Reset time		< 45 ms at 2 Id		

Inputs			
Designation	**Syntax**	**Equations**	**Logipam**
Protection reset	P87T_1_101	■	■
Protection blocking	P87T_1_113	■	■
Restraint on closing	P87T_1_118	■	■

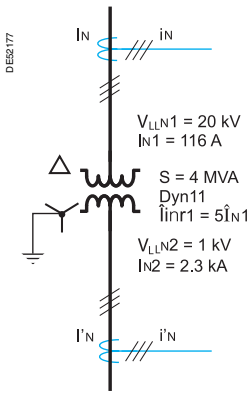
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Protection output	P87T_1_3	■	■	■
Protection blocked	P87T_1_16	■	■	-
High set point	P87T_1_33	■	■	-
Percentage-based threshold	P87T_1_34	■	■	-
CT loss	P87T_1_39	■	■	-
Test mode	P87T_1_41	■	■	-

(1) *Under reference conditions (IEC 60255-6).*

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Transformer Differential
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Example 1

4 MVA, Dyn11, 20 kV/1 kV transformer, the peak closing current is: $\hat{I}inr = 5\hat{I}N$

The transformer operates normally at its rated load, but will tolerate operation at up to 120% of its rated power.

Sensor selection

The rated current of the windings is:

$$IN1 = \frac{S}{3V_{LLN1}} = \frac{4\ MVA}{3\ 20\ kV} = 116\ A \quad \text{and} \quad IN2 = \frac{S}{3V_{LLN2}} = \frac{4\ MVA}{3\ 1\ kV} = 2.3\ kA$$

The CTs can support an overload of 120%:

IN > 116 A x 1.2 = 139.2 A and **I'n > 2.3 kA x 1.2 = 2.76 kA**

The main currents of the CTs must also meet the following requirements:

$$0.1\frac{S}{3V_{LLN1}}\ y\ In\ y\ 2.5\frac{S}{3V_{LLN1}} \quad \text{and} \quad 0.1\frac{S}{3V_{LLN2}}\ y\ I'n\ y\ 2.5\frac{S}{3V_{LLN2}}$$

So, for this transformer:

11.6 A ≤ IN ≤ 290 A and **230 A ≤ I'N ≤ 5.75 kA**

Taking these two restrictions into account, the values selected are those standardized by ANSI:

IN = 150 A and **I'N = 3 kA**

The tripping current is $\hat{I}inr = 5\hat{I}N$, so, for both winding 1 and winding 2:

$\hat{I}inr1 = 5 \times 2 \times 116\ A = 820\ A$

$\hat{I}inr2 = 5 \times 2 \times 2.3\ kA = 16.3\ kA$

These tripping currents must be compared with the rated current of the current sensors in order to select the accuracy limit factor:

$$\frac{\hat{I}inr1}{2IN} = \frac{820\ A}{2 \times 150\ A} = 3.9 < 6.7 \quad \text{and} \quad \frac{\hat{I}inr2}{2I'N} = \frac{16.3\ kA}{2 \times 3\ kA} = 3.8 < 6.7$$

The accuracy limit factor is, therefore, 20, with a rated burden of:

VACT ≥ Rw.iN².

The following sensors are selected:

- for winding 1: 150 A/1 A, 5P20 where VACT1
- for winding 2: 3 kA/1 A, 5P20 where VACT2.

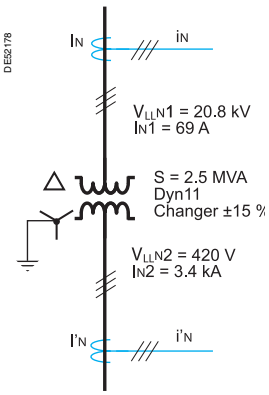
Setting the Percentage-based Curve and the Maximum Threshold

As this transformer does not feature a tap changer or an auxiliary winding, the tripping threshold is, therefore, set to a minimum value (Ids = 30%) and the slope to Id/It = 15%.

As the ratio between the closing current and the rated current is less than $8/\sqrt{2}$, the self-adaptive harmonic restraint is selected. The second slope on the percentage-based curve and the maximum threshold are not necessary and are not, therefore, used.

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Example 2

2.5 MVA, Dyn11, 20.8 kV/420 V transformer, the peak closing current is:
$\hat{I}_{inr} = 9.6\ \hat{I}_N$

The transformer features a tap changer with a tap range of ±15% of the rated voltage of winding 2.

Sensor selection

The rated current of the windings is:

$$I_{N1} = \frac{S}{\sqrt{3}V_{LLn1}} = \frac{2.5\ MVA}{\sqrt{3}20.8\ kV} = 69\ A \quad \text{and} \quad I_{N2} = \frac{S}{\sqrt{3}V_{LLn2}} = \frac{2.5\ MVA}{\sqrt{3}420\ V} = 3.4\ kA$$

Thanks to the tap changer, the current sensors can support an overload of 115%:
$I_N > 69\ A \times 1.15 = 79.4\ A$ and $I'_N > 3.4\ kA \times 1.15 = 3.91\ kA$

The main currents of the CTs must also meet the following requirements:

$$0.1\frac{S}{\sqrt{3}V_{LLn1}} \text{ y } I_N \text{ y } 2.5\frac{S}{\sqrt{3}V_{LLn1}} \qquad \text{and} \quad 0.1\frac{S}{\sqrt{3}V_{LLn2}} \text{ y } I'_N \text{ y } 2.5\frac{S}{\sqrt{3}V_{LLn2}}$$

So, for this transformer:
$6.9\ A \le I_N \le 173\ A$ and $340\ A \le I'_N \le 8.5\ kA$

Taking these two restrictions into account, the values selected are those standardized by the IEC:
$I_n = 100\ A$ and $I'_n = 4\ kA$

The tripping current is $\hat{I}_{inr} = 9.6\ \hat{I}_N$, so, for both winding 1 and winding 2:

$\hat{I}_{inr1} = 9.6 \times \sqrt{2} \times 69\ A = 937\ A$

$\hat{I}_{inr2} = 9.6 \times \sqrt{2} \times 3.4\ kA = 46.2\ kA$

These tripping currents must be compared with the rated current of the CTs in order to select the accuracy limit factor:

$$\frac{\hat{I}_{inr1}}{2I_N} = \frac{937\ A}{2 \times 100\ A} = 6.6 < 6.7 \quad \text{and} \quad \frac{\hat{I}_{inr2}}{2I'_N} = \frac{46.2\ kA}{2 \times 4\ kA} = 8.2 > 6.7$$

The accuracy limit factor is, therefore, 20 for the sensors in winding 1

and equal to $3\frac{\hat{I}_{inr2}}{2I'_N} = 3\frac{46.2\ kA}{2 \times 4\ kA} = 24.5$ for winding 2.

The closest standard value, 30, is selected.

The following sensors are selected:
- for winding 1: 100 A/1A, 5P20
- for winding 2: 4 kA/1A, 5P30.

Setting the Percentage-Based Curve and the Maximum Threshold

This transformer features a tap changer. The continuous differential current due to the voltage variation of the tap changer is:

$$Id_{changer} = \frac{x}{1-x} \times 100\%$$

where x is the maximum variation of the tap changer. In this example, x = 0.15.

The differential current due to the change in the transformation ratio is:

$$Id_{changer} = \frac{0.15}{1-0.15} \times 100\% = 17.6\%$$

Type 5P sensors with a maximum measurement error tolerance of 10% are used.
The measurement accuracy of the relay is ±1% for Ids and Id/It.
The minimum setting is, therefore:
$Ids = IdChanger + IdMeasure + IdRelay + margin$.

Assuming a margin of approximately 5%, the minimum setting is, therefore:
$Ids = 17.6 + 10 + 1 + 5 \approx 34\%$
Ids and the Id/It slope are set to 34%.

The ratio between the closing current and the rated current is 9.6. As this ratio is greater than $8/\sqrt{2}$, the conventional harmonic restraint is selected.

The second slope on the percentage-based curve is set to 70%, starting at 6 I_{N1} in order to ensure sufficient stability of the protection fault in the event of external faults.

The high set point is set to a value higher than that of the closing current with the following margin:

$$Id_{max} = 2 \times \frac{\hat{I}_{inr}}{\hat{I}_N} = 2 \times 9.6\ In1 = 13.6\ In1$$

The conventional harmonic restraint is set with:
- a second-harmonic set point equal to 20%, with cross-blocking
- a fifth-harmonic set point equal to 25%, without cross-blocking.

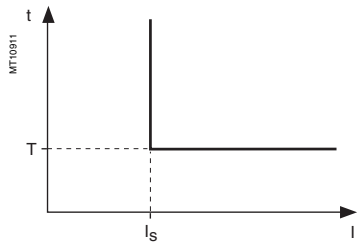
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Presentation of tripping curve operation and settings for protection functions using:
- *definite time*
- *IDMT*
- *timer hold.*

Definite Time Protection

The tripping time is constant. The time delay is started when the set point is overrun.



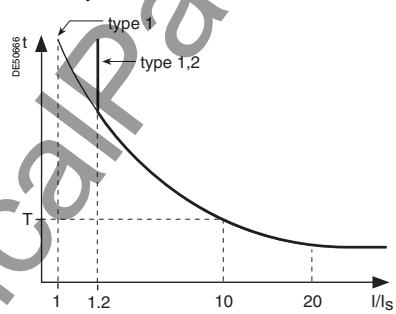
Definite time protection principle

IDMT Protection

The operation time depends on the protected value (phase current, ground fault current, etc.) in accordance with standards IEC 60255-3, BS 142 and IEEE C-37112.
Operation is represented by a characteristic curve, e.g.:
- t = f(I) curve for the **phase overcurrent** function
- t = f(Ir) curve for the **ground fault** function.

The rest of the document is based on t = f(I); the reasoning may be extended to other variables Ir, etc.
The curve is defined by:
- its type (standard inverse, very inverse, extremely inverse, etc.)
- current setting Is which corresponds to the vertical asymptote of the curve
- time delay T which corresponds to the operation time for I = 10 Is

These three settings are made in order of type, Is current, and time delay T.
Changing the time delay T setting by x% changes all of the operation times in the curve by x%.



IDMT protection principle

The tripping time for I/Is values less than 1.2 depends on the type of curve selected.

Name of Curve	Type
Standard inverse time (SIT)	1.2
Very inverse time (VIT or LTI)	1.2
Extremely inverse time (EIT)	1.2
Ultra inverse time (UIT)	1.2
RI curve	1
IEC inverse time SIT / A	1
IEC very inverse time VIT or LTI / B	1
IEC extremely inverse time EIT / C	1
IEEE moderately inverse (IEC / D)	1
IEEE very inverse (IEC / E)	1
IEEE extremely inverse (IEC / F)	1
IAC inverse	1
IAC very inverse	1
IAC extremely inverse	1

- when the monitored value is more than 20 times the set point, the tripping time is limited to the value corresponding to 20 times the set point.
- if the monitored value exceeds the measurement capacity of Sepam™ (40 In for the phase current channels, 20 Inr for the residual current channels), the tripping time is limited to the value corresponding to the largest measurable value (40 In or 20 Inr).

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Current IDMT Tripping Curves

Multiple IDMT tripping curves are offered, to cover most applications:

- IEC curves (SIT, VIT/LTI, EIT)
- IEEE curves (MI, VI, EI)
- commonly used curves (UIT, RI, IAC).

IEC Curves

Equation

$$t_d(I) = \frac{k}{\left(\frac{I}{I_s}\right)^{\alpha} - 1} \times \frac{T}{\beta}$$

Curve Type	Coefficient Values		
	k	α	β
Standard inverse / A	0.14	0.02	2.97
Very inverse / B	13.5	1	1.50
Long time inverse / B	120	1	13.33
Extremely inverse / C	80	2	0.808
Ultra inverse	315.2	2.5	1

RI curve

Equation: $t_d(I) = \frac{1}{0.339 - 0.236\left(\frac{I}{I_s}\right)^{-1}} \times \frac{T}{3.1706}$

IEEE Curves

Equation

$$t_d(I) = \left(\frac{A}{\left(\frac{I}{I_s}\right)^{p} - 1} + B\right) \times \frac{T}{\beta}$$

Curve Type	Coefficient Values			
	A	B	p	β
Moderately inverse	0.010	0.023	0.02	0.241
Very inverse	3.922	0.098	2	0.138
Extremely inverse	5.64	0.0243	2	0.081

IAC Curves

Equation

$$t_d(I) = \left(A + \frac{B}{\left(\frac{I}{I_s} - C\right)} + \frac{D}{\left(\frac{I}{I_s} - C\right)^2} + \frac{E}{\left(\frac{I}{I_s} - C\right)^3}\right) x \frac{T}{\beta}$$

Curve Type	Coefficient Values					
	A	B	C	D	E	β
Inverse	0.208	0.863	0.800	-0.418	0.195	0.297
Very inverse	0.090	0.795	0.100	-1.288	7.958	0.165
Extremely inverse	0.004	0.638	0.620	1.787	0.246	0.092

Voltage IDMT Tripping Curves

Equation for ANSI 27 - Undervoltage

$$t_d(V) = \frac{T}{1 - \left(\frac{V}{V_s}\right)}$$

Equation for ANSI 59N - Neutral Voltage Displacement

$$t_d(V) = \frac{T}{\left(\frac{V}{V_S}\right) - 1}$$

Voltage/Frequency Ratio IDMT Tripping Curves

Equation for ANSI 24 - Overexcitation (V/Hz)

Where G = V_{Ln}/f or V_{LL}/f

CurveType	p
A	0.5

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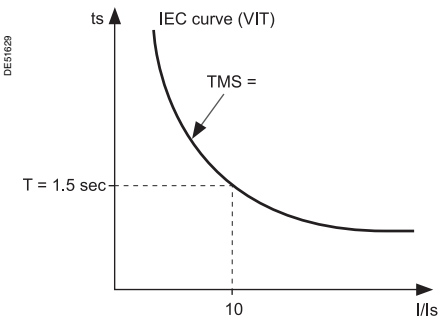
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B	1
C	2

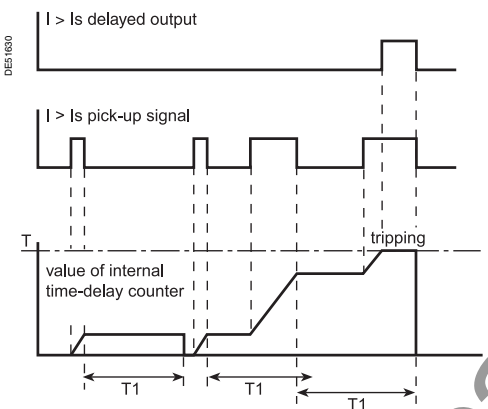
$$t_d(G) = \frac{1}{\left(\frac{G}{G_s} - 1\right)^p} \times T$$

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Example.



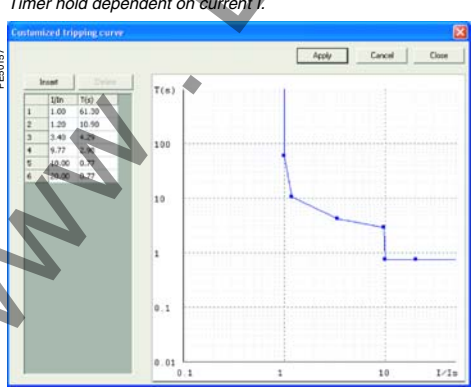
Detection of restriking faults with adjustable timer hold.

DE50755

Timer hold dependent on current I.

DE50754

Constant timer hold.



Customized tripping curve set using SFT2841 software.

Setting IDMT Tripping Curves, Time Delay T or TMS Factor

The time delays of current IDMT tripping curves (except for customized and RI curves) may be set as follows:

- time T, operating time at 10 x Is
- TMS factor, factor shown as T/β in the equations on the left.

Example: $\mathbf{t(I) = \frac{13.5}{\frac{I}{Is} - 1} \times TMS}$ where $\mathbf{TMS = \frac{T}{1.5}}$.

The IEC curve of the VIT type is positioned so as to be the same with TMS = 1 or T = 1.5 s.

TMS Setting Mode

Retrofit Sepam™ to electromechanical relay may be done as the following example shows. With a U.S. built VIT relay having #3 TDS, 4A Tap, 500:5A CT, use a primary current setting of 4A x 500/5 = 400A with an IEEE VIT curve set on TMS#3. To verify coordination, plot the associated equation with T/β replaced by TMS value and all coefficients inserted. Another method takes the plotted family (IEEE VIT) of curves and transposes them by a factor of β.

Timer Hold

The adjustable timer hold T1 is used for:

- detection of restriking faults (DT curve)
- coordination with electromechanical relays (IDMT curve).
- Timer hold may be blocked if necessary.

Equation for IDMT Timer Hold Curve

Equation: $\mathbf{t_r(I) = \frac{T1}{1 - \left(\frac{I}{Is}\right)^2} \times \frac{T}{\beta}}$ where $\mathbf{\frac{T}{\beta} = TMS}$.

T1 = timer hold setting (timer hold for I reset = 0 and TMS = 1)
T = tripping time delay setting (at 10 Is)

β = basic tripping curve value at $\mathbf{\frac{k}{10^{\alpha} - 1}}$.

Customized Tripping Curve

Defined point by point using the SFT2841 setting and operating software tool (application menu), this curve may be used to solve all special cases involving protection coordination or installation renovation.

It offers between 2 and 30 points whose coordinates must be:

- increasing on the I/Is axis
- decreasing on the t axis.

The two end points define the curve asymptotes. There must be at least one point on the horizontal coordinate 10 I/Is to serve as a reference point to set the function time delay by curve shifting.

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Implementing IDMT curves: examples of problems to be solved.

Problem 1.
Given the type of IDMT, determine the Is current and time delay T settings.

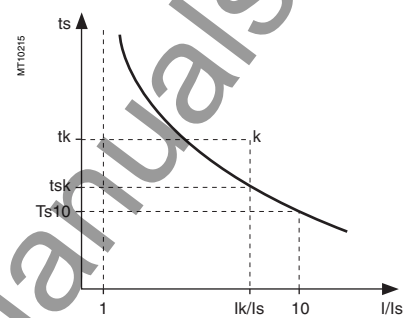
Theoretically, the Is current setting corresponds to the maximum continuous current. It is generally the rated current of the protected equipment (cable, transformer). The time delay T corresponds to operation at 10 Is on the curve. This setting is determined by factoring the constraints involved in discrimination with the upstream and downstream protection devices.

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

Problem 2.
Given the type of IDMT, the Is current setting and a point k (Ik, tk) on the operation curve, determine the time delay setting T.
On the standard curve of the same type, read the operation time tsk that corresponds to the relative current **Ik/Is** and the operation time Ts10 that corresponds to the relative current **I/Is = 10.**

The time delay setting to be used so that the operation curve passes through the point k (Ik, tk) is:

$$T = Ts10 \times \frac{tk}{tsk}$$



Another practical method:
the table below gives the values of **K = ts/ts10** as a function of **I/Is.**
In the column that corresponds to the type of time delay, read the value **K = tsk/Ts10** on the line for **Ik/Is.**
The time delay setting to be used so that the operation curve passes through point k (Ik, tk) is: **T = tk/k.**

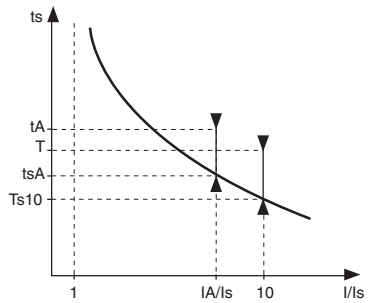
Example
Data:
- type of time delay: standard inverse time (**SIT**)
- set point: Is
- a point k on the operation curve: k (3.5 Is; 4 s)

Question: What is the time delay T setting (operation time at 10 Is)?
Reading the table: **SIT** column, line **I/Is** = **3.5** therefore **K = 1.858**
Answer: The time delay setting is **T = 4/1.858 = 2.15 s**

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Problem 3.
Given the Is current and time delay T settings for a type of time delay (standard inverse, very inverse, extremely inverse), find the operation time for a current value IA. On the standard curve of the same type, read the operation time tsA that corresponds to the relative current IA/Is and the operation time Ts10 that corresponds to the relative current **I/Is = 10.**
The operation time tA for the current IA with the Is and T settings is **tA = tsA x T/Ts10.**



Another practical method:
the table below gives the values of **K = ts/Ts10** as a function of **I/Is.**
In the column that corresponds to the type of time delay, read the value **K = tsA/Ts10** on the line for **IA/Is,** the operation time tA for the current IA with the Is and T settings is **tA = K . T.**

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 the current IA = 6 Is?
Reading the table: **VIT** column**,** line I/Is = 6, therefore k = 1.8

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

Table of K Values

I/Is	SIT and IEC/A	VIT, LTI and IEC/B	EIT and IEC/C	UIT	RI	IEEE MI (IEC/D)	IEEE VI (IEC/E)	IEEE EI (IEC/F)	IAC I	IAC VI	IAC EI
1.0	—	—	—	—	3.062	—	—	—	62.005	62.272	200.226
1.1	24.700 (1)	90.000 (1)	471.429 (1)	—	2.534	22.461	136.228	330.606	19.033	45.678	122.172
1.2	12.901	45.000	225.000	545.905	2.216	11.777	65.390	157.946	9.413	34.628	82.899
1.5	5.788	18.000	79.200	179.548	1.736	5.336	23.479	55.791	3.891	17.539	36.687
2.0	3.376	9.000	33.000	67.691	1.427	3.152	10.199	23.421	2.524	7.932	16.178
2.5	2.548	6.000	18.857	35.490	1.290	2.402	6.133	13.512	2.056	4.676	9.566
3.0	2.121	4.500	12.375	21.608	1.212	2.016	4.270	8.970	1.792	3.249	6.541
3.5	1.858	3.600	8.800	14.382	1.161	1.777	3.242	6.465	1.617	2.509	4.872
4.0	1.676	3.000	6.600	10.169	1.126	1.613	2.610	4.924	1.491	2.076	3.839
4.5	1.543	2.571	5.143	7.513	1.101	1.492	2.191	3.903	1.396	1.800	3.146
5.0	1.441	2.250	4.125	5.742	1.081	1.399	1.898	3.190	1.321	1.610	2.653
5.5	1.359	2.000	3.385	4.507	1.065	1.325	1.686	2.671	1.261	1.473	2.288
6.0	1.292	1.800	2.829	3.616	1.053	1.264	1.526	2.281	1.211	1.370	2.007
6.5	1.236	1.636	2.400	2.954	1.042	1.213	1.402	1.981	1.170	1.289	1.786
7.0	1.188	1.500	2.063	2.450	1.033	1.170	1.305	1.744	1.135	1.224	1.607
7.5	1.146	1.385	1.792	2.060	1.026	1.132	1.228	1.555	1.105	1.171	1.460
8.0	1.110	1.286	1.571	1.751	1.019	1.099	1.164	1.400	1.078	1.126	1.337
8.5	1.078	1.200	1.390	1.504	1.013	1.070	1.112	1.273	1.055	1.087	1.233
9.0	1.049	1.125	1.238	1.303	1.008	1.044	1.068	1.166	1.035	1.054	1.144
9.5	1.023	1.059	1.109	1.137	1.004	1.021	1.031	1.077	1.016	1.026	1.067
10.0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10.5	0.979	0.947	0.906	0.885	0.996	0.981	0.973	0.934	0.985	0.977	0.941
11.0	0.959	0.900	0.825	0.787	0.993	0.963	0.950	0.877	0.972	0.957	0.888
11.5	0.941	0.857	0.754	0.704	0.990	0.947	0.929	0.828	0.960	0.939	0.841
12.0	0.925	0.818	0.692	0.633	0.988	0.932	0.912	0.784	0.949	0.922	0.799
12.5	0.910	0.783	0.638	0.572	0.985	0.918	0.896	0.746	0.938	0.907	0.761
13.0	0.895	0.750	0.589	0.518	0.983	0.905	0.882	0.712	0.929	0.893	0.727
13.5	0.882	0.720	0.546	0.471	0.981	0.893	0.870	0.682	0.920	0.880	0.695
14.0	0.870	0.692	0.508	0.430	0.979	0.882	0.858	0.655	0.912	0.868	0.667
14.5	0.858	0.667	0.473	0.394	0.977	0.871	0.849	0.631	0.905	0.857	0.641
15.0	0.847	0.643	0.442	0.362	0.976	0.861	0.840	0.609	0.898	0.846	0.616
15.5	0.836	0.621	0.414	0.334	0.974	0.852	0.831	0.589	0.891	0.837	0.594
16.0	0.827	0.600	0.388	0.308	0.973	0.843	0.824	0.571	0.885	0.828	0.573
16.5	0.817	0.581	0.365	0.285	0.971	0.834	0.817	0.555	0.879	0.819	0.554
17.0	0.808	0.563	0.344	0.265	0.970	0.826	0.811	0.540	0.874	0.811	0.536
17.5	0.800	0.545	0.324	0.246	0.969	0.819	0.806	0.527	0.869	0.804	0.519
18.0	0.792	0.529	0.307	0.229	0.968	0.812	0.801	0.514	0.864	0.797	0.504
18.5	0.784	0.514	0.290	0.214	0.967	0.805	0.796	0.503	0.860	0.790	0.489
19.0	0.777	0.500	0.275	0.200	0.966	0.798	0.792	0.492	0.855	0.784	0.475
19.5	0.770	0.486	0.261	0.188	0.965	0.792	0.788	0.482	0.851	0.778	0.463
20.0	0.763	0.474	0.248	0.176	0.964	0.786	0.784	0.473	0.848	0.772	0.450

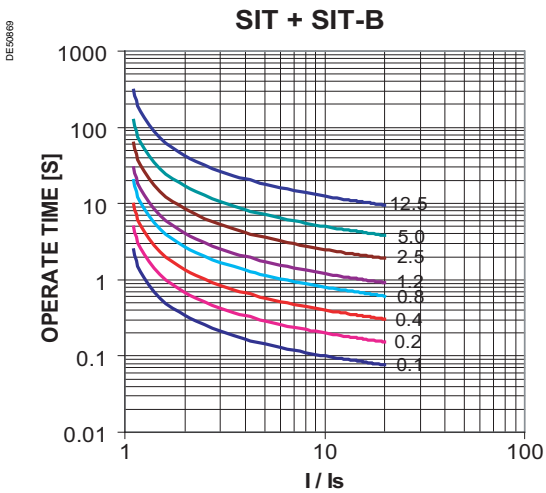
(1) *Values suitable only for IEC A, B and C curves.*

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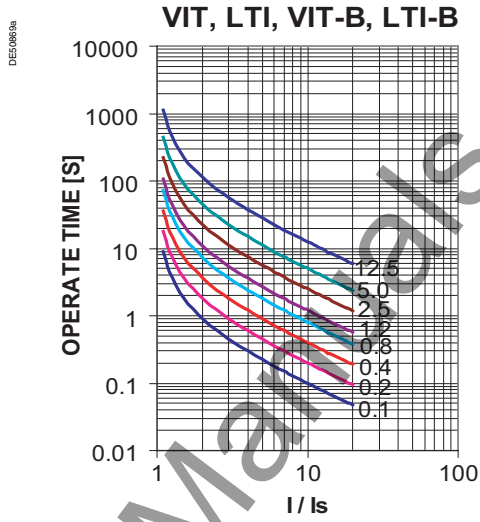
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General
Trip Curves

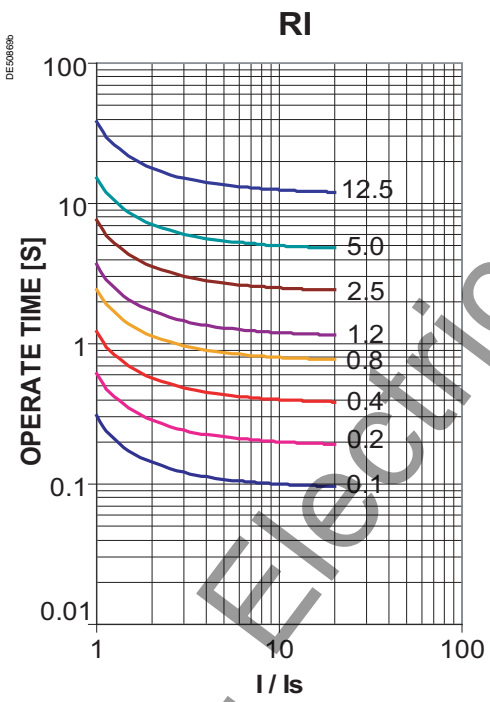
Standard Inverse Time (SIT) Curve



Very Inverse Time (VIT) or LTI Curve



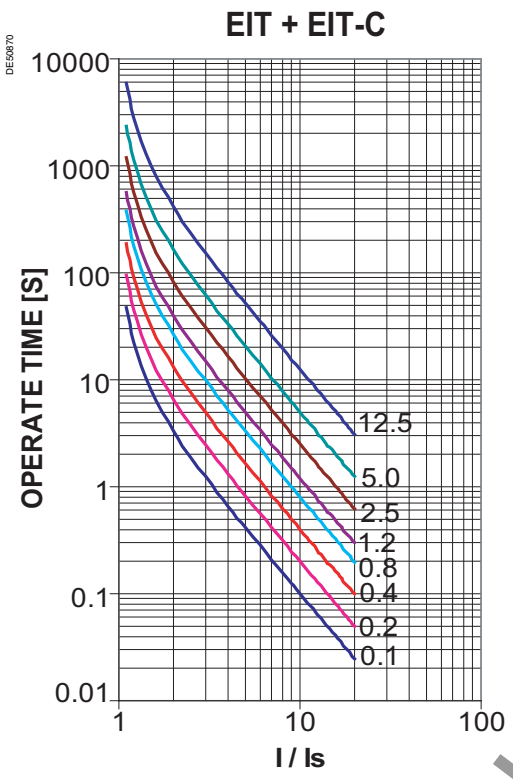
RI Curve



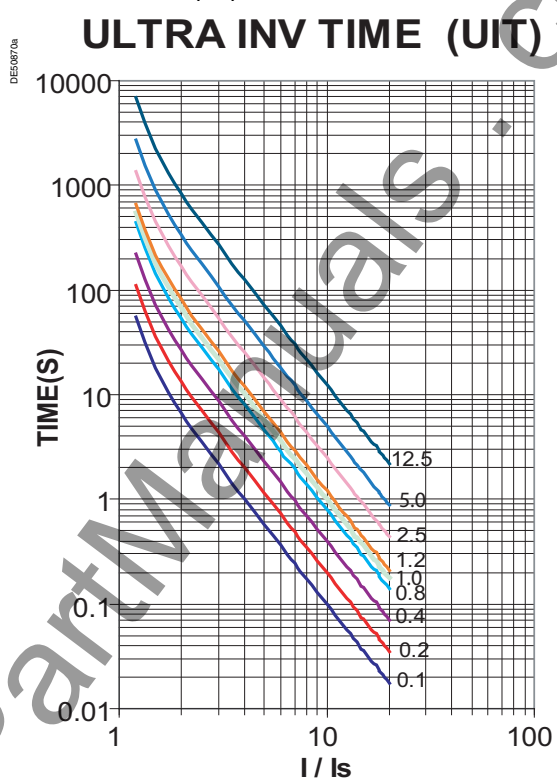
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Extremely Inverse Time (EIT) Curve



Ultra Inverse Time (UIT) Curve

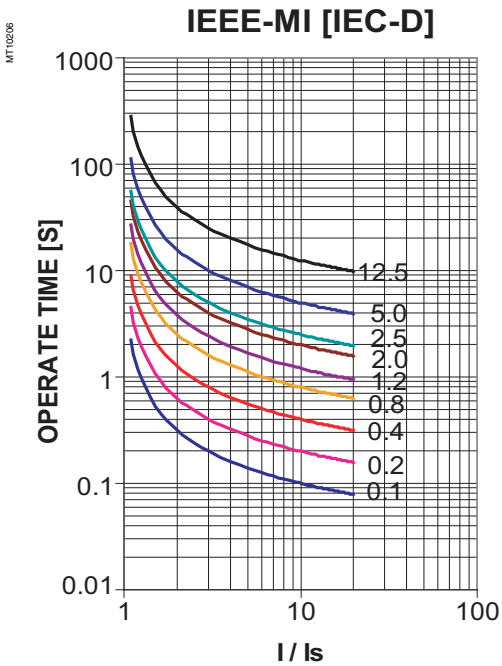


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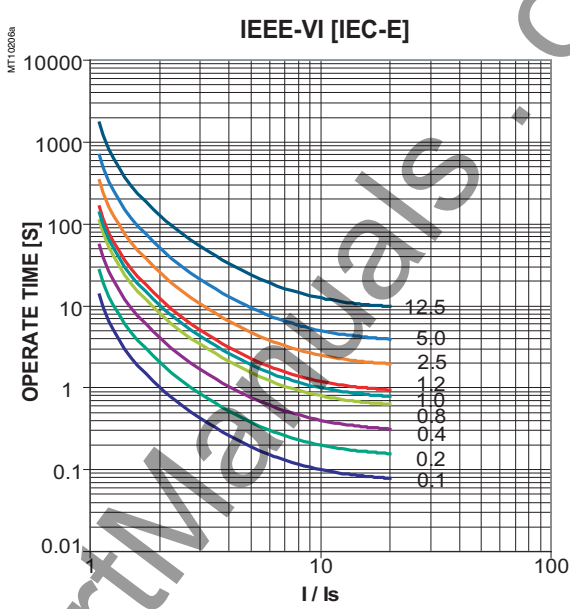
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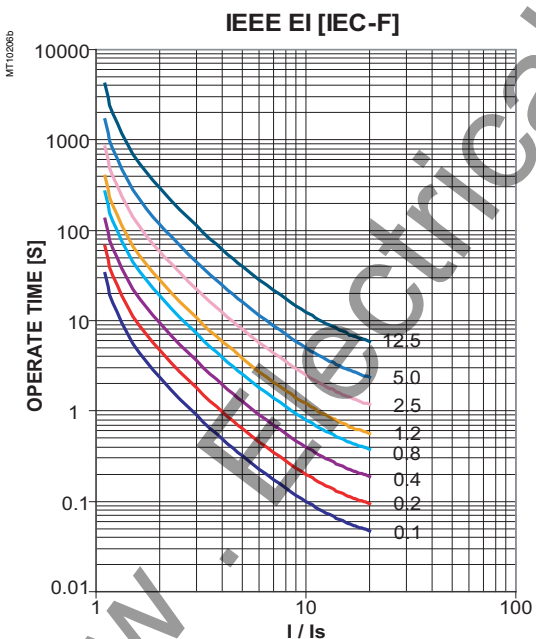
IEEE Curves



IEEE Curves



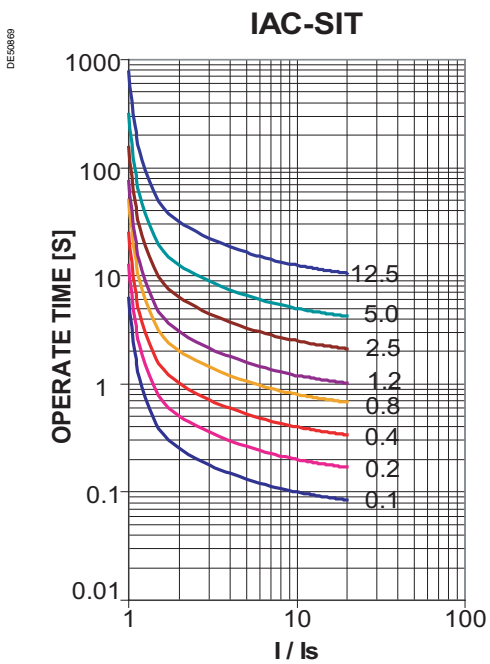
IEEE Curves



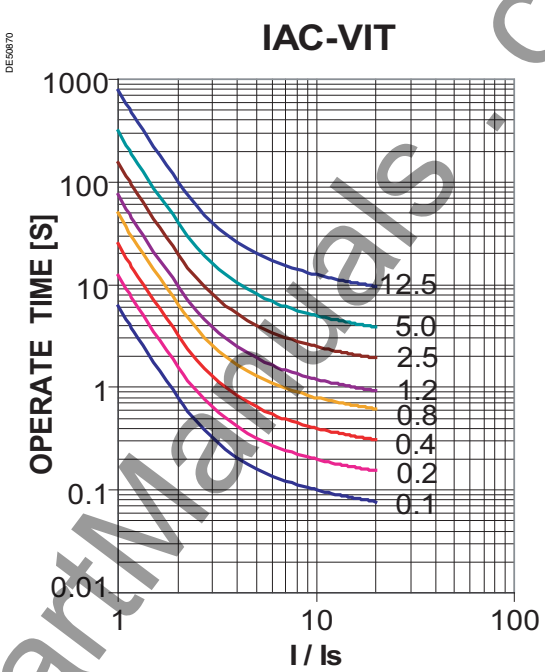
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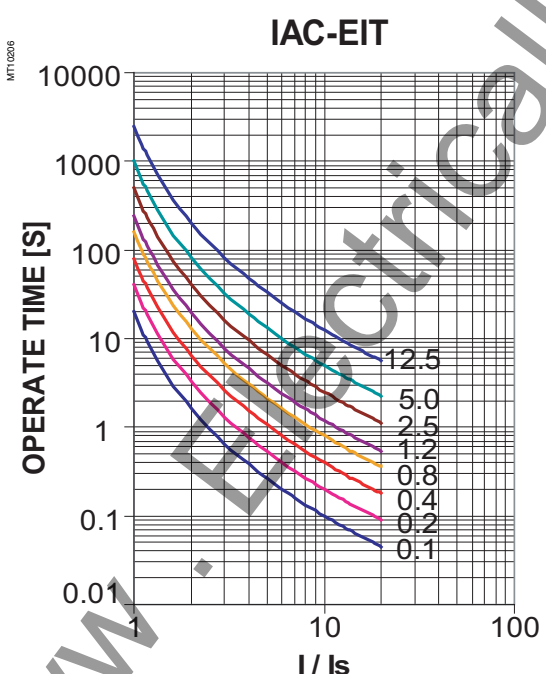
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IAC Curves



IAC Curves



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Description

Sepam™ performs all the control and monitoring functions required for electrical network operation. The main control and monitoring functions are predefined and fit the most frequent cases of use. They are ready to use and are implemented by simple parameter setting after the necessary logic inputs / outputs are assigned.

The predefined control and monitoring functions can be adapted for particular needs using the SFT2841 software, which offers the following customization options:
- logic equation editor, to adapt and complete the predefined control and monitoring functions
- creation of personalized messages for local annunciation
- creation of personalized mimic diagrams corresponding to the controlled devices
- customization of the control matrix by changing the assignment of output relays, LEDs and annunciation messages

With the Logipam option, Sepam™ provides the most varied control and monitoring functions, programmed using the SFT2885 programming software that implements the Logipam ladder language.

Operating Principle

The processing of each control and monitoring function may be broken down into three phases:

1 acquisition of input data:
- results of protection function processing
- external logic data, connected to the logic inputs of an optional MES120 input / output module
- local control commands transmitted by the mimic-based UMI
- remote control commands (TC) received via the communication link

2 actual processing of the control and monitoring function

3 utilization of the processing results:
- activation of output relays to control a device
- information sent to the facility manager:
  - by message and/or LED on the Sepam™ display and SFT2841 software
  - by remote indication (TS) via the communication link
  - by real-time indications on device status on the animated mimic diagram.

Logic Inputs and Outputs

The number of Sepam™ inputs / outputs must be adapted to fit the control and monitoring functions used.

The five outputs included in the Sepam™ Series 80 base unit may be extended by adding one, two, or three MES120 modules with 14 logic inputs and 6 output relays each.

After the number of MES120 modules needed for an application is set, the logic inputs are assigned to functions. The functions are chosen from a list that covers the whole range of possible uses. The functions are adapted to meet needs within the limits of the logic inputs available. The inputs may also be inverted for undervoltage type operation.

A default input / output assignment is proposed for the most frequent uses.

PE50249



Maximum Sepam™ series 80 configuration with 3 MES120 modules: 42 inputs and 23 outputs

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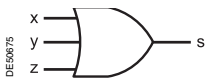
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Definition of Symbols

This page gives the meaning of the symbols used in the block diagrams illustrating the different control and monitoring functions in this chapter.

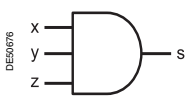
Logic Functions

"OR"



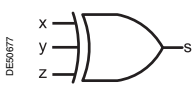
Equation: s = x **or** y **or** z.

"AND"



Equation: s = x **and** y **and** z.

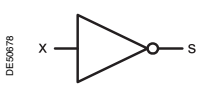
exclusive OR "XOR"



s = 1 if one and only one input is set to 1
(s = 1 **if** x **or** y **or** z = 1).

Complement

These functions may use the complement of one or more input values.

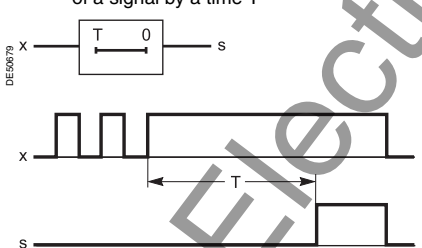


Equation: s = $\overline{x}$ (s = 1 if x = 0).

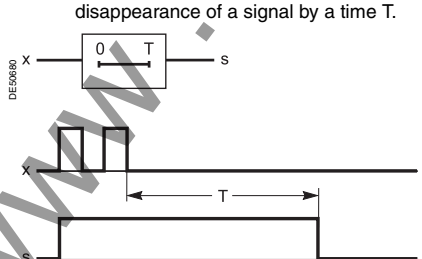
Delay Timers

There are two types of delay timers:

- "**on**" delay timer: used to delay the appearance of a signal by a time T



- "**off**" delay timer: used to delay the disappearance of a signal by a time T.



Pulse Mode Operation

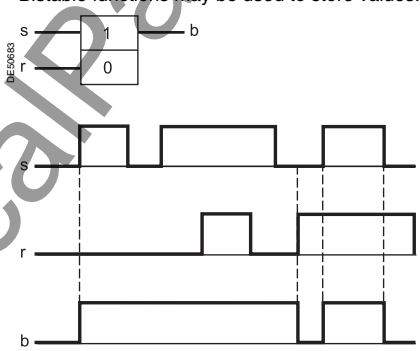
The "on" pulse: used to create a short-duration pulse (200 ms) each time a signal appears

- "off" pulse: used to create a short-duration pulse (200 ms) each time a signal disappears.

Note : *the disappearance of a signal may be caused by an auxiliary power failure.*

Bistable Functions

Bistable functions may be used to store values.



Equation: B = S + $\overline{R}$ x B.

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Logic Input/Output Assignment

Inputs and outputs may be assigned to predefined control and monitoring functions using the SFT2841 software, according to the uses listed in the table below. The control logic of each input may be inverted for undervoltage type operation.

All logic inputs, whether assigned to predefined functions or not, can be used for the customization functions according to specific application needs:

- in the control matrix (SFT2841 software), to connect an input to a logic output, a LED on the front of Sepam™ or a message for local indication on the display
- in the logic equation editor (SFT2841 software), as logic equation variables
- in Logipam (SFT2885 software) as input variables for the program in ladder language

Logic Output Assignment Table

Functions	S80	S81	S82	S84	T81	T82 T87	M87	M81 M88	G87	G82 G88	B80	B83	C86	Assignment
Tripping / contactor control	■	■	■	■	■	■	■	■	■	■	■	■	■	O1
Block closing	■	■	■	■	■	■	■	■	■	■	■	■	■	O2 by default
Closing	■	■	■	■	■	■	■	■	■	■	■	■	■	O3 by default
Watchdog	■	■	■	■	■	■	■	■	■	■	■	■	■	O5
Zone selective Interlocking, blocking send 1	■	■	■	■	■	■	■	■	■	■	■	■	■	O102 by default
Zone selective Interlocking, blocking send 2			■	■		■			■	■				O103 by default
Genset shutdown									■	■				Free
De-excitation									■	■				Free
Load shedding							■	■						Free
AT, closing of NO circuit breaker	■	■	■	■	■	■			■	■	■	■		Free
AT, closing of tie breaker	■	■	■	■	■	■			■	■	■	■		Free
AT, opening of tie breaker	■	■	■	■	■	■			■	■	■	■		Free
Tripping of capacitor step (1 to 4)													■	Free
Tripping of capacitor step (1 to 4)													■	Free

Note: *The logic outputs assigned by default may be freely reassigned.*

Assignment Table for Logic Inputs Common to all Applications

Functions	S80	S81	S82	S84	T81	T82 T87	M87	M81 M88	G87	G82 G88	B80	B83	C86	Assignment
Closed circuit breaker	■	■	■	■	■	■	■	■	■	■	■	■	■	I101
Open circuit breaker	■	■	■	■	■	■	■	■	■	■	■	■	■	I102
Synchronization of Sepam™ internal clock via external pulse	■	■	■	■	■	■	■	■	■	■	■	■	■	I103
Switching of groups of settings A/B	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
External reset	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
Grounding switch closed	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
Grounding switch open	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
External trip 1	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
External trip 2	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
External trip 3	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
End of charging position	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
Block remote control (Local)	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
SF6 pressure default	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
Block closing	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
Open command	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
Close command	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
Phase VT fuse blown	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
Vr VT fuse blown	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
External positive active energy meter	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
External negative active energy meter	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
External positive reactive energy meter	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
External negative reactive energy meter	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
Racked out circuit breaker	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
Switch A closed	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
Switch A open	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
Switch B closed	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
Switch B open	■	■	■	■	■	■	■	■	■	■	■	■	■	Free
Closing-coil monitoring	■	■	■	■	■	■	■	■	■	■	■	■	■	Free

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Assignment Table of Logic Inputs by Application

Functions	S80	S81	S82	S84	T81	T82 T87	M87	M81 M88	G87	G82 G88	B80	B83	C86	Assignment
Block recloser	■	■	■	■										Free
Block thermal overload		■	■	■	■	■	■	■	■	■			■	Free
Switching of thermal settings					■	■	■	■	■	■				Free
Blocking reception 1	■	■	■	■	■	■			■	■	■	■		Free
Blocking reception 2			■	■		■			■	■				Free
Buchholz trip					■	■		■		■				Free
Thermostat trip					■	■		■		■				Free
Pressure trip					■	■		■		■				Free
Thermistor trip					■	■	■	■	■	■				Free
Buchholz alarm					■	■		■		■				Free
Thermostat alarm					■	■		■		■				Free
Pressure alarm					■	■		■		■				Free
Thermistor alarm					■	■	■	■	■	■				Free
Rotor speed measurement							■	■	■	■				Ia04
Rotor rotation detection							■	■						Free
Motor re-acceleration							■	■						Free
Load shedding request							■	■						Free
Block undercurrent							■	■						Free
Priority genset shutdown									■	■				Free
De-excitation									■	■				Free
Close enable (ANSI 25)	■	■	■	■	■	■			■	■	■	■		Free
Block opposite-side remote control (local)	■	■	■	■	■	■			■	■	■	■		Free
Block remote-control tie breaker (local)	■	■	■	■	■	■			■	■	■	■		Free
Tie Breaker open	■	■	■	■	■	■			■	■	■	■		Free
Tie Breaker closed	■	■	■	■	■	■			■	■	■	■		Free
Opposite side open	■	■	■	■	■	■			■	■	■	■		Free
Opposite side closed	■	■	■	■	■	■			■	■	■	■		Free
Selector set to Manual (ANSI 43)	■	■	■	■	■	■			■	■	■	■		Free
Selector set to Auto (ANSI 43)	■	■	■	■	■	■			■	■	■	■		Free
Selector set to Circuit breaker (ANSI 10)	■	■	■	■	■	■			■	■	■	■		Free
Selector set to Tie Breaker (ANSI 10)	■	■	■	■	■	■			■	■	■	■		Free
Opposite-side circuit breaker disconnected	■	■	■	■	■	■			■	■	■	■		Free
Tie Breaker circuit disconnected	■	■	■	■	■	■			■	■	■	■		Free
Tie Breaker close command	■	■	■	■	■	■			■	■	■	■		Free
Opposite-side voltage OK	■	■	■	■	■	■			■	■	■	■		Free
Block closing of tie breaker	■	■	■	■	■	■			■	■	■	■		Free
Automatic closing command	■	■	■	■	■	■			■	■	■	■		Free
External closing command 1											■	■		Free
External closing command 2											■	■		Free
Additional phase voltage transformer fuse blown											■	■		Free
Additional Vr voltage transformer fuse blown												■		Free

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Logic Input/Output Assignment

Assignment Table of Logic Inputs by Application

Functions	S80	S81	S82	S84	T81	T82 T87	M87	M81 M88	G87	G82 G88	B80	B83	C86	Assignment
Capacitor step 1 open													■	Free
Capacitor step 1 closed													■	Free
Capacitor step 2 open													■	Free
Capacitor step 2 closed													■	Free
Capacitor step 3 open													■	Free
Capacitor step 3 closed													■	Free
Capacitor step 4 open													■	Free
Capacitor step 4 closed													■	Free
Step 1 opening command													■	Free
Step 2 opening command													■	Free
Step 3 opening command													■	Free
Step 4 opening command													■	Free
Step 1 closing command													■	Free
Step 2 closing command													■	Free
Step 3 closing command													■	Free
Step 4 closing command													■	Free
Step 1 external trip													■	Free
Step 2 external trip													■	Free
Step 3 external trip													■	Free
Step 4 external trip													■	Free
Capacitor step 1 VAR control													■	Free
Capacitor step 2 VAR control													■	Free
Capacitor step 3 VAR control													■	Free
Capacitor step 4 VAR control													■	Free
External capacitor step control block													■	Free
Manual capacitor step control													■	Free
Automatic capacitor step control													■	Free

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Logic Input/Output Assignment

The table below lists the logic input assignment obtained with the SFT2841 configuration software by clicking on the "standard assignment" button.

Functions	Standard Assignment	Application
Closed circuit breaker	I101	All
Open circuit breaker	I102	All
Blocking reception 1	I103	All except M8x
Blocking reception 2	I104	All except S80, S81, T81, M8x, B8x, C86
Close enable (ANSI 25)	I104	S80, S81, T81, B8x
SF6 pressure default	I105	All
Open command	I106	All
Close command	I107	All
Block recloser	I108	S80, S81
Buchholz trip	I108	T8x, M88, G88
Thermostat trip	I109	T8x, M88, G88
Pressure trip	I110	T8x, M88, G88
Thermistor trip	I111	T8x, M88, G88
Buchholz alarm	I112	T8x, M88, G88
Thermostat alarm	I113	T8x, M88, G88
Pressure alarm	I114	T8x, M88, G88
Selector set to Circuit Breaker (ANSI 10)	I201	S8x, T8x, G8x, B8x
Selector set to Tie Breaker (ANSI 10)	I202	S8x, T8x, G8x, B8x
Selector set to Auto (ANSI 43)	I203	S8x, T8x, G8x, B8x
Selector set to Manual (ANSI 43)	I204	S8x, T8x, G8x, B8x
Opposite side closed	I205	S8x, T8x, G8x, B8x
Opposite side open	I206	S8x, T8x, G8x, B8x
Opposite-side voltage OK	I207	S8x, T8x, G8x, B8x
Block opposite side remote control (local)	I208	S8x, T8x, G8x, B8x
Automatic closing command	I209	S8x, T8x, G8x, B8x
Tie Breaker open	I210	S8x, T8x, G8x, B8x
Tie Breaker closed	I211	S8x, T8x, G8x, B8x
Block closing of tie breaker	I212	S8x, T8x, G8x, B8x
Tie Breaker close command	I213	S8x, T8x, G8x, B8x
Block remote-control tie breaker (local)	I214	S8x, T8x, G8x, B8x

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Predefined circuit breaker or contactor control function.

Operation

The Switchgear control function can control the following types of breaking device:

- circuit breakers with NO or NC contacts
- latching contactors with NO contacts
- contactors with latched commands.

This function comprises two parts:

- processing of internal switchgear control commands:
  - open [1], [2], [3]
  - close with or without sync-check [6], [7], [8]
  - block closing [4], [5]
- execution of internal commands by control logic outputs according to the type of device to be controlled.

Processing Internal Switchgear Control Commands

The Switchgear control function processes all breaking device closing and tripping conditions, based on:

- protection functions (configured to trip the breaking device)
- breaking device status data
- remote control via the communication link
- local control commands by logic input or mimic-based UMI
- internal control commands created by logic equation or Logipam
- specific predefined control functions for each application:
  - recloser
  - genset shutdown, de-excitation
  - load shedding
  - sync-check
  - automatic transfer
  - capacitor step control.

The function also blocks breaking device closing, according to the operating conditions.

Anti-Pumping Function

To prevent simultaneous breaking device open and close commands and to give priority to open commands, breaker device close commands are of the pulse type.

Switchgear Control with Lockout Function (ANSI 86)

The ANSI 86 function traditionally performed by lockout relays may be ensured by Sepam™ using the Switchgear control function, with latching of all the tripping conditions (protection function outputs and logic inputs).
Sepam™ performs the following functions:

- grouping the tripping conditions and breaking device control
- latching the tripping command, with closing block, until the cause of tripping disappears and is acknowledged by the user (see Latching / acknowledgement function)
- indication of the cause of tripping:
  - locally by LEDs (Trip and others) and by messages on the display
  - remotely by remote indications (see Indications function).

Closing with Sync-Check [9]

The Sync-check function checks the voltages upstream and downstream of a circuit breaker to ensure safe closing. It is put into service by parameter setting.

For sync-check to operate, one of the "Close enable" logic outputs of an MCS025 remote module must be connected to a Sepam™ logic input assigned to the Close enable function.

If it is necessary to close the circuit breaker without taking into account the synchronization conditions, this may be done by a logic equation or by Logipam via the V_CLOSE_NOCTRL input.

Controlling Logic Outputs

Logic commands from the Switchgear control function are used to control the Sepam™ logic outputs that control breaking device opening and closing.

Logic output control is set up to match the device to be controlled, i.e. a circuit breaker or contactor.

Controlling Capacitor Banks

The Sepam™ C86 Switchgear control function can control the breaking device and 1 to 4 capacitor step switches.

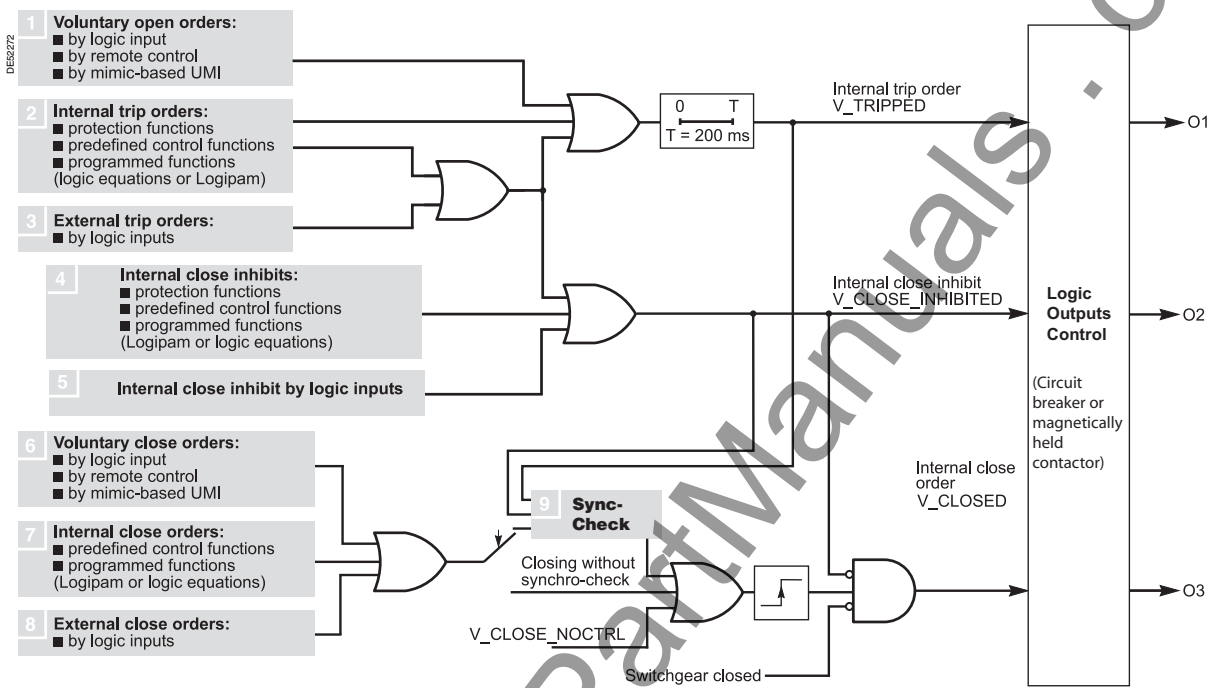
This particular function is described separately.

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Processing Internal Switchgear Control Commands

Block Diagram



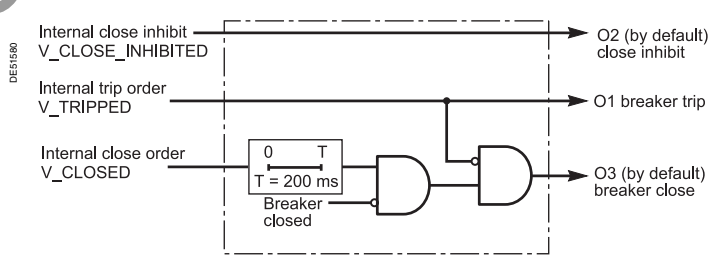
Control of Logic Outputs

Controlling a Circuit Breaker or Contactor with Mechanical Latching

The block diagram below represents the following parameter setting:

- type of switchgear = Circuit Breaker
- output O1 = trip
- output O2 = close block
- output O3 = close.

(See Logic diagram above)

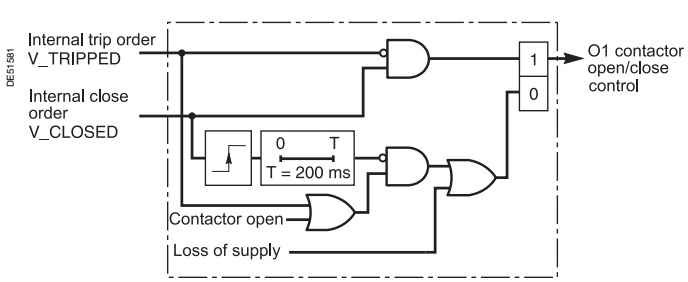


Controlling a Contactor Without Mechanical Latching

The block diagram below represents the following parameter setting:

- type of switchgear = Contactor
- output O1 = open / close.

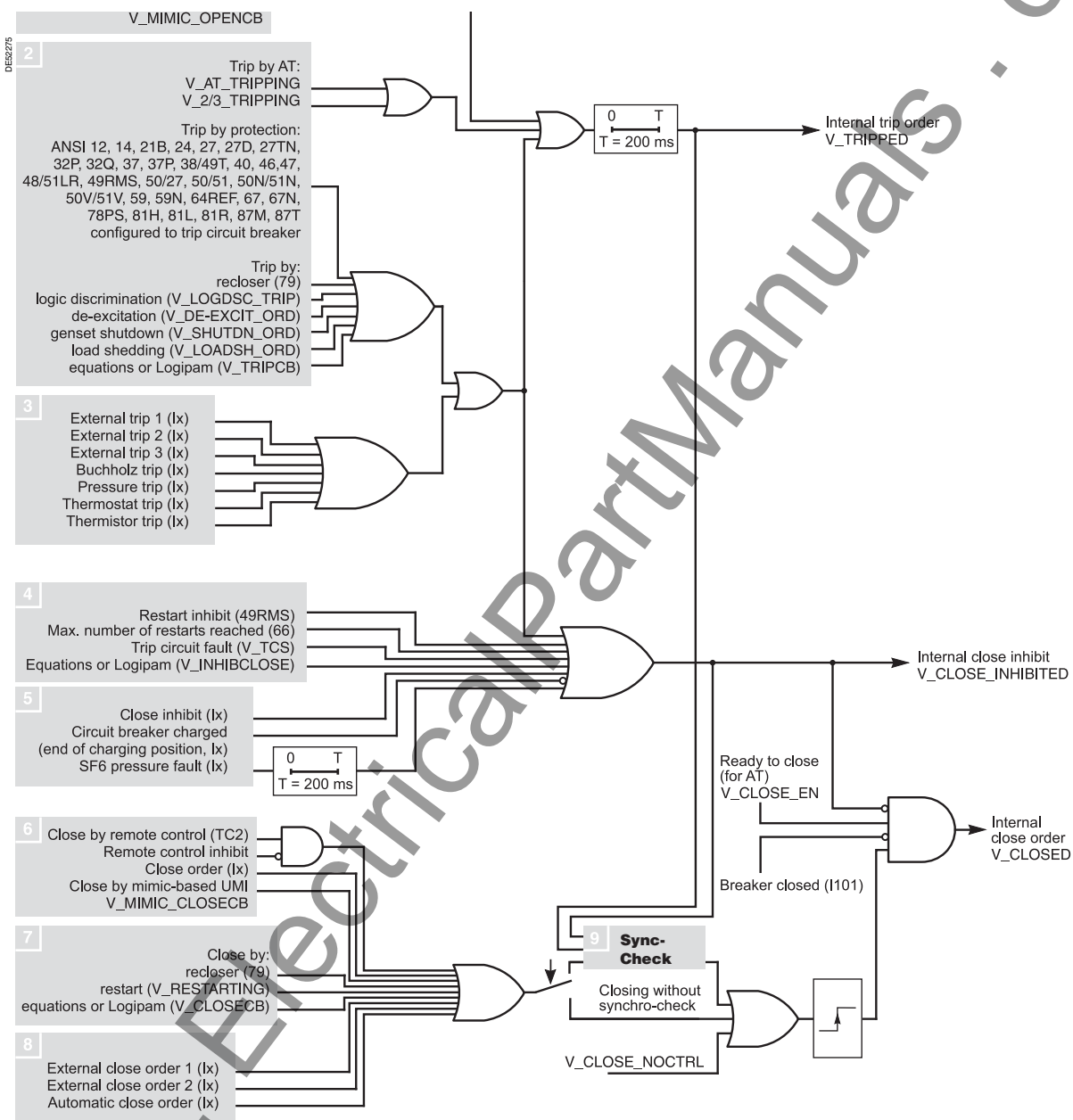
(See Logic diagram above)



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Processing Internal Switchgear Control Commands

Block Diagram



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Close Enable by the Sync-Check Function

Operation

The close request, made locally or remotely, is maintained by Sepam™ during the close request delay and triggers the appearance of a "SYNC.IN PROCESS" message. It is deactivated when a tripping command or circuit breaker blocking command is received and triggers the "STOP SYNC." message.

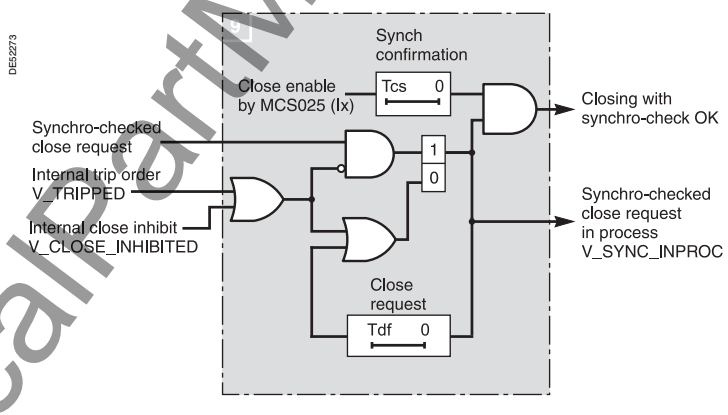
The closing command is given if the close enable is received before the close request delay runs out. When this is the case, the message "SYNC. OK" is displayed.

If the close enable is not received, the message "SYNC. FAILURE" is displayed. When possible and if the MCS025 remote module is connected by the CCA785 cord to the Sepam™ to which the close request has been made, an additional message indicates the type of synchronization failure:

- "SYNC. FAILED dU" for too high a voltage difference
- "SYNC. FAILED DF" for too high a frequency difference
- "SYNC. FAILED dPhi" for too high a phase difference.

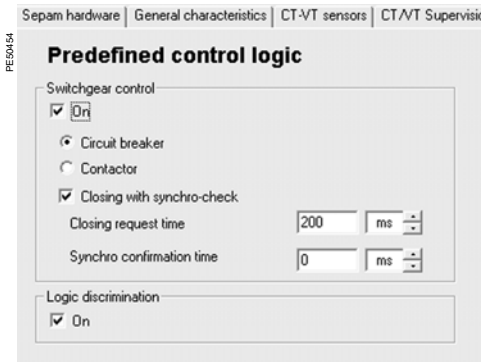
An additional delay is used to confirm the close enable to guarantee that the closing conditions last long enough.

Block Diagram

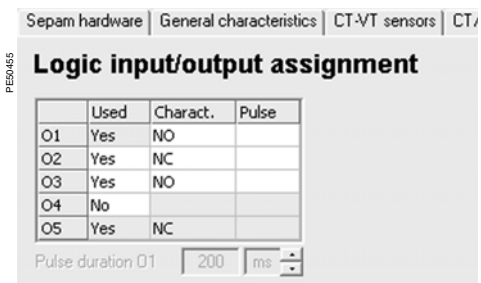


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SFT2841: parameter setting of Switchgear control



SFT2841: default parameter setting of the logic outputs assigned to Switchgear control

Parameter Setting

The Switchgear control function is set up and adapted to match the type of breaking device to be controlled using the SFT2841 software.

"Control Logic" Tab

- activation of the Switchgear control function
- choice of the type of breaking device to be controlled: circuit breaker (by default) or contactor
- activation of the Sync-check function, if necessary.

"Logic I/Os" Tab

- assignment of the logic inputs required
- definition of logic output behavior.

By default, the following outputs are used:

Logic Output	Associated Internal Command	Circuit Breaker Contacts
O1	Trip (V_TRIPPED)	Normally Open (NO)
O2	Close block (V_CLOSE_BLOCKED)	Normally Closed (NC)
O3	Close (V_CLOSED)	Normally Open (NO)

- the Trip command is always associated with output O1.
  If output O1 is set up for pulse type operation, the pulse command duration may be set up.
- the optional Close block and Close commands may be assigned to any logic output.

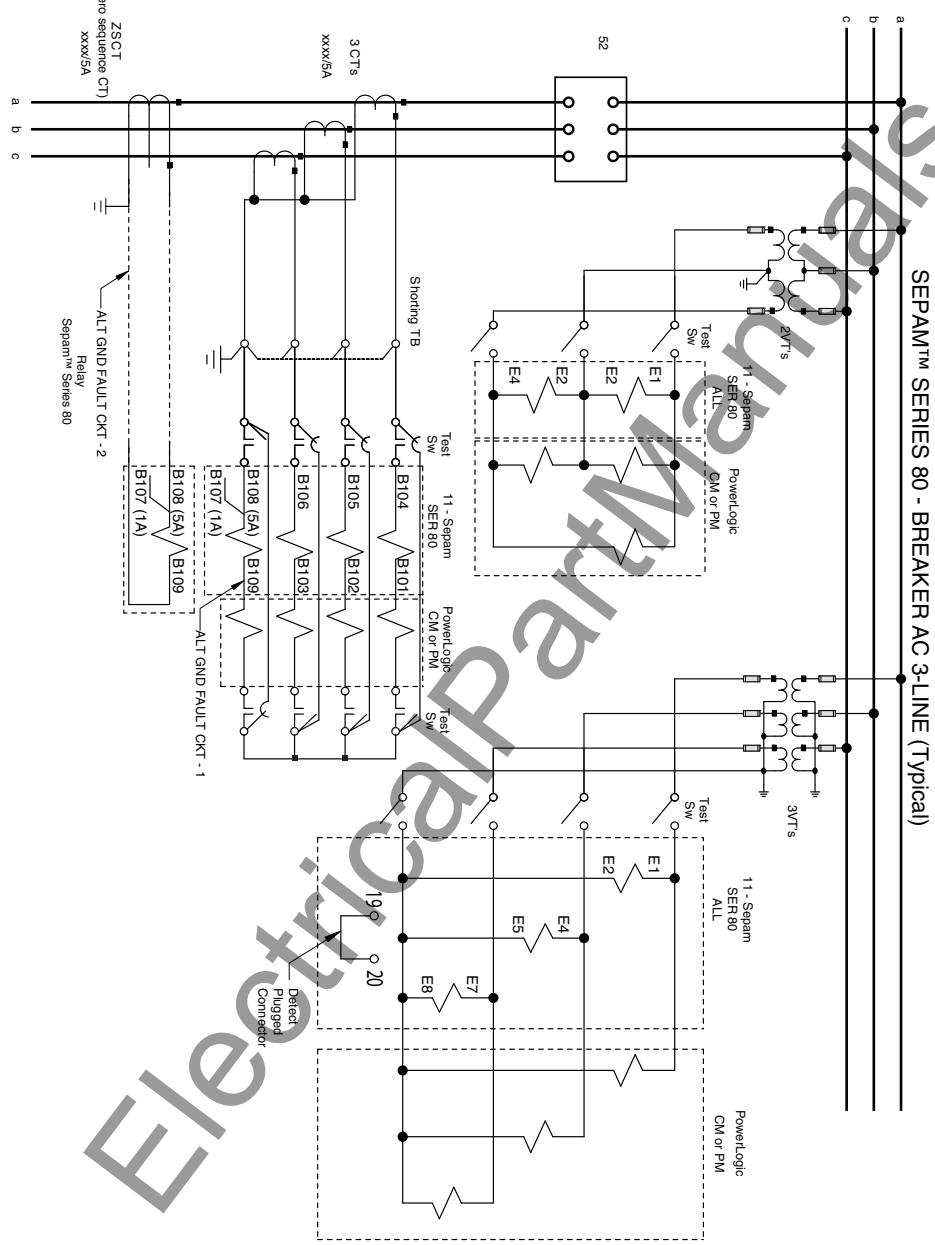
"Matrix" Screen, "Logic" Button

Modification of the default internal command assignment to outputs O2 and O3, if necessary.

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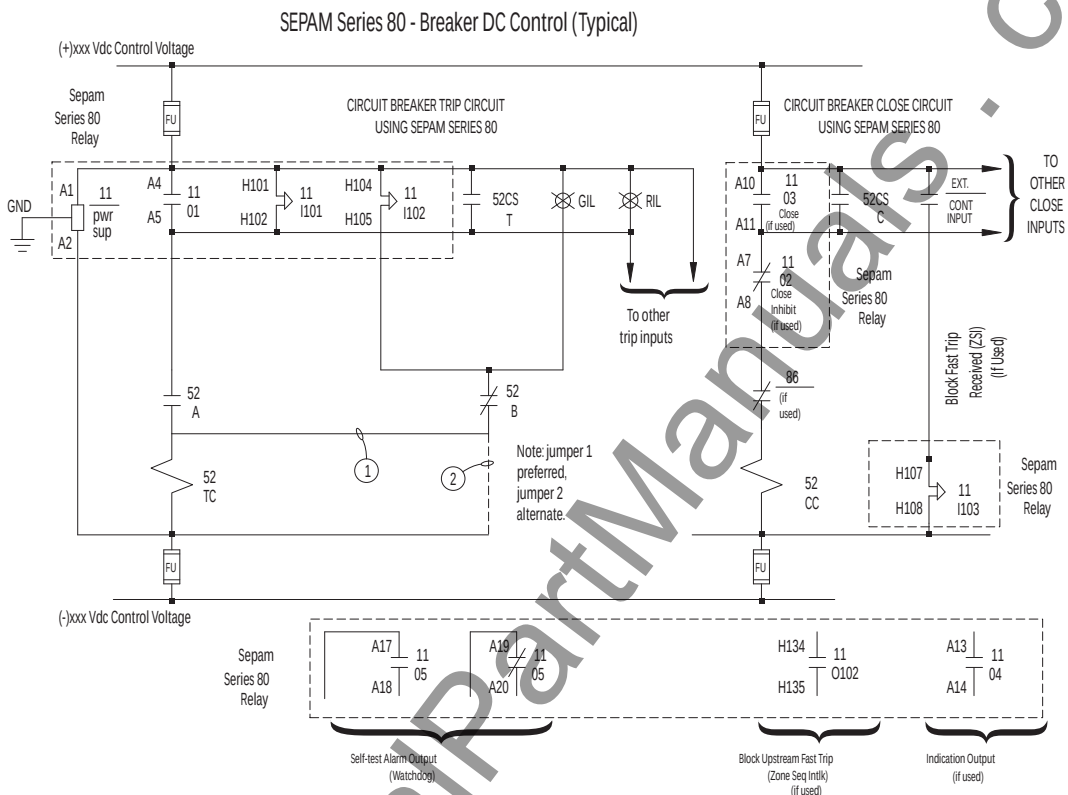
Switchgear Control
Typical Breaker & Contactor Diagrams
Breaker AC 3-Line (Typical)



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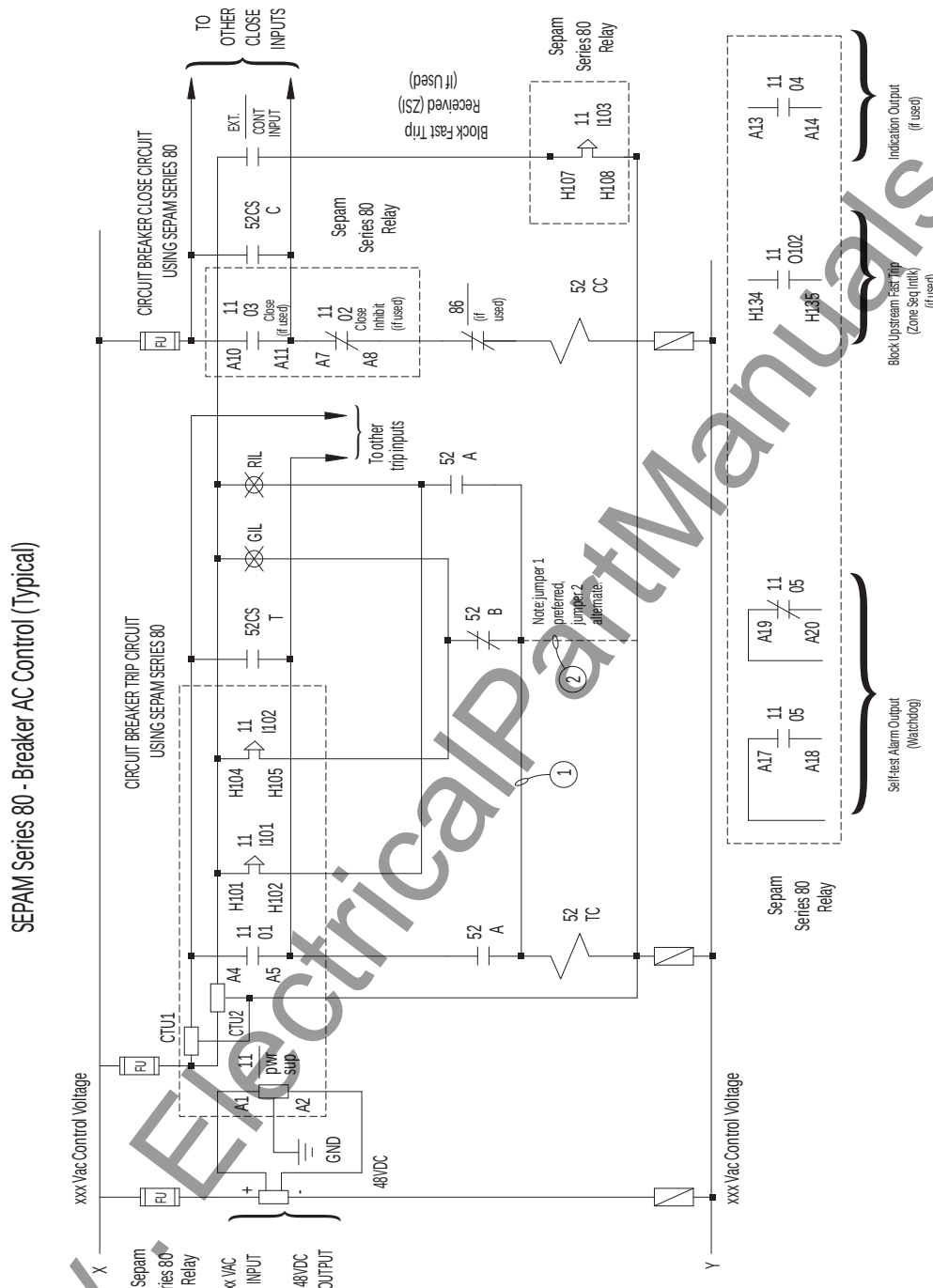
Switchgear Control
Typical Breaker & Contactor Diagrams
Breaker DC Control (Typical)



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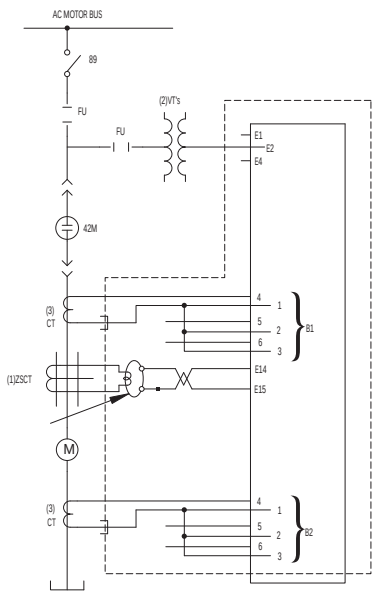
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Switchgear Conrtol
Typical Breaker & Contactor Diagrams
Breaker AC Control (Typical)

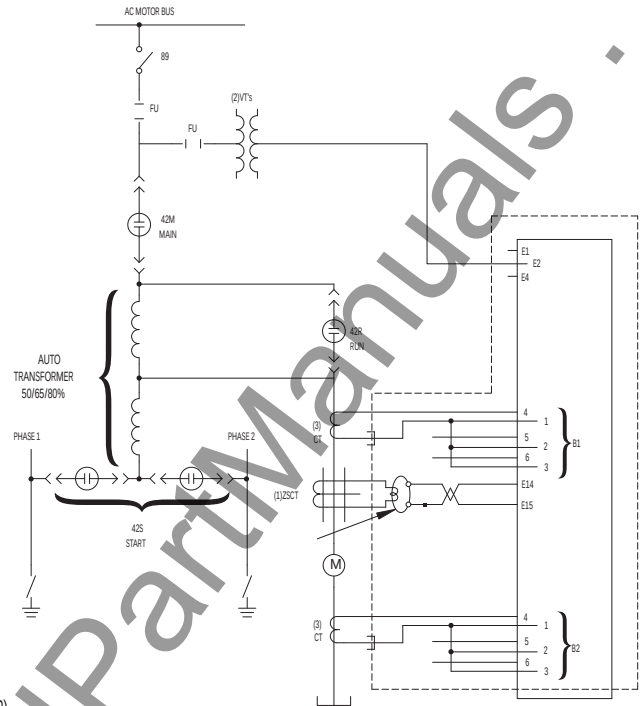


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Motor AC Contactor 1-Line



Series 80/Full Voltage Non-Reversing (FVNR)



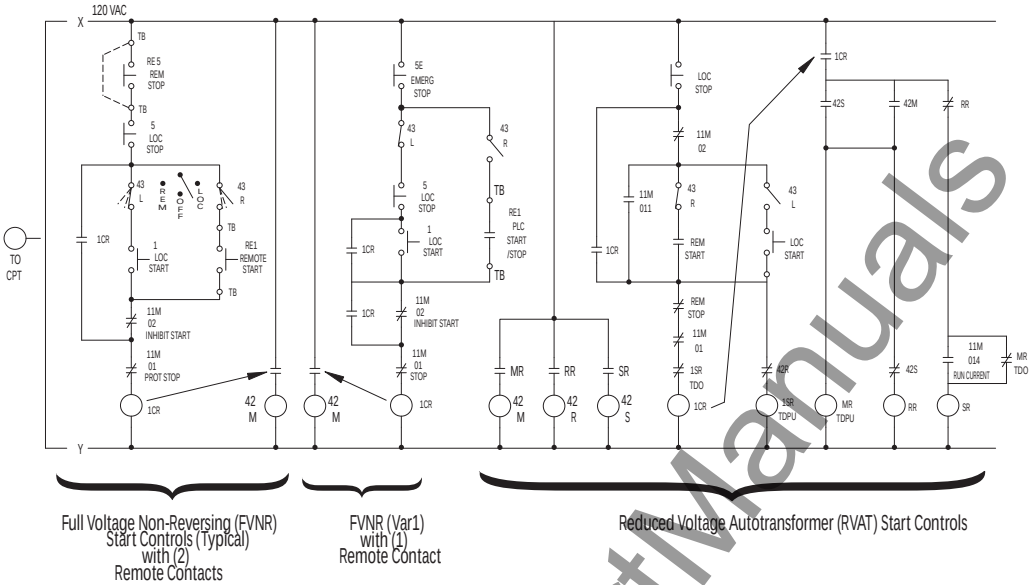
Series 80/Reduced Voltage Autotransformer (RVAT)

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Switchgear Control
Motor AC Contactor Control
Timing Diagram

SEPAM Series 80/Motor AC Contactor Control

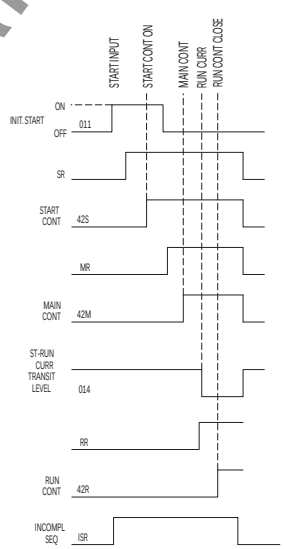


Full Voltage Non-Reversing (FVNR) Start Controls (Typical) with (2) Remote Contacts

FVNR (Var1) with (1) Remote Contact

Reduced Voltage Autotransformer (RVAT) Start Controls

Timing Diagram



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4

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Characteristics

Settings				
Switchgear Control				
Setting range	On / Off			
Type of Device				
Setting range	Circuit breaker / Contactor			
Tripping Pulse Duration (Output O1)				
Setting range	200 ms to 300 s			
Accuracy (1)	±2% or from -10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Closing with Sync-Check				
Setting range	On / Off			
Close Request Time Delay Tdf				
Setting range	0 to 300 s			
Accuracy (1)	±2% or from -10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Sync Confirmation Time Delay Tcs				
Setting range	0 to 300 s			
Accuracy (1)	±2% or from -10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Tripping, opening	V_TRIPCB	■	■	
Block closing	V_BLOCKCLOSE	■	■	
Closing	V_CLOSECB	■	■	
Closing without sync-check	V_CLOSE_NOCTRL	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Switchgear control on	V_SWCTRL_ON		■	
Tripping, opening	V_TRIPPED	■	■	■
Block closing	V_BLOCK_CLOSE	■	■	■
Closing	V_CLOSED	■	■	■
Contactor control	V_CONTACTOR		■	■
Sync-check on	V_SYNC_ON		■	■
Sync-check close request in process	V_SYNC_INPROC		■	■
Sync-check close request stop	V_SYNC_STOP		■	■
Sync-check close request successful	V_SYNC_OK		■	■
Sync-check close request failure	V_NOSYNC		■	■
Sync-check close request failure - Voltage difference too high	V_NOSYNC_DU		■	■
Sync-check close request failure - Frequency difference too high	V_NOSYNC_DF		■	■
Sync-check close request failure - Phase difference too high	V_NOSYNC_DPHI		■	■

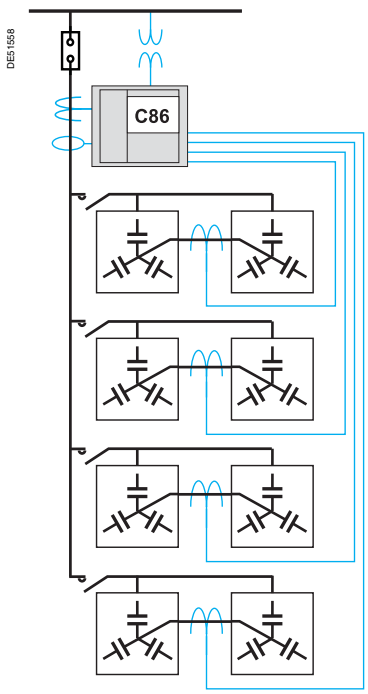
(1) *Under reference conditions (IEC 60255-6).*

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Capacitor Bank Switchgear Control
ANSI Code 94/69

Predefined function for the control of circuit breakers protecting capacitor banks and the switches of each capacitor bank step.
This function only concerns Sepam™ C86 units.



Example of a Sepam™ C86 application: circuit breaker protection of a 4-step capacitor bank

Operation

The Sepam™ C86 Switchgear control function performs:

- control of the circuit breaker protecting the capacitor bank (circuit breaker with normally open, **NO,** or normally closed, **NC**, contacts)
- control of the capacitor bank step switches (maximum of 4 steps), with processing of:
  - voluntary manual control commands
  - automatic control commands, received from reactive-energy regulators

Control of Logic Outputs

The logic commands from the Switchgear control function are used to control the Sepam™ logic outputs which control:

- opening and closing of the circuit breaker.
- opening and closing of each capacitor step switch.

Logic output control is set up to match the type of device to be controlled, like a circuit breaker or capacitor step switch.

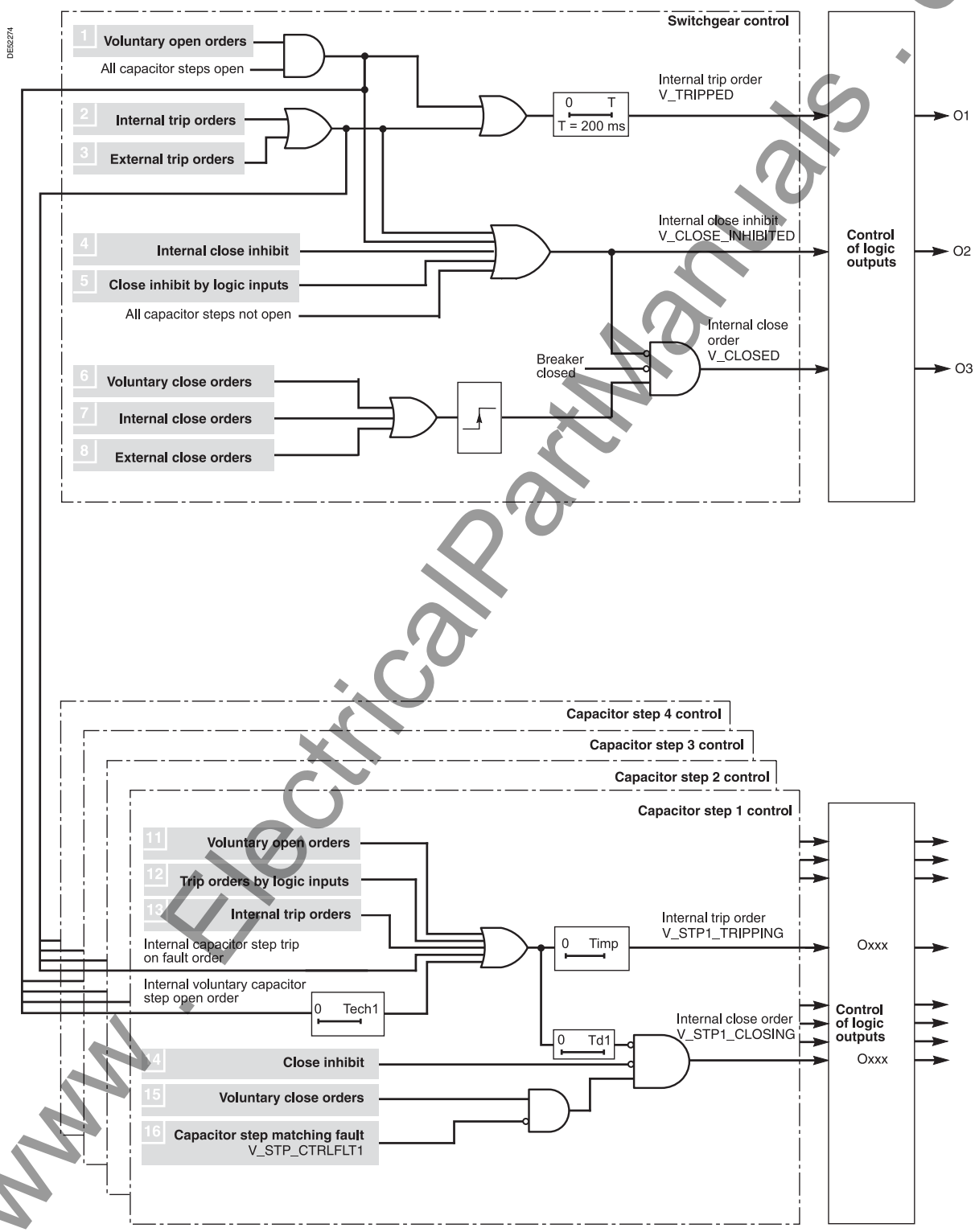
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Capacitor Bank Switchgear Control
ANSI Code 94/69

Processing Internal Switchgear Commands

Block Diagram



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Capacitor Bank Switchgear Control
ANSI Code 94/69

Controlling the Circuit Breaker

This function comprises two parts:

1 processing of internal circuit breaker control commands:
- open circuit breaker 1, 2, 3
- close circuit breaker 6, 7, 8
- block circuit breaker closing 4, 5

2 executing internal commands by control logic outputs according to the type of device to be controlled.

Processing Internal Circuit Breaker Control Commands

The Switchgear control function processes all the circuit breaker close and trip conditions, based on
- protection functions (configured to trip the circuit breaker)
- circuit breaker and capacitor step switch status data
- remote control commands via the communication link
- local control commands by logic input or mimic-based UMI
- internal control commands created by logic equation or Logipam.

The function also blocks circuit breaker closing according to the operating conditions.

Circuit Breaker Opening

The circuit breakers open under two conditions:

1 ***Voluntary open*** – A circuit breaker open command triggers the staggered opening of capacitor step switches. This command is maintained for a time T1, the time required for the staggered opening of the capacitor step switches and the circuit breaker. The circuit breaker opens after all the capacitor step switches to avoid breaking the capacitive current.

2 ***Trip*** – The protection functions (units configured to trip the circuit breaker and external protection units) send a trip command to the circuit breaker. After the circuit breaker opens, an open command is sent to all the capacitor step switches at the same time.

Circuit Breaker Closing

The circuit breaker only closes if all the capacitor step switches are open.

Anti-Pumping Function

To prevent simultaneous breaking device open and close commands and to give priority to open commands, breaker device close commands are of the pulse type

Switchgear Control with Lockout Function (ANSI 86)

The ANSI 86 function usually performed by lockout relays can be provided by Sepam™ by using the Switchgear control function, with latching of all the tripping conditions (protection function outputs and logic inputs). Under these conditions Sepam™ performs the following:
- grouping all tripping conditions and circuit breaker control
- latching the trip command, with blocking of closing, until the cause of tripping disappears and is acknowledged by the user (see Latching / acknowledgement function)
- indicating the cause of tripping:
  - locally by LEDs (Trip and others) and by messages on the display
  - remotely by remote indications (see Indications function).

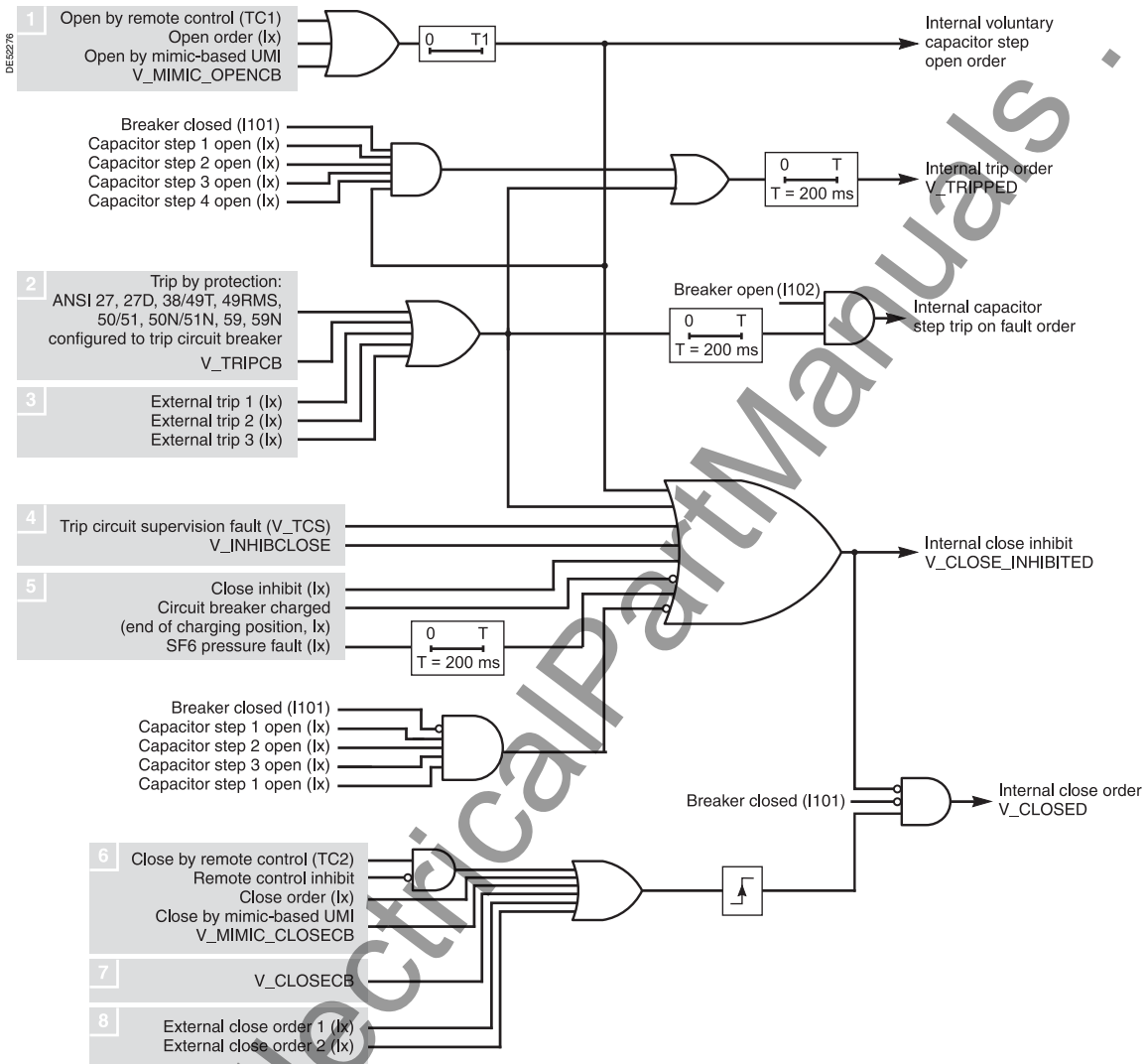
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Capacitor Bank Switchgear Control
ANSI Code 94/69

Processing Internal Switchgear Commands

Block Diagram



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Capacitor Step Control

Automatic Control
When the "Automatic capacitor step control" logic input is on, each step is controlled automatically by the reactive energy regulator (VAR). In this case, one input per step is used to open and close one capacitor step switch:
- input in state 1: closing of capacitor step x switch
- input in state 0: opening of capacitor step x switch.

Manual Control
When the "Manual capacitor step control" logic input is on, each step may be opened and closed manually:
- locally by specific logic inputs (one open input and one close input per step)
- remotely by remote control.

Blocking Voluntary Capacitor Step Control
Voluntary capacitor step switch control can be blocked by a logic input. However, this input does not block fault tripping or opening after circuit breaker opening.

Capacitor Step Opening
Any opening of a capacitor step, whether voluntary or by tripping, activates a discharge time delay which blocks closing to ensure that the step capacitors discharge correctly.
- voluntary open: manual or automatic capacitor step switch control command
- trip, triggered by:
  - ANSI 51C unbalance protection units associated with the capacitor step and configured to trip the step 13
  - "Tripping of step x" logic input (one input per capacitor step) 12
  - logic equation or Logipam 13.

Latched trip commands block capacitor step closing until the commands are reset 14. Open commands must be at least as long as the duration of open and close control pulses.

Capacitor Step Closing 15
Close commands are always voluntary for manual and automatic control. They are as long as the duration of open and close control pulses.

Capacitor step switches only close after the capacitor step discharge time delay has run out and after the circuit breaker has closed, if there is no protection fault or blocking.

Capacitor Step Switch Matching Fault 16
This function checks for capacitor step switch positions matching when the positions are set up on logic inputs (Ix).

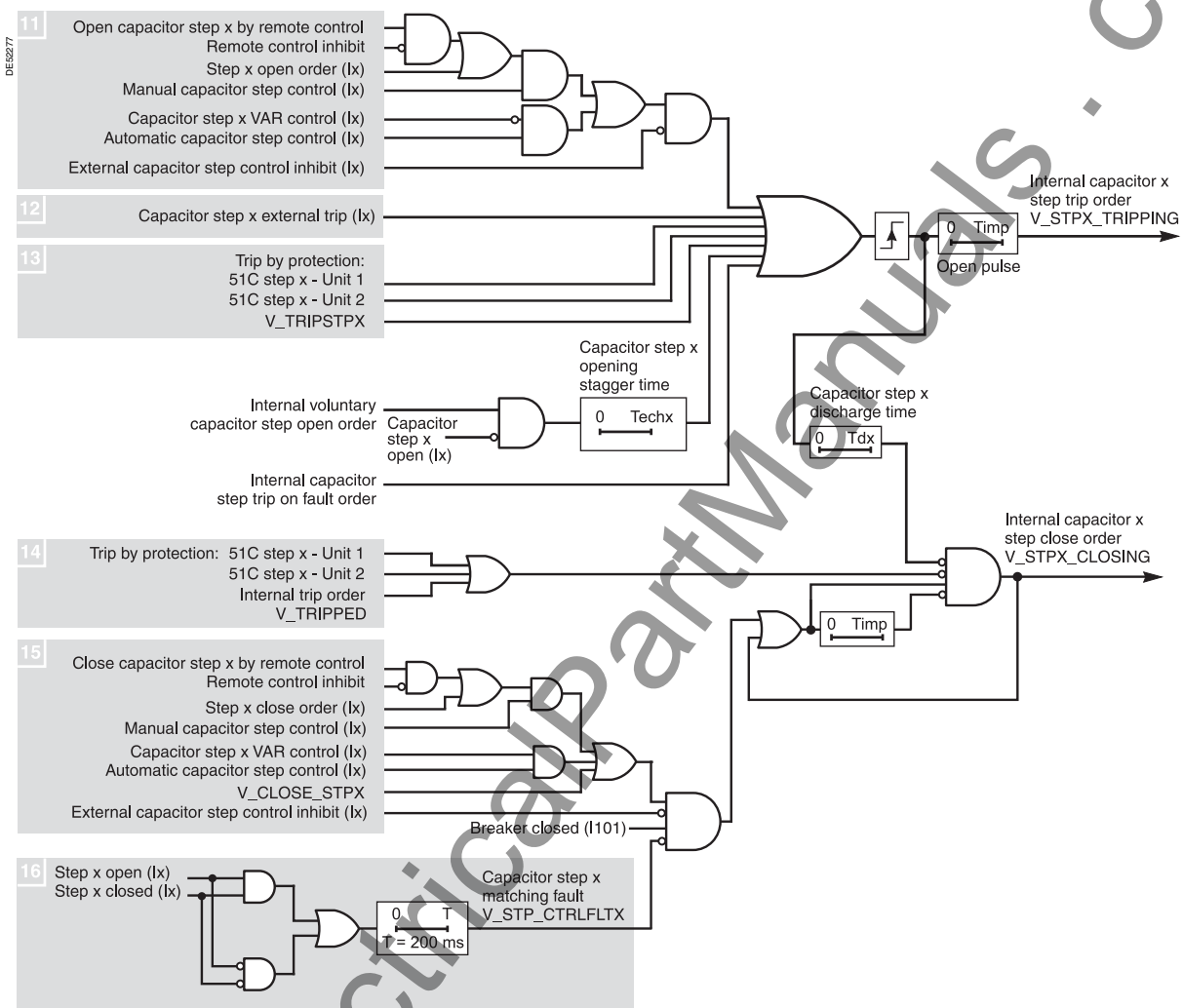
In the event of a capacitor step switch matching fault, the switch close command is blocked.

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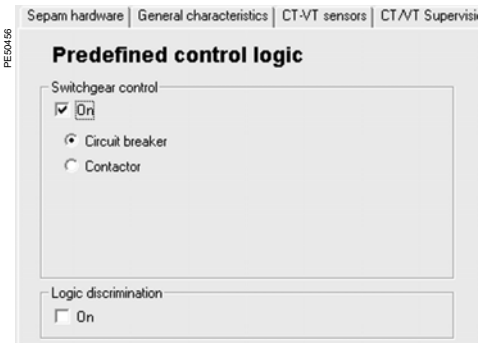
Capacitor Bank Switchgear Control
ANSI Code 94/69

Block Diagram

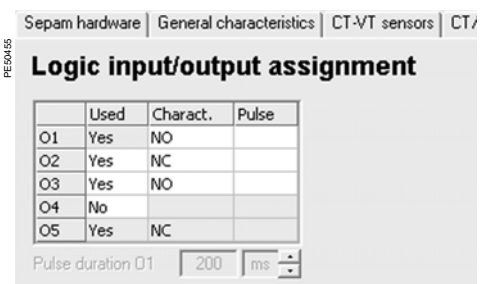


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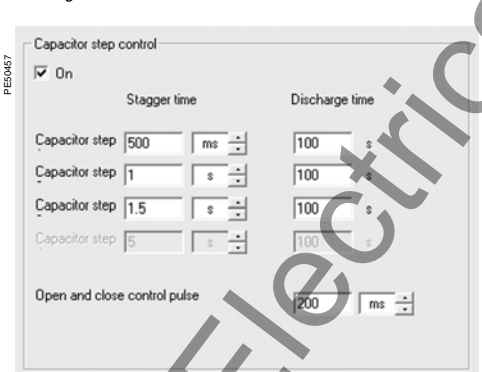
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SFT2841: Switchgear conrtol parameter setting



SFT2841: default parameter setting of logic outputs assigned to Switchgear control



SFT2841: Capacitor step control functionis parameter setting

Setting the Circuit Breaker Control Parameter

The function is set up and adapted to match the type of circuit breaker to be controlled using the SFT2841 software.

"Control Logic" Tab
- activation of the Switchgear control function
- type of device to be controlled: Circuit breaker.

"Logic I/Os" Tab
- assignment of the logic inputs required
- definition of logic output behavior.

By default, the following outputs are used:

Logic Output	Associated Internal Command	Circuit Breaker Contacts
O1	Trip (V_TRIPPED)	Normally open (NO)
O2	Close block (V_CLOSE_BLOCKED)	Normally closed (NC)
O3	Close (V_CLOSED)	Normally open (NO)

- the Trip command is always associated with output O1.
  If output O1 is set up for pulse type operation, the pulse command duration may be set up.
- the optional Close block and Close commands may be assigned to any logic output.

"Matrix" Screen, "Logic" Button
Modification of the default internal command assignment to outputs O2 and O3, if necessary.

Setting the Capacitor Step Control Parameter

The function is set up and adapted using the SFT2841 software.

"Particular Characteristics" Tab
Setup of the capacitor bank, with setting of the number of steps.

"Control Logic" Tab
Setup of capacitor step control:
- activation of the Capacitor step control function
- setting of capacitor step staggered opening times, capacitor step discharge times and capacitor step switch control pulse duration.

"Logic I/Os" Tab
- assignment of the logic inputs required
- definition of the behavior of logic outputs assigned to capacitor step control

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Capacitor Bank Switchgear Control
ANSI Code 94/69

Characteristics

Settings				
Switchgear Control				
Setting range	On / Off			
Device Type				
Setting range	Circuit breaker / Contactor			
Tripping Pulse Duration (Output O1)				
Setting range	200 ms to 300 s			
Accuracy (1)	±2% or from –10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Control of Capacitor Banks				
Setting range	On / Off			
Staggered Capacitor Step Opening Time Delay Techx (1 delay per step)				
Setting range	0 to 300 s			
Accuracy (1)	±2% or from –10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Capacitor Step Discharge Time Delay Tdx (1 delay per step)				
Setting range	0 to 300 s			
Accuracy (1)	±2% or from –10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Capacitor Step Open and Close Control Pulse Duration Timp				
Setting range	0 to 300 s			
Accuracy (1)	±2% or from –10 ms to +25 ms			
Resolution	10 ms or 1 digit			

Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Tripping, opening	V_TRIPCB	■	■	
Block closing	V_BLOCKCLOSE	■	■	
Closing	V_CLOSECB	■	■	
Capacitor step 1 tripping	V_TRIP_STP1		■	
Capacitor step 2 tripping	V_TRIP_STP2		■	
Capacitor step 3 tripping	V_TRIP_STP3		■	
Capacitor step 4 tripping	V_TRIP_STP4		■	
Capacitor step 1 closing	V_CLOSE_STP1		■	
Capacitor step 2 closing	V_CLOSE_STP2		■	
Capacitor step 3 closing	V_CLOSE_STP3		■	
Capacitor step 4 closing	V_CLOSE_STP4		■	

Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Switchgear control on	V_SWCTRL_ON		■	
Tripping, opening	V_TRIPPED	■	■	■
Block closing	V_BLOCK_CLOSE	■	■	■
Closing	V_CLOSED	■	■	■
Contactor control	V_CONTACTOR		■	■
Capacitor bank control on	V_BANK_ON		■	
Tripping of capacitor step 1	V_STP1_TRIPPING		■	■
Tripping of capacitor step 2	V_STP2_TRIPPING		■	■
Tripping of capacitor step 3	V_STP3_TRIPPING		■	■
Tripping of capacitor step 4	V_STP4_TRIPPING		■	■
Closing of capacitor step 1	V_STP1_CLOSING		■	■
Closing of capacitor step 2	V_STP2_CLOSING		■	■
Closing of capacitor step 3	V_STP3_CLOSING		■	■
Closing of capacitor step 4	V_STP4_CLOSING		■	■
Capacitor step 1 matching fault	V_STP1_CTRLFLT		■	■
Capacitor step 2 matching fault	V_STP2_CTRLFLT		■	■
Capacitor step 3 matching fault	V_STP3_CTRLFLT		■	■
Capacitor step 4 matching fault	V_STP4_CTRLFLT		■	■

(1) *Under reference conditions (IEC 60255-6).*

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Operation

The tripping outputs of all protection functions and logic inputs can be latched individually.

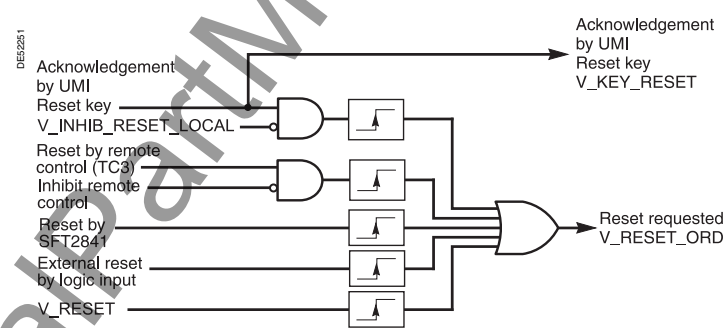
Logic outputs cannot be latched. Logic outputs set up as pulse-type outputs maintain pulse-type operation even when they are linked to latched data. Latched data is saved in the event of an auxiliary power loss

All latched data are acknowledged together, at the same time. Acknowledgement is done:

- locally on the UMI using the (reset) key
- or remotely via a logic input, the SFT2841 software or via the communication link
- or by logic equation or Logipam.

The remote indication TS5 remains present after latching operations until acknowledgement takes place. The Latching/acknowledgement function associated with the Switchgear control function can be used to perform the ANSI 86 Lockout relay function.

Block Diagram



Characteristics

Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Blocking UMI Reset key	V_BLOCK_RESET_LOCAL	■	■	
Acknowledgement by logic equation or Logipam	V_RESET	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Reset requested	V_RESET_ORD		■	
Acknowledgement by UMI Reset key	V_KEY_RESET		■	

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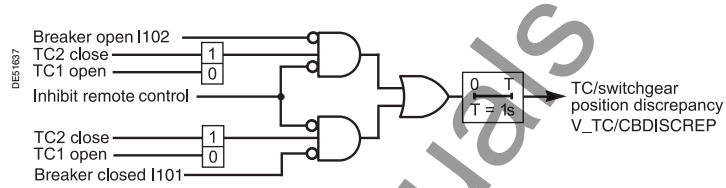
TC/ Switchgear Position Discrepancy

Operation

This function detects any discrepancy between the last remote control command received and the actual position of the circuit breaker or contactor.

The information is accessible in the matrix and via the remote indication TS3.

Block Diagram



Characteristics

Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
TC/ switchgear position discrepancy	V_TC/CBDISCREP		■	

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Operation

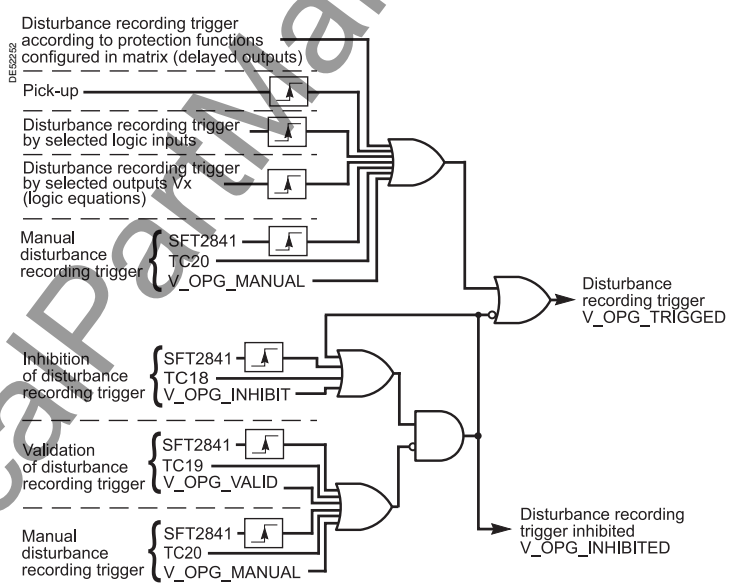
Recording analog and logic signals can be triggered by different events, according to control matrix parameter setting or by manual action:

- triggering by the grouping of all pick-up signals of the protection functions in service
- triggering by the delayed outputs of selected protection functions
- triggering by selected logic inputs
- triggering by selected outputs Vx (logic equations)
- manual triggering by a remote control command (TC20)
- manual triggering via the SFT2841 software tool
- manual triggering by Logipam

Disturbance recording can be:

- blocked by SFT2841 software, remote control command (TC18), or Logipam
- validated by SFT2841 software, remote control command (TC19), or by Logipam

Block Diagram



Characteristics

Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Blocks disturbance recording function	V_OPG_BLOCK		■	
Validates disturbance recording function	V_OPG_VALID		■	
Manual trigger of disturbance recording function	V_OPG_MANUAL		■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Disturbance recording function triggered	V_OPG_TRIGGED		■	
Disturbance recording function blocked	V_OPG_BLOCKED		■	■
Disturbance recording on	V_OPG_ON		■	

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Switching Groups of Settings

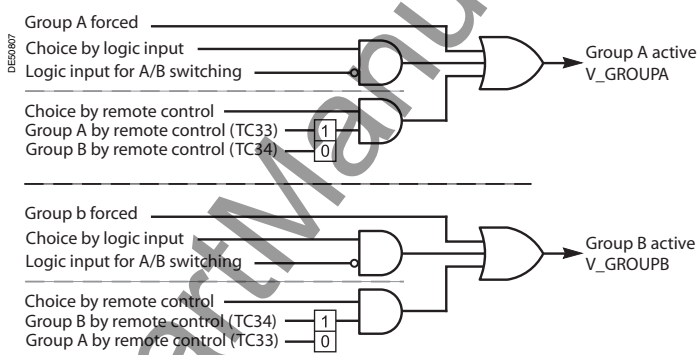
Operation

There are two groups of settings, A and B, for the phase overcurrent, ground fault, directional phase overcurrent and directional ground fault protection functions. Switching from one group to another makes it possible to adapt the protection characteristics to suit the electrical environment of the application (change of grounding system, changeover to local power generation). Switching settings is global and applies to all the units of the protection functions mentioned above.

The groups of settings switching mode is determined by parameter setting:

- switching according to the position of a logic input (0 = group A, 1 = group B)
- switching by remote control command (TC33, TC34)
- forced group A or group B.

Block Diagram



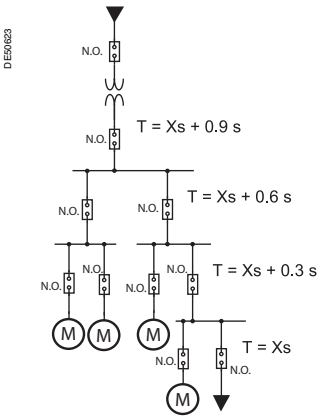
Characteristics

Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Group of settings A active	V_GROUPA		■	
Group of settings B active	V_GROUPB		■	

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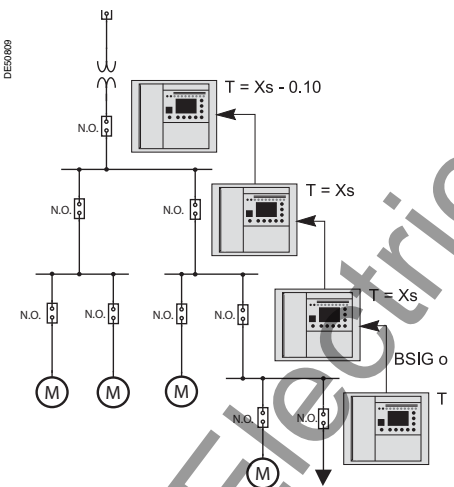
Zone Selective Interlocking
Principle



Example: radial distribution with use of time-based discrimination (T: protection setting time. As an approximation for definite time curves, this is assumed to be equal to the protection tripping time).

The upstream protection units are typically delayed by 0.3 s to give the downstream protection units time to trip. When there are many levels of discrimination, the fault clearing time at the source is long.

In this example, if the fault clearing time for the protection unit furthest downstream is Xs = 0.2 s, the fault clearing time at the source is T = Xs + 0.9 s = 1.1 s



Example: radial distribution with use of zone selective interlocking
(T: protection setting time. As an approximation for definite time curves, this is assumed to be equal to the protection tripping time).
When a fault appears, the protection units that detect it block the upstream protection units. The protection unit furthest downstream trips since it is not blocked by another protection unit. The delays are to be set in accordance with the device to be protected.
In this example, if the fault clearing time for the protection device furthest downstream is Xs = 0.2 s, the fault clearing time at the source is T = Xs - 0.1 s = 0.1 s.

Operation

This function significantly reduces the tripping time of the circuit breakers closest to the source. It can be used for zone selective interlocking (ZSI) in closed ring networks. It applies to the phase overcurrent 50/51, directional phase overcurrent 67, ground fault 50N/51N and directional ground fault 67N protection functions, definite time and IDMT.

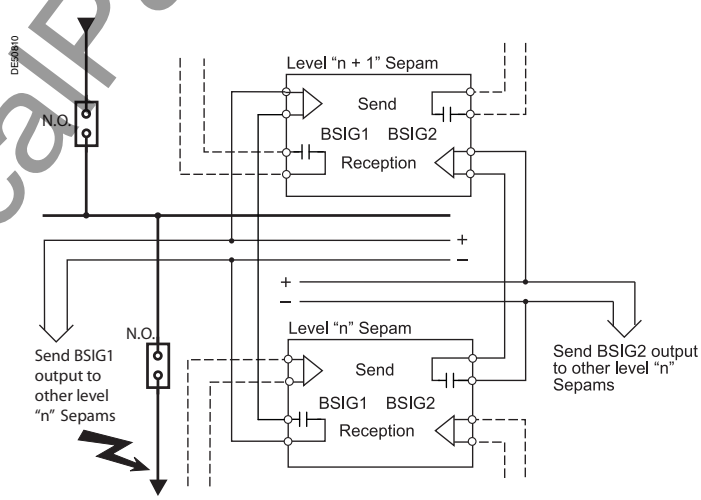
Sepam™ Series 80 ZSI logic includes two logic groups. Each group includes:
- logic thresholds: protection units that send blocking signals (BSIG) and may be prevented from tripping by the reception of blocking signals.
- time-based thresholds: protection units that may not be prevented from tripping by blocking signals and do not send blocking signals. They are used as backup for the logic thresholds.

When a fault occurs:
- the logic thresholds detecting the fault send blocking signals upstream
- the logic thresholds detecting the fault send a tripping command if they are not blocked by blocking signals
- the time-based (backup) thresholds detecting the fault send a tripping command

The logic and time-based threshold assignments of the protection units depend on the type of application and the parameter setting of the logic inputs/outputs.
The first logic group is active if one of the following two conditions is met:
- blocking reception **1** is assigned to a logic input Ixxx, except for motors which do not have this input.
- blocking send **1** is assigned to an output Oxxx. (O102 by default).

When the second logic group is present in the application, it is active under one of the following two conditions:
- blocking reception **2** is assigned to a logic input Ixxx
- blocking send **2** is assigned to an output Oxxx (O103 by default).

The SFT 2841 software indicates the type of threshold, logic or time-based, according to the input/output parameter setting.



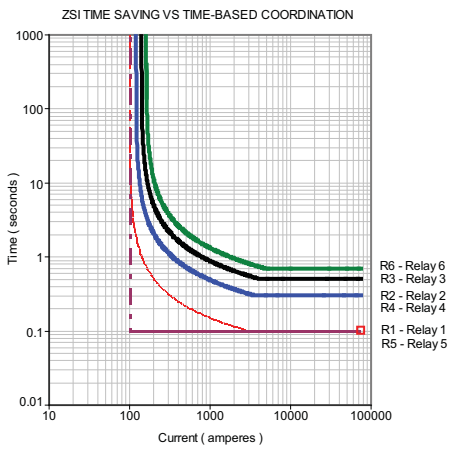
Assigning protection devices to the two ZSI groups is fixed and cannot be modified. When ZSI is used, it is important to ensure that the measurement origin and logic group to which the unit is assigned are in accordance.

By default, the same logic group has the same measurement origin. When several origins are possible, the main channels Ia, Ib, Ic and Ir are assigned by default to the first group and the additional channels I'a, I'b, I'c, I'r to the second.

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Zone Selective Interlocking
Principle



The duration of blocking signals lasts as long as it takes to clear the fault. If Sepam™ issues a tripping command, the blocking signals are interrupted after a time delay that takes into account the breaking device operating time and the protection unit reset time. This system guarantees safety in downgraded operating situations (faulty wiring or switchgear).

Pilot Wire Test

Use the output relay test function in the SFT2841 software to test the pilot wires that carry interlocks between breaker/relay functions.

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Zone Selective Interlocking
S80, S81, T81, B80, and B83 Applications

Threshold Assignment

Type of Protection	Unit Number Time-Based	Send Logic		Reception Logic	
		Group 1	Group 2	Group 1	Group 2
50/51	3, 4, 5, 6, 7, 8	1, 2	-	1, 2	-
50N/51N	3, 4, 5, 6, 7, 8	1, 2	-	1, 2	-
67N	2	1	-	1	-

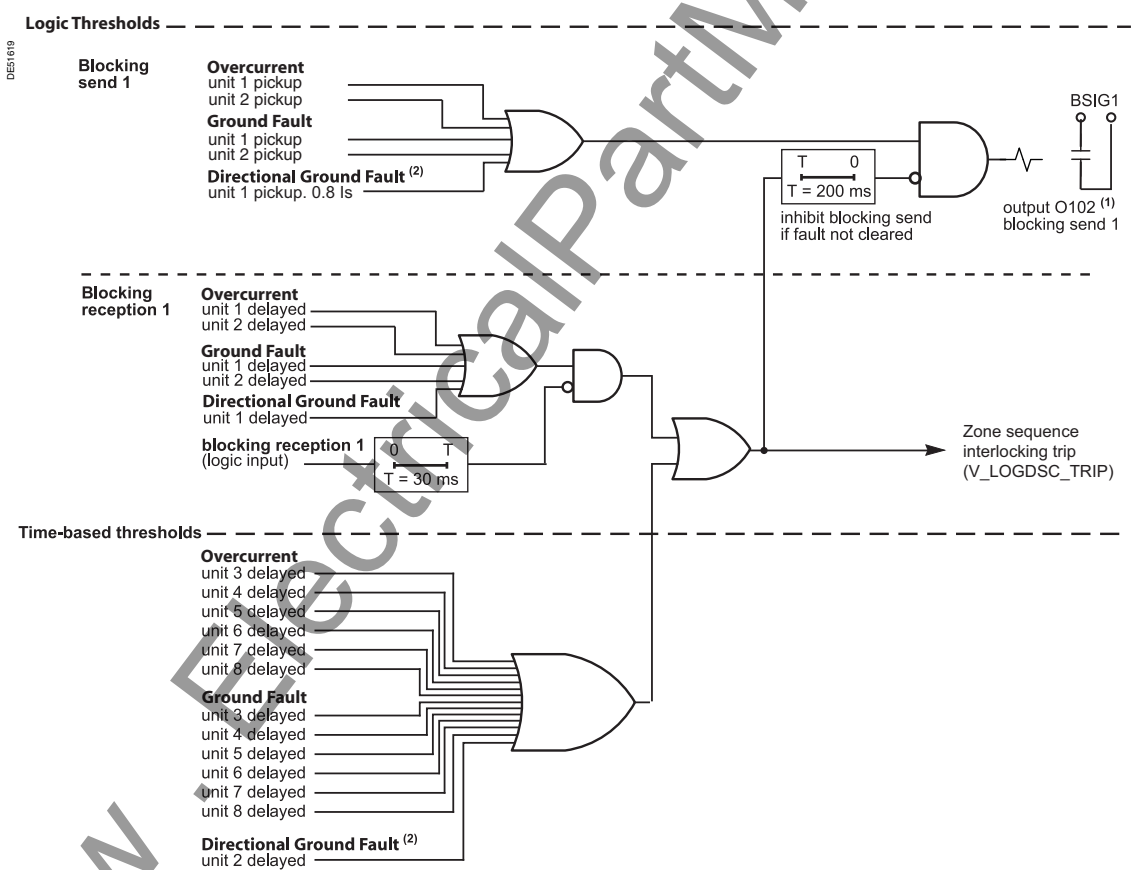
(1) *According to application.*

Characteristics

Settings				
Activity				
Setting range	On / Off			
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Zone selective Interlocking trip	V_LOGDSC_TRIP	■	■	■ (1)
Blocking send 1	V_LOGDSC_BL1	■	■	■
Zone selective Interlocking on	V_LOGDSC_ON		■	

(1) *Only if switchgear control is not in service.*

Block Diagram



(1) *By default.*
(2) *According to application.*

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Zone Selective Interlocking
M81, M87, M88, and C86 Applications

Threshold Assignment

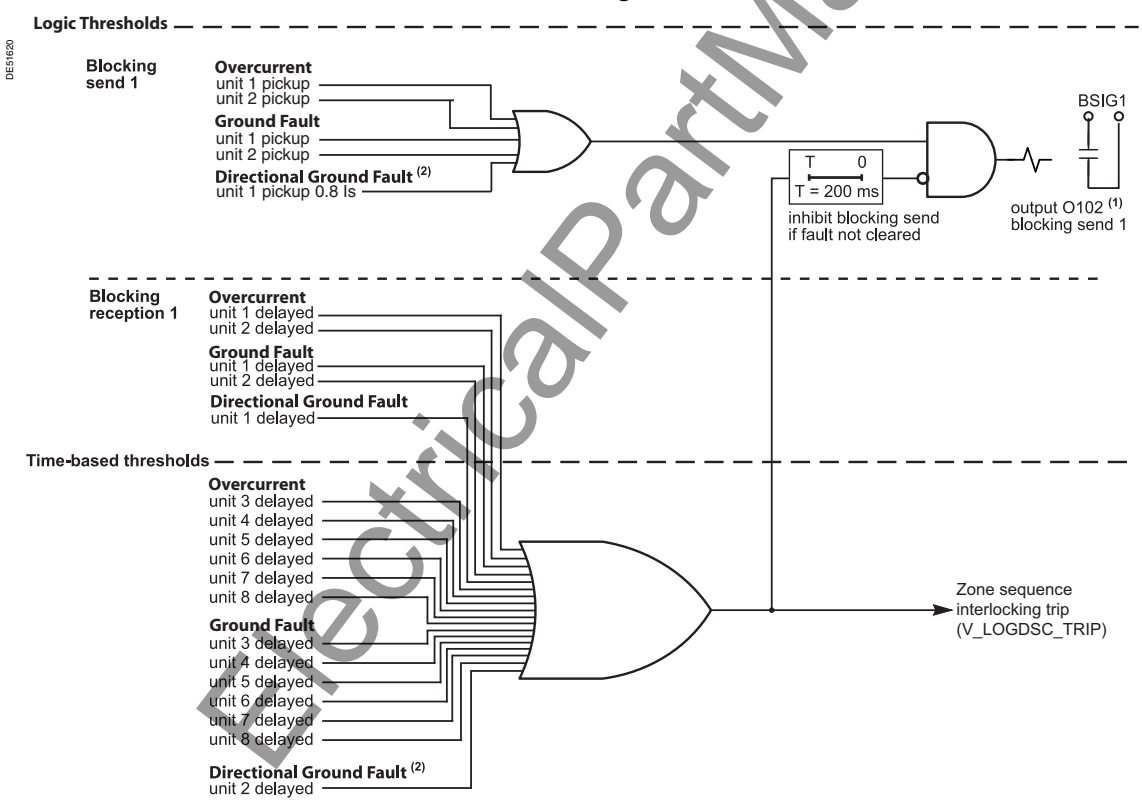
Type of Protection	Unit Number Time-Based	Send Logic		Reception Logic	
		Group 1	Group 2	Group 1	Group 2
50/51	3, 4, 5, 6, 7, 8	1, 2	-	-	-
50N/51N	3, 4, 5, 6, 7, 8	1, 2	-	-	-
67N	2	1	-	-	-

Characteristics

Settings				
Activity				
Setting range	On / Off			
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Zone selective Interlocking trip	V_LOGDSC_TRIP		■	■ (1)
Blocking send 1	V_LOGDSC_BL1		■	■
Zone selective Interlocking on	V_LOGDSC_ON		■	

(1) *Only if switchgear control is not in service.*

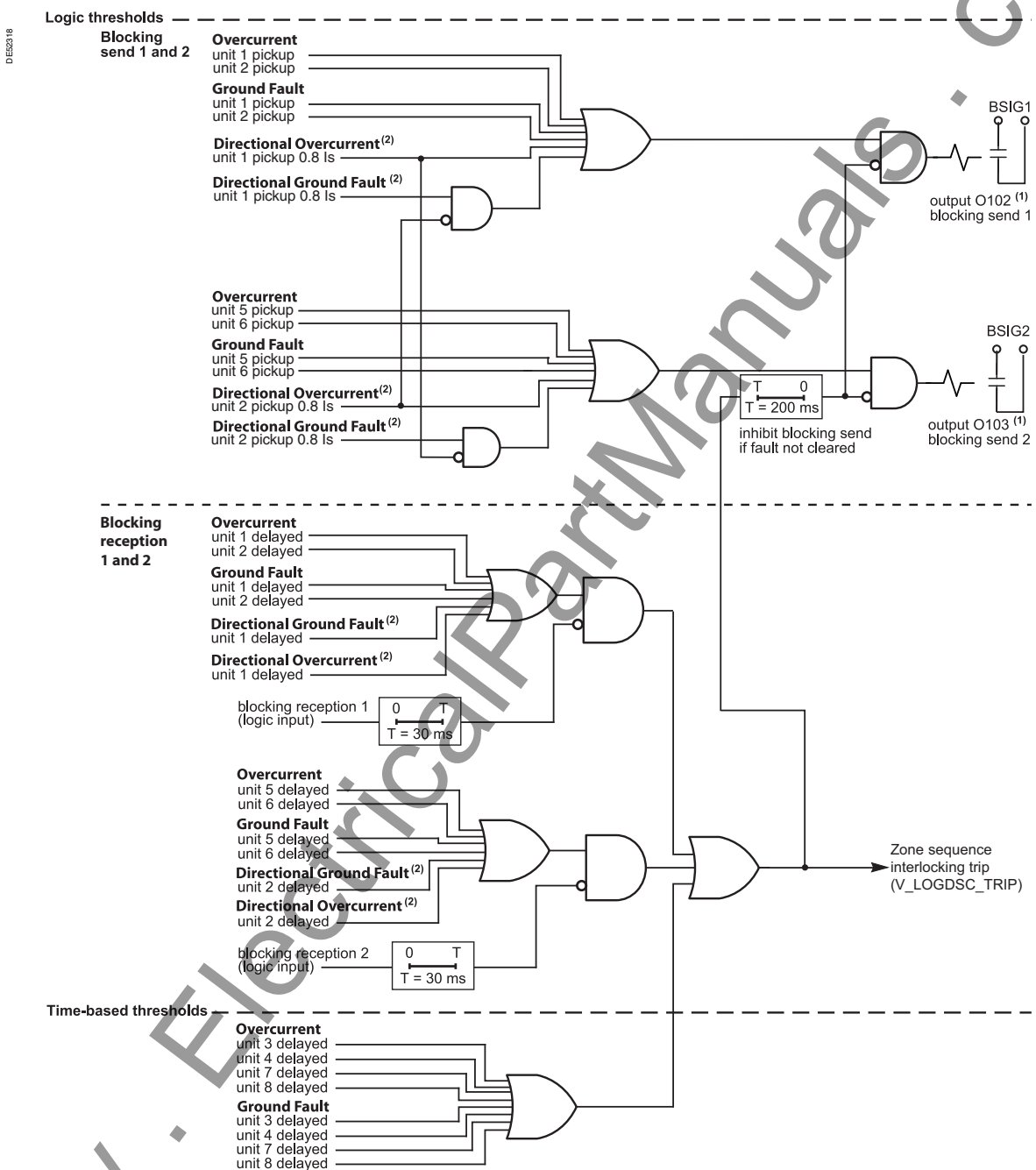
Block Diagram



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Block Diagram



***(1)** By default.*
***(2)** According to application.*

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Zone Selective Interlocking
S82, S84, T82, T87, G82, G87, and G88 Applications

Threshold Assignment

Type of Protection	Unit Number Time-Based	Send Logic		Reception Logic	
		Group 1	Group 2	Group 1	Group 2
50/51	3, 4, 7, 8	1, 2	5, 6	1, 2	5, 6
50N/51N	3, 4, 7, 8	1, 2	5, 6	1, 2	5, 6
67 (1)	-	1	2	1	2
67N (1)	-	1	2	1	2

(1) *According to application.*

Characteristics

Settings				
Activity				
Setting range	On / Off			
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Zone selective Interlocking trip	V_LOGDSC_TRIP		■	■ (1)
Blocking send 1	V_LOGDSC_BL1		■	■
Blocking send 2	V_LOGDSC_BL2		■	■
Zone selective Interlocking on	V_LOGDSC_ON		■	

(1) *Only if switchgear control is not in service.*

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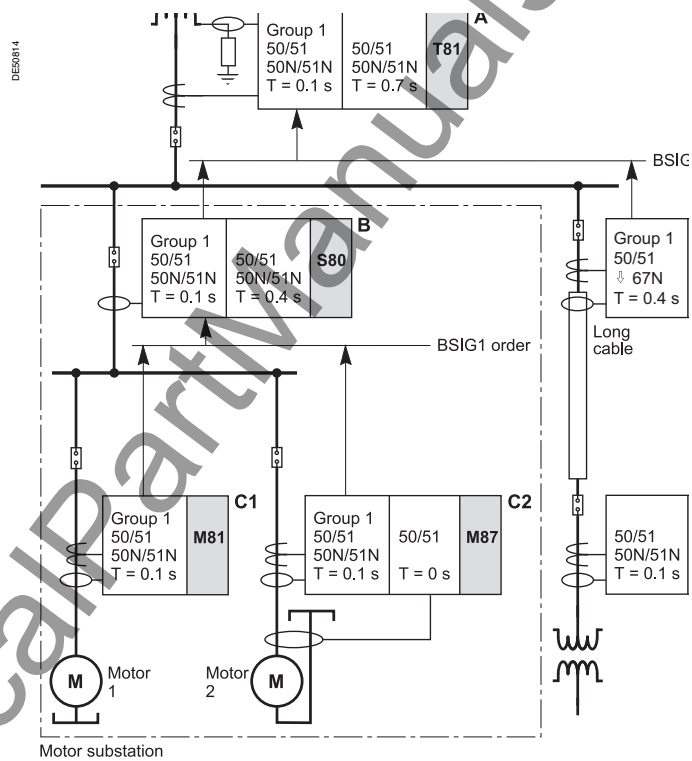
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Zone Selective Interlocking
Example: Radial Network

When a fault occurs in a radial network, the fault current flows through the circuit between the source and the location of the fault: The protection units upstream from the fault are triggered. The protection units downstream from the fault are not triggered. Only the first protection unit upstream from the fault should trip.

Example of Setting

A 20 kV installation, supplied by a transformer, comprises the main bus which in turn supply a feeder to a motor substation and a long feeder to a distant MV/LV transformer. The installation is grounded via a resistor at the incoming transformer neutral point, which limits the current to about 10 Amps.



⇧ *: direction of protection function detection*

▲ *: direction of blocking signal orders*

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Zone Selective Interlocking
Example: Radial Network

Based on a network coordination study, the installation relay settings are as follows:

- main: Sepam™ T81 (relay A)
  - bus fault thresholds
    50/51, 50N/51N: T =0.1 s (DT)

Zone selective Interlocking group 1:
- blocked by relays B and D
- blocking send 1 to high voltage relays

- backup thresholds

50/51, 50N/51N: T = 0.7 s (DT)
Time-based thresholds

- feeder to motor substation: Sepam™ S80 (relay B)
  - bus fault thresholds

50/51, 50N/51N: T = 0.1 s (DT)
Zone selective Interlocking group 1:
- blocked by relays C1 and C2
- blocking send 1 to relay A

- backup thresholds

50/51, 50N/51N: T = 0.4 s (DT)
Time-based thresholds

- motor feeders:
- motor 1: Sepam™ M81 (relay C1)
  - motor fault thresholds

50/51, 50N/51N: T = 0.1 s (DT)
Zone selective Interlocking group 1:
- blocking send 1 to relay B

- motor 2: Sepam™ M87 (relay C2)
  - motor fault thresholds
    - 50/51, 50N/51N: T = 0.1 s (DT)

Zone selective Interlocking group 1: blocking send 1 to relay B
Measurement origin: Ia, Ib, Ic
- 50/51 self-balancing differential scheme: T =0s (DT)

Time-based threshold
Measurement origin: I'a, I'b, I'c

- transformer feeder
  - cable fault thresholds

50/51, 67N: T = 0.4 s (DT)
Zone selective Interlocking group 1:
- these thresholds are set time-wise in relation to relay E
- blocking send 1 to relay A.

The logic input and output settings for all the relays concerned are:

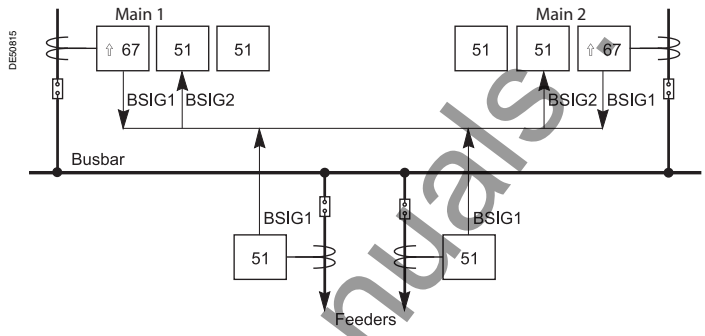
- blocking reception 1 on I103
- blocking send 1 on O102.

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Zone Selective Interlocking
Example: Parallel Mains

Substations supplied by two (or more) parallel mains may be protected using Sepam™ S82, T82, or G82, by a combination of directional phase (67) and ground fault (67N) protection functions, with the zone selective interlocking function.



⇧ *: direction of protection function detection*

: direction of blocking signal orders

To avoid both mains tripping when a fault occurs upstream from one main, the main protection devices must operate as follows:

- protection function 67 of the faulty main detects the fault current in the "line" direction, the protection tripping direction:
  - sends a blocking signal to block the phase overcurrent protection functions (50/51) of both mains
  - and initiates tripping of the main circuit breaker
- protection function 67 of the fault-free main is insensitive to fault current in the "bus" direction.

Example of Setting

- logic input / output assignment:
  - I104: blocking reception 2 - **Do not assign any inputs to blocking reception 1**
  - O102: blocking send 1
- protection function 67 unit 1: tripping direction = line
  - instantaneous output: blocking send 1
  - delayed output: not blocked (no input assigned to blocking signal 1), circuit breaker tripping on faults upstream from main
- protection function 50/51, unit 5:
  - delayed output:
    - blocked by protection 67, unit 1 if there is a fault upstream from the main
    - not blocked for bus faults
    - blocked for feeder faults
- protection function 50/51, unit 3 as backup.

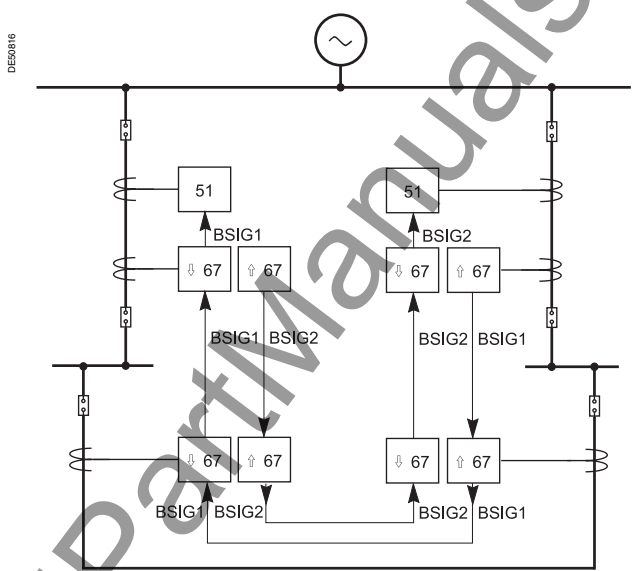
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Zone Selective Interlocking
Example: Closed Ring Network

Closed ring network protection may be provided by Sepam™ S82 or T82. This includes the following functions:

- two units of directional phase (67) and ground fault (67N) protection functions:
  - one unit to detect faults in the "line" direction
  - one unit to detect faults in the "bus" direction
- use of two discrimination groups:
  - sending two blocking signals according to the detected fault direction
  - receiving two blocking signals to block the directional protection relays according to the detection direction.



⇧, ⇩ : *direction of protection function detection*

: *direction of blocking signal orders*

With the combination of directional protection functions and the zone selective interlocking function, the faulty section may be isolated with a minimal delay by tripping of the circuit breakers on either side of the fault.

Blocking signals are initiated by both protection functions 67 and 67N. Priority is given to protection function 67: when protection functions 67 and 67N detect faults in opposite directions at the same time, the blocking signal sent is determined by the direction of the fault detected by protection function 67.

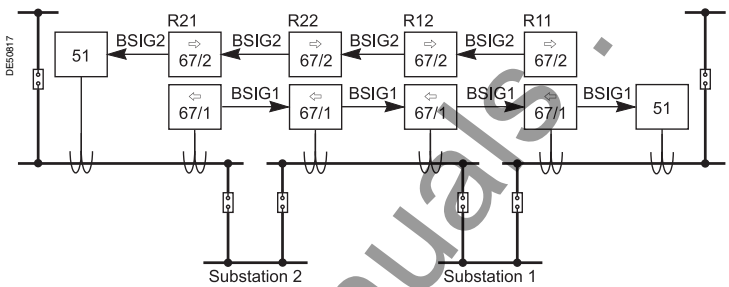
The instantaneous output of protection functions 67 and 67N, activated at 80% of the Is threshold, is used to send blocking signals. This avoids uncertainty when the fault current is close to the Is threshold.

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Zone Selective Interlocking
Example: Closed Ring Network

Example:
Case of a closed ring with two substations, each of which comprises two Sepam™ S82 relays, marked R11, R12 and R21, R22.



⇨, ⇦ : *direction of protection function detection*
: *direction of blocking signal orders*

Starting at one end of the ring, the detection direction of units 1 and 2 of the directional protection functions should be alternated between line and bus.

Example of setting of the different Sepam™ relays linked to zone selective interlocking:

Substation 1	
Sepam™ S82 No. R11	**Sepam™ S82 No. R12**
■ Logic input/output assignment: I103: blocking reception 1 O102: blocking send 1 O103: blocking send 2 ■ 67, 67N, unit 1: tripping direction = bus ■ 67, 67N, unit 2: tripping direction = line	■ Logic input/output assignment: I103: blocking reception 1 I104: blocking reception 2 O102: blocking send 1 O103: blocking send 2 ■ 67, 67N, unit 1: tripping direction = line ■ 67, 67N, unit 2: tripping direction = bus
Substation 2	
Sepam™ S82 No. R22	**Sepam™ S82 No. R21**
■ Logic input/output assignment: I103: blocking reception 1 I104: blocking reception 2 O102: blocking send 1 O103: blocking send 2 ■ 67, 67N, unit 1: tripping direction = bus ■ 67, 67N, unit 2: tripping direction = line	■ Logic input/output assignment: I103: blocking reception 1 O102: blocking send 1 O103: blocking send 2 ■ 67, 67N, unit 1: tripping direction = line ■ 67, 67N, unit 2: tripping direction = bus

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Load Shedding

Operation

The purpose of load shedding is to reduce the load on the electrical network in order to keep the voltage within an acceptable range.
Load shedding may be triggered by:

- a command from outside Sepam™ in the presence of a logic input assigned for the reception of load shedding commands. Commands can be delayed
- a voltage dip detected by the delayed output of Sepam™ 27D protection unit 1 (typical setting 40% $V_{LL}N$).

Load shedding triggers:

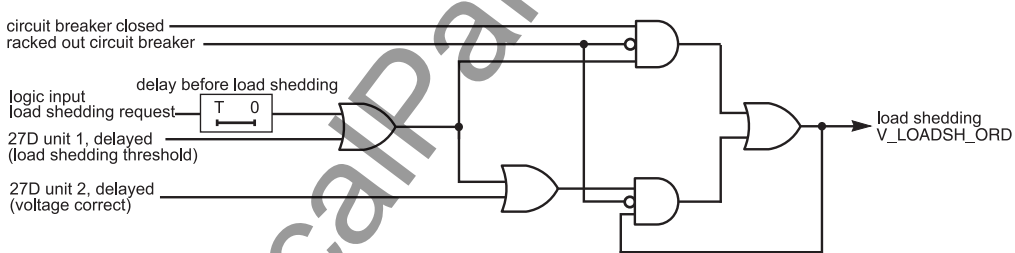
- tripping by the switchgear control function
- Block closing as long as the load shedding command is maintained.

The load shedding command is maintained as long as one of the following three conditions is present:

- external command via logic input
- positive sequence voltage detected by 27D unit 1 less than load shedding voltage threshold
- insufficient positive sequence voltage detected by the delayed 27D unit 2 for a restart command to be given. The time delay for the detection of correct voltage recovery must be shorter than the load shedding delay (27D unit 1) in order for the load shedding command to be maintained correctly. This unit is also used by the restart function.

The function may be validated by the switchgear closed and not racked out conditions.

Block Diagram



Characteristics

Settings				
Activity				
Setting range	On / Off			
Delay Before Load Shedding				
Setting range	0 to 300 s			
Accuracy (1)	±2% or from –10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Load shedding command	V_LOADSH_ORD		■	■
Load shedding on	V_LOADSH_ON		■	

(1) *Under reference conditions (IEC 60255-6).*

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Operation

This function enables motors to be automatically restarted after a shutdown caused by load shedding. It allows staggered restarting of process motors, as long as the voltage dip that caused load shedding was brief.

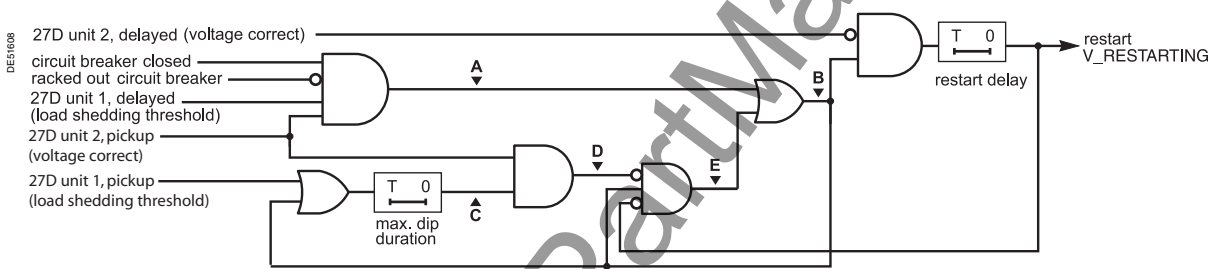
When tripping occurs due to a dip in the network supply voltage detected by 27D protection unit 1, two outcomes are possible:

- the voltage dip lasts for a period longer than the maximum voltage dip duration: tripping is final. External action is required for restart (see example 2).
- the voltage dip lasts for a period shorter than the maximum dip duration: a restart command is given. Delayed restart allows motor restart commands to be staggered to avoid network overload (see example 3).

Enabling restart is detected after the delayed output of protection 27D unit 2 drops out. This threshold allows the return of voltage to be detected independently with respect to the load shedding threshold. The typical setting is 50% $V_{LL}N$.

The restart command is given by the switchgear control function.

Block Diagram



Characteristics

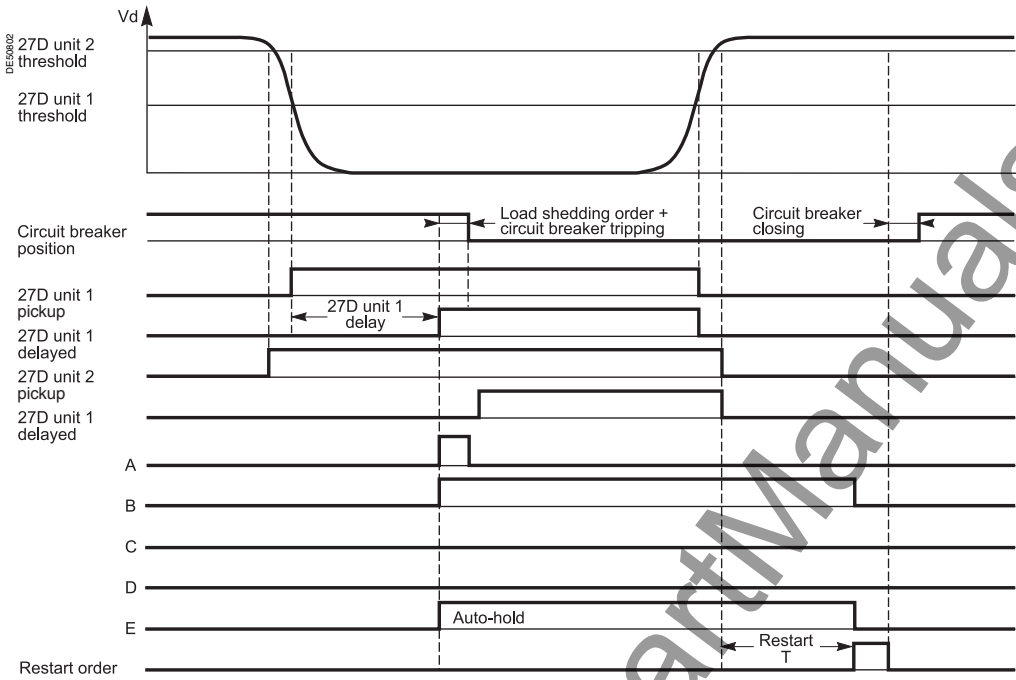
Settings				
Activity				
Setting range	On / Off			
Maximum Voltage Dip Duration				
Setting range	0 to 300 s			
Accuracy (1)	±2% or from –10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Restart Delay				
Setting range	0 to 300 s			
Accuracy (1)	±2% or from –10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Restart command	V_RESTARTING		■	
Restart on	V_RESTART_ON		■	

(1) *Under reference conditions (IEC 60255-6).*

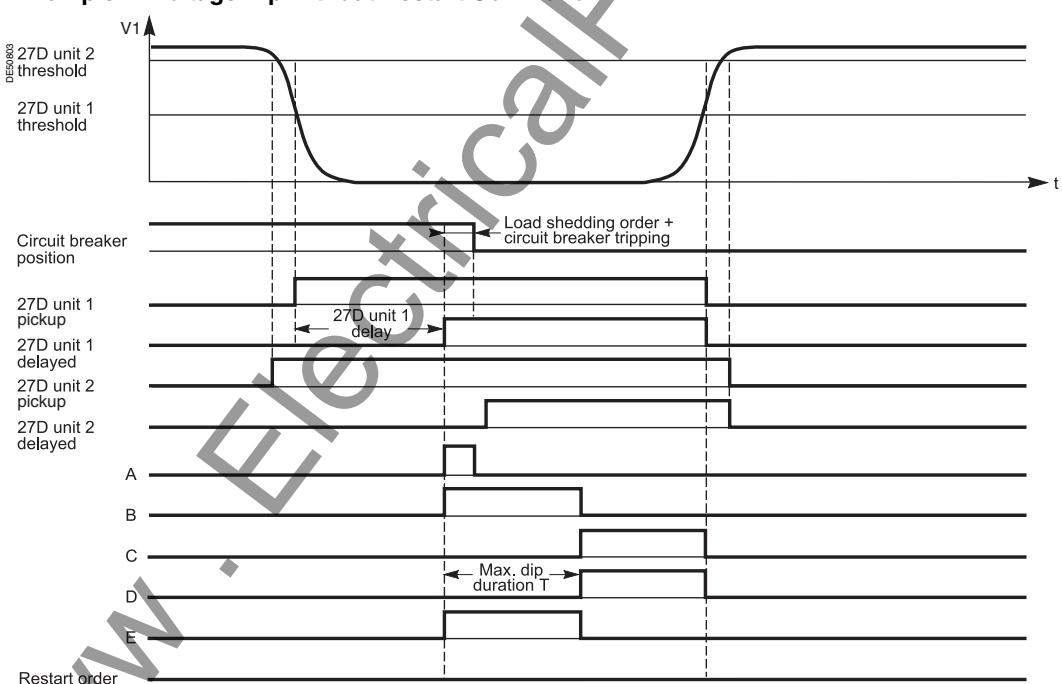
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Example 1: Voltage Dip with Restart Command



Example 2: Voltage Dip without Restart Command



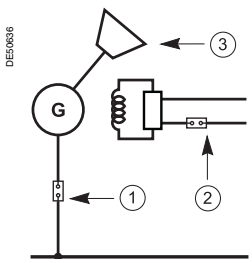
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Generator Shutdown & Tripping

Operation

This function controls the following:
- shutdown of the driving machine
- tripping of the breaking device
- interruption of the generator excitation supply in case of:
  - detection of an internal generator fault
  - receipt of a genset shutdown command on a logic input or via the communication link.



Generator shutdown and tripping involve:
① tripping of the circuit breaker connecting the machine to the network
② tripping of the excitation circuit breaker
③ shutdown of the prime mover.

The combination of these three commands determines four types of shutdown and tripping commands:
- total shutdown (simultaneous tripping)
- generator tripping
- generator separation
- sequential tripping.

Total Shutdown

This type of control function gives the following commands simultaneously:
- a trip command to the generator circuit breaker
- a trip command to the excitation circuit breaker
- a shutdown command to the prime mover.

This mode is reserved for internal faults in generators and transformers of generator-transformer units.

Generator Tripping

This type of control function gives the following commands:
- a trip command to the generator circuit breaker
- a trip command to the excitation circuit breaker.

The prime mover is not shut down.

This mode is reserved for power system faults and allows the generator to be quickly reconnected after the fault is cleared.

Generator Separation

This type of control function gives a trip command to the generator utility tie circuit breaker. The machine remains excited and the prime mover is not shut down.

This mode is used to isolate the machine from a utility power system which no longer meets the utility tie conditions (voltage, frequency, loss of power system source). The generator may continue to supply loads locally.

Sequential Tripping

This type of control function gives the following commands consecutively:
- a trip command to the generator circuit breaker
- a delayed trip command to the excitation circuit breaker
- a delayed shutdown command to the prime mover.

This mode is reserved for steam turbine generators and other such machines that may be adversely affected by overspeed during shutdown.

Sepam™ enables these operating modes by combining:
- switchgear control for tripping of the generator circuit breaker
- de-excitation function for tripping of the excitation circuit breaker
- genset shutdown function to command the shutdown of the prime mover.

Function output delays are used for sequential tripping.

Typical Parameter Setting for Industrial Network Generators

Protection Functions	Circuit Breaker Tripping	Genset Shutdown	De-Excitation
12	■		
21B	■		
24	■	■	■
27	■		
32Q	■	■	■
37P	■		
40	■	■	■
46	■		
47	■		
49RMS	■		
50/27	■		
50/51	■		
50N/51N 50G/51G	■	■	■
50V/51V	■		
59	■		
59N	■	■	■
64G2/27TN (1)			
64REF	■	■	■
67	■	■	■
67N/NC	■	■	■
78PS	■		
81H	■		
81L	■		
81R	■		
87M	■	■	■
87T	■	■	■

(1) Generally initiates an alarm, but may otherwise initiate circuit breaker tripping, genset shutdown and de-excitation.

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Generator Shutdown & Tripping
Genset Shutdown

Operation

This function is available in generator applications. It is used to shut down the genset in one of two ways:

- mechanical shutdown by shutting down the prime mover
- electrical shutdown by tripping the generator.

Genset shutdown may be initiated in the following ways:

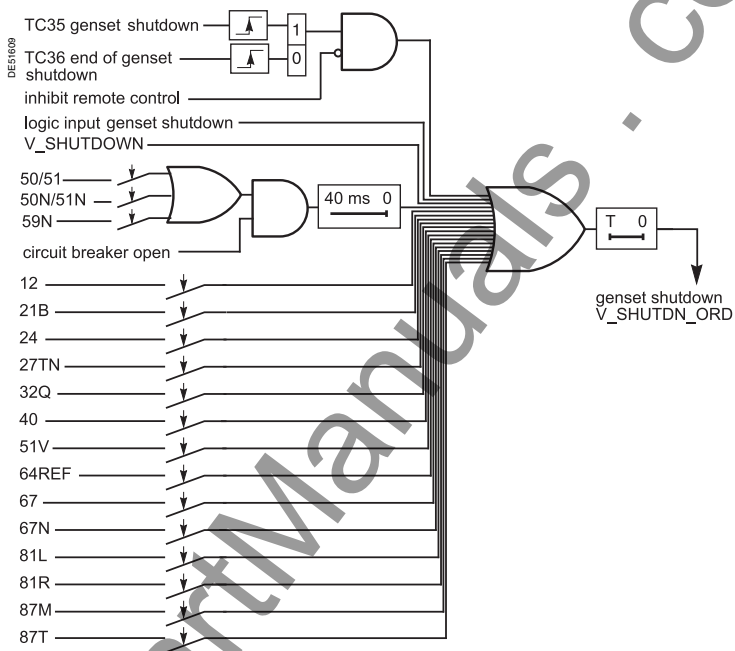
- by a external shutdown command
  - remote control command if enabled
  - logic input if set up
- by logic equation or by Logipam to take into account all specific generator installation characteristics
- by delayed protection functions.

The protection functions concerned are those that detect internal faults in generators or transformers of generator-transformer units. They are divided into 2 groups: protection functions that contribute to shutdown regardless of the circuit breaker position and those whose contribution is dependent on the circuit breaker position:

- protection functions unrelated to circuit breaker position 12, 21B, 24, 27TN, 32Q, 40, 51V, 64REF, 67, 67N, 81L, 87M, 87T
- protection functions dependent on circuit breaker position 50/51, 50N/51N, 59N. The delayed, unlatched outputs of these protection units activate shutdown, only if the circuit breaker is open.

Participation in the function is an individual setting, located in the protection setting tabs of the SFT2841 software for each protection unit that can take part in genset shutdown. At the same time, the function gives a tripping command via switchgear control to disconnect the generator from the power network. It must be associated with a logic output in the matrix to initiate genset shutdown.

Block Diagram



Characteristics

Settings				
Activity				
Setting range	On / Off			
Selection of Protection Functions Activating Genset Shutdown				
Setting range per protection unit	Enabled / disabled			
Genset Shutdown Time Delay				
Setting range	0 to 300 s			
Accuracy (1)	±2% or from -10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Genset shutdown	V_SHUTDOWN	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Genset shutdown	V_SHUTDN_ORD		■	■
Genset shutdown on	V_SHUTDN_ON		■	

(1) *Under reference conditions (IEC 60255-6).*

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Generator Shutdown & Tripping
De-Excitation

Operation

This function, available in generator applications, is used to quickly cut off the power supply to an internal fault when the generator is disconnected from the network:

- de-excitation of the generator
- electrical shutdown by tripping.

De-excitation may be initiated in the following ways:

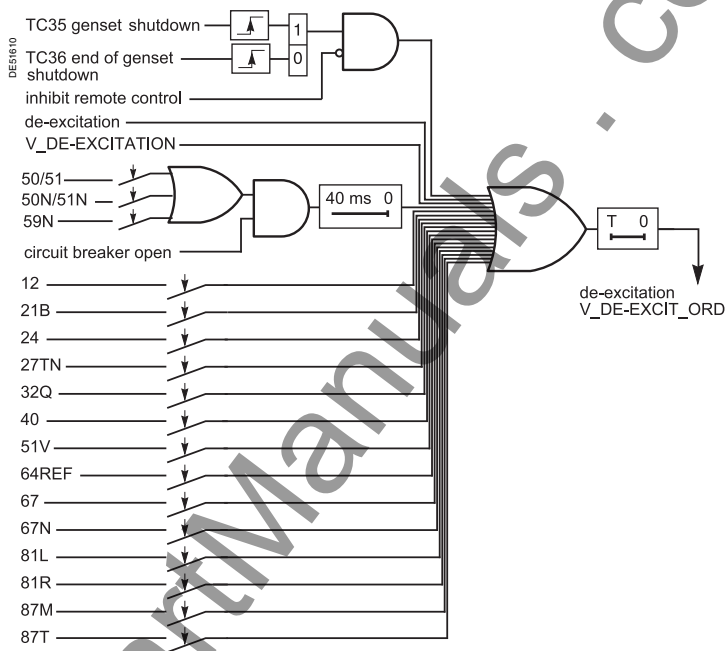
- by a command
  - remote control command if enabled
  - logic input if set up
- by logic equation or by Logipam to take into account all specific generator installation characteristics
- by delayed protection functions.

The protection functions concerned are those that detect internal faults in generators or transformers of generator-transformer units. They are divided into 2 groups: protection functions that contribute to de-excitation regardless of the circuit breaker position and those whose contribution is dependent on the circuit breaker position:

- protection functions unrelated to circuit breaker position 12, 21B, 24, 27TN, 32Q, 40, 51V, 59, 64REF, 67, 67N.81L, 87M, 87T
- protection functions dependent on circuit breaker position 50/51, 50N/51N, 59N. The delayed, unlatched outputs of these protection units trigger de-excitation only if the circuit breaker is open.

Participation in the function is to be set individually in the protection function setting tabs of the SFT2841 software for each protection unit that can take part in de-excitation.
At the same time, the function gives a tripping command via switchgear control to disconnect the generator from the power network. It must be associated with a logic output in the control matrix to initiate the de-excitation command.

Block Diagram



Characteristics

Settings				
Activity				
Setting range	On / Off			
Selection of Protection Functions	**Activating De-Excitation**			
Setting range per protection unit	Enabled / disabled			
De-Excitation Time Delay				
Setting range	0 to 300 s			
Accuracy (1)	±2% or from -10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
De-excitation	V_DE-EXCITATION	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
De-excitation	V_DE-EXCIT_ORD		■	■
De-excitation on	V_DE-EXCIT_ON		■	

(1) *Under reference conditions (IEC 60255-6).*

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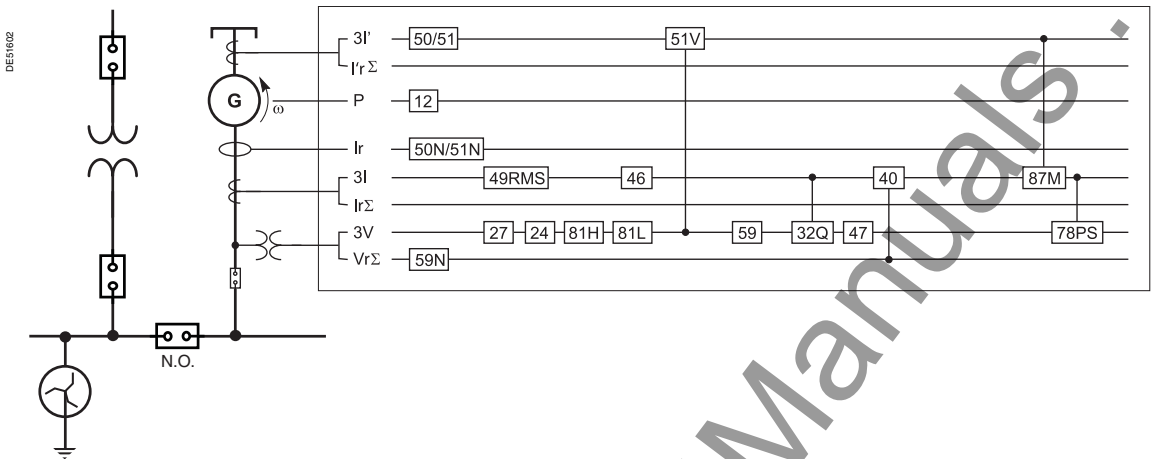
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Generator Shutdown & Tripping
Example

Installation Description

The electrical installation consists of a bus that connects to::

- a main supplied by a 10 MVA transformer
- a 3.15 MVA power generator



In normal operation, the generator and transformer are connected to the bus. The generator provides backup power to the installation in the absence of the transformer power supply. The installation is grounded by a neutral inductance. When the generator is not connected to the network, its neutral is isolated. When faults occur, the generator is over-excited for 3 - 10 seconds. Its fault current is equal to 3 times its rated current. After the 3 - 10 seconds have elapsed, the fault current drops to 0.5 times the rated current.

The generator is protected:

- against network electrical short-circuits by a phase overcurrent protection function 50/51 and a backup protection function 50V/51V
- against internal faults in generators by a generator differential protection function 87M.
- against ground faults by a ground fault protection function 50N/51N when the generator is connected to the bus and by a neutral voltage displacement protection function when the generator is not connected
- against overloads by a thermal overload protection function 49RMS
- against unbalance by a negative sequence / unbalance protection function 46
- against frequency variations by underfrequency and overfrequency protection functions 81L and 81H
- against voltage variations by undervoltage and overvoltage protection functions 27 and 59
- against field loss by a protection function 40
- against faults due to the prime mover by a reverse active power protection function 32P
- against loss of synchronization of the main network by a protection function 78PS.

Setting Genset Shutdown and De-Excitation

The participation of these protection functions in circuit breaker tripping, genset shutdown and de-excitation depends on the type of faults detected:

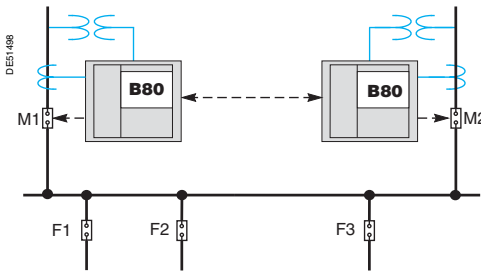
- circuit breaker tripping against network faults:
  - 50/51, 50V/51V, 50N/51N, 49RMS, 46, 81L, 81H, 27, 59, 78PS
- genset shutdown for prime mover faults and internal faults:
  - 50/51, 87M, 59N, 40
- de-excitation for internal faults:
  - 50/51, 87M, 59N, 40.

Shutdown is total and not sequential. The genset shutdown and de-excitation time delays are zero.

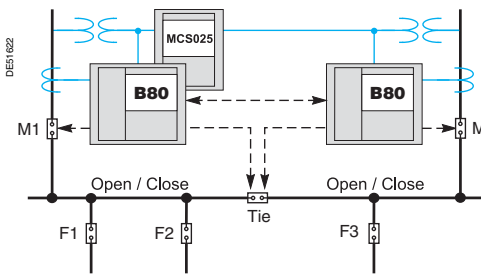
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Automatic Transfer



Automatic "transfer "MAIN-MAIN"



Automatic transfer "MAIN-TIE-MAIN" with sync-check managed by Sepam™ Series 80

Description

The automatic transfer function is used to transfer bus supply from one source to another.
The function reduces bus supply interruptions, thereby increasing the service continuity of the network supplied by the bus.

Automatic transfer performs:

- automatic transfer with interruption if there is a loss of voltage or a fault upstream
- manual transfer and return to normal operation without interruption, with or without sync-check
- control of the tie circuit breaker (optional)
- selection of the normal operating mode
- the necessary logic to ensure that at the end of the sequence, only one circuit breaker out of 2 or 2 out of 3 are closed.

Automatic "Main-Main" or "Main-Tie-Main" Transfer

Operating and implementing the automatic transfer function depends on the type of substation:

- "Main-main" transfer is suitable for dual-main substations without a tie
- "Main-tie-main" transfer is suitable for dual-main substations with a tie

These two applications are described separately

The automatic transfer function is symmetrical:

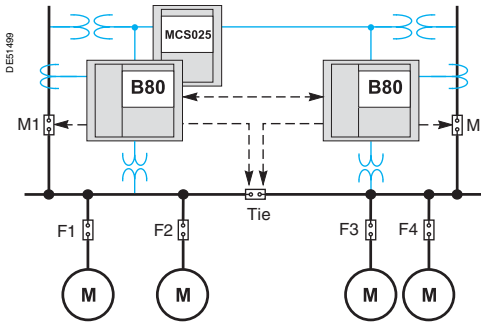
- hardware symmetry: dual-main substations, with two incoming circuit breakers, and each main is protected by a Sepam™ Series 80 unit
- functional symmetry: automatic transfer is distributed between the two Sepam™ Series 80 units protecting the two mains.

Each function is described from the viewpoint of one of the two mains, the other main being referred to as the "opposite side" main.

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Automatic Transfer



Automatic "main-tie-main" transfer with sync-check managed by Sepam™ B80.

Equipment Used

Sepam™ Protection Relay
Each main is protected by a Sepam™ Series 80 unit.

At least two MES120 modules should be added to each Sepam™.

The sync-check function (ANSI 25) is performed by an optional MCS025 module connected to one of the two Sepam™ units.

For busses with motors, it is necessary to check the remnant voltage on the bus during automatic transfer.

Two solutions are proposed:
- protecting the two mains with Sepam™ B80 to:
  - measure the three phase voltages upstream of the circuit breaker and detect the loss of phase voltage
  - measure one additional phase voltage on the bus and detect the presence of remnant voltage
- protecting the two mains with another type of Sepam™ Series 80 and checking the remaining voltage on the bus with Sepam™ B21.

Local Control of Automatic Transfer
Local control of automatic transfer requires the following components:
- one "NO circuit breaker" selector (ANSI 10), 2- or 3-position selector which designates the circuit breaker that remains open at the end of voluntary transfer without interruption
- one optional "Manual / Auto" selector (ANSI 43)
  - in Auto mode, automatic transfer is enabled
  - in Manual mode, automatic transfer is disabled
  - when this optional selector is not included, all the automatic transfer functions are enabled.
- as many as three optional "Local / Remote" selectors (one selector for the function or one selector per circuit breaker)
  - in Remote mode, automatic transfer on voltage loss is enabled and the other functions are disabled
  - in Local mode, automatic transfer on voltage loss is disabled and the other functions are enabled
  - when these optional selectors are not included, all the automatic transfer functions are enabled.
- two or three optional pushbuttons with LEDs (one pushbutton per circuit breaker):
  - "Breaker closing" pushbutton
  - "Closing ready" LED.

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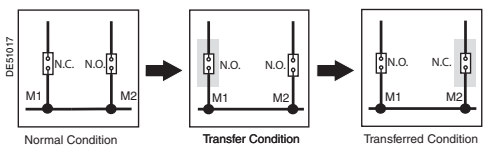
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Automatic Transfer "Main-Main" Operation

Definition

The automatic "main-main" transfer is suitable for substations supplied by two mains with no tie. This automatic transfer has two functions:

- automatic transfer with bus supply interruption
- voluntary return to normal without bus supply interruption.



Automatic "Main-Main" Transfer

Automatic Transfer with Supply Interruption

Description

The function transfers bus supply from one source to the other after detecting a voltage loss or fault upstream from the source.

Automatic source transfer takes place in two steps:

- circuit breaker tripping, triggered by detecting the loss of voltage or an external trip command (from upstream protection units): loss of bus supply
- closing the opposite side circuit breaker to resupply the bus (when motors are connected to the bus, it is necessary to check for remaining voltage on the bus using the ANSI 27R Remnant undervoltage function).

Mandatory Transfer Conditions

These conditions are always required to enable transfer:

- the incoming circuit breaker is closed
- no phase-to-phase fault detected by the main on the bus or downstream
- no phase-to-ground fault detected by the main on the bus or downstream
- voltage present on the opposite main.

Optional Transfer Conditions

These conditions are required when the associated optional functions are enabled:

- the "Auto / Manual" selector is in the Auto position
- the two "Local / Remote" selectors are in the Remote position
- the two incoming circuit breakers are racked in
- no VT fault detected by the VT Supervision function (ANSI 60FL), to avoid transfer on the loss of voltage transformers
- no block of transfer by V_TRANS_STOP by logic equations or by Logipam.

Initializing Transfer

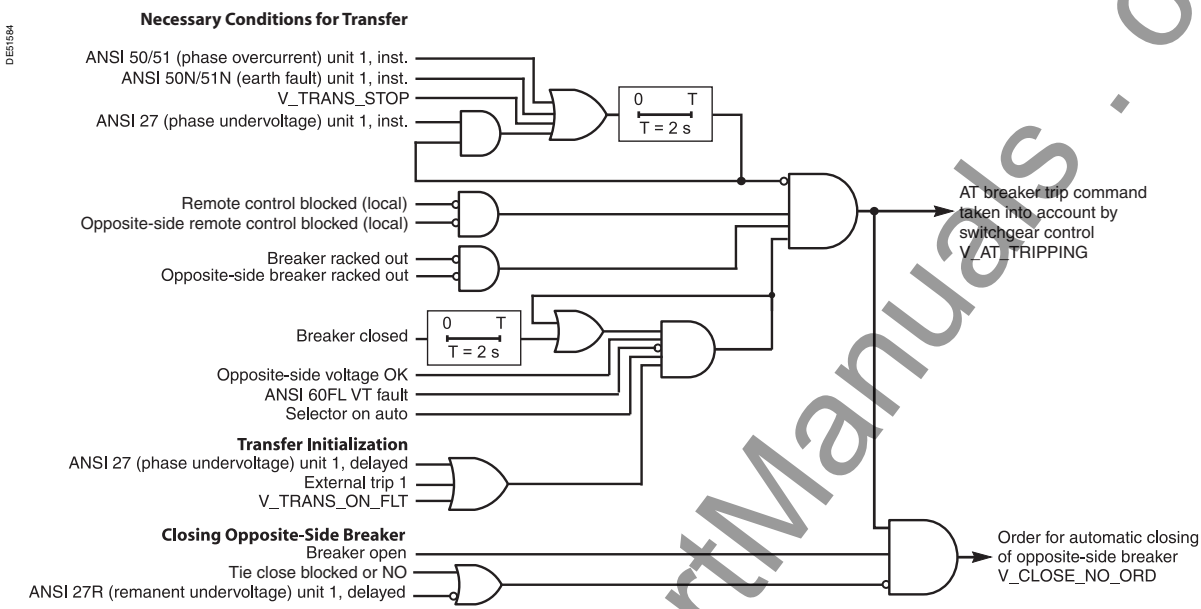
Any of the events below can trigger automatic transfer:

- loss of voltage detected on the main by the Phase undervoltage function (ANSI 27)
- detection of a fault by the protection units upstream of the main, with intertripping command on the "External tripping 1" logic input
- V_TRANS_ON_FLT, initialization of transfer by logic equations or by Logipam.

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Block Diagram



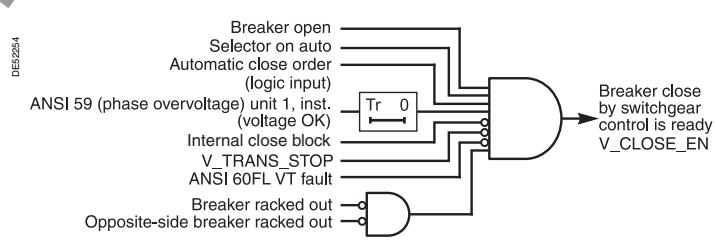
Closing the Opposite Side Circuit Breaker

The following conditions are required to command the closing of the opposite side circuit breaker:

- the circuit breaker is open
- no opposite side circuit breaker block close conditions
- no remnant voltage on the bus (checking necessary when motors are connected to the bus)

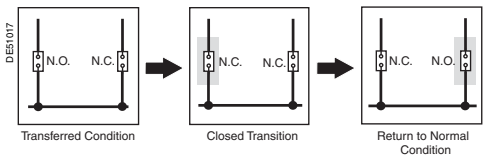
The opposite side circuit breaker closing command is transmitted by a Sepam™ logic output to a logic input of the opposite side Sepam™.
It is taken into account by the Switchgear control function of the opposite side Sepam™.

Block Diagram (Opposite Side Sepam™)



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Voluntary Return to Normal Without Interruption

Description

The voluntary return to normal without interruption involves two separate control functions:

- closing of the open incoming circuit breaker, with or without sync-check: the two incoming circuit breakers are closed
- then opening of the normally open circuit breaker, designated by the "NO circuit breaker" selector.

These two functions may also be used to transfer the bus supply source without any interruption.

Mandatory Transfer Conditions

These conditions are required to enable transfer:

- the incoming circuit breaker is open
- the voltage is OK upstream of the incoming circuit breaker.

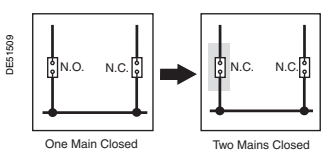
Optional Transfer Conditions

These conditions are required when the associated optional functions are enabled:

- the "Auto / Manual" selector is in the Manual position
- the 2 "Local / Remote" selectors are in the Local position
- the 2 main circuit breakers are racked in
- no VT fault detected by the VT Supervision function (ANSI 60FL), to avoid transfer on the loss of voltage transformers
- no blocking of transfer by V_TRANS_STOP by logic equations or by Logipam.

Initializating the Return to Normal

- voluntary incoming circuit breaker close command.



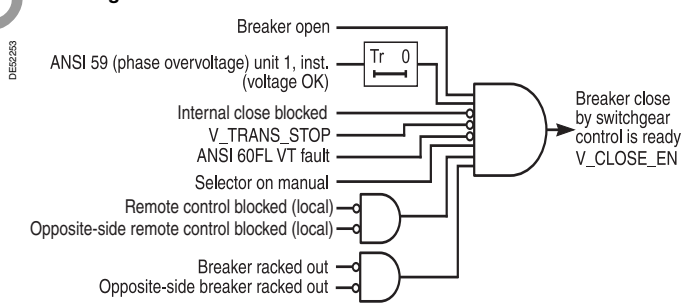
Closing an Open Circuit Breaker

Description

Circuit breaker closing is ensured by the Switchgear control function, with or without sync-check.

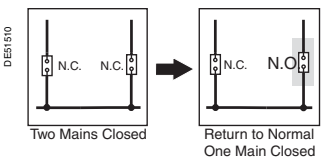
The AT function checks that all the required conditions are met and indicates to the user that the return to normal is possible.

Block Diagram



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Opening a Normally Open Circuit Breaker

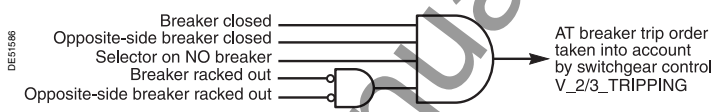
Description

This function controls the opening of circuit breakers that are designated "normally open" by the position of the "NO circuit breaker" selector when the two main circuit breakers are closed.

For those automatic control sequences that put the two sources in parallel, it guarantees that only one circuit breaker of the two is closed at the end of the transfer.

The open command is taken into account by the Switchgear control function.

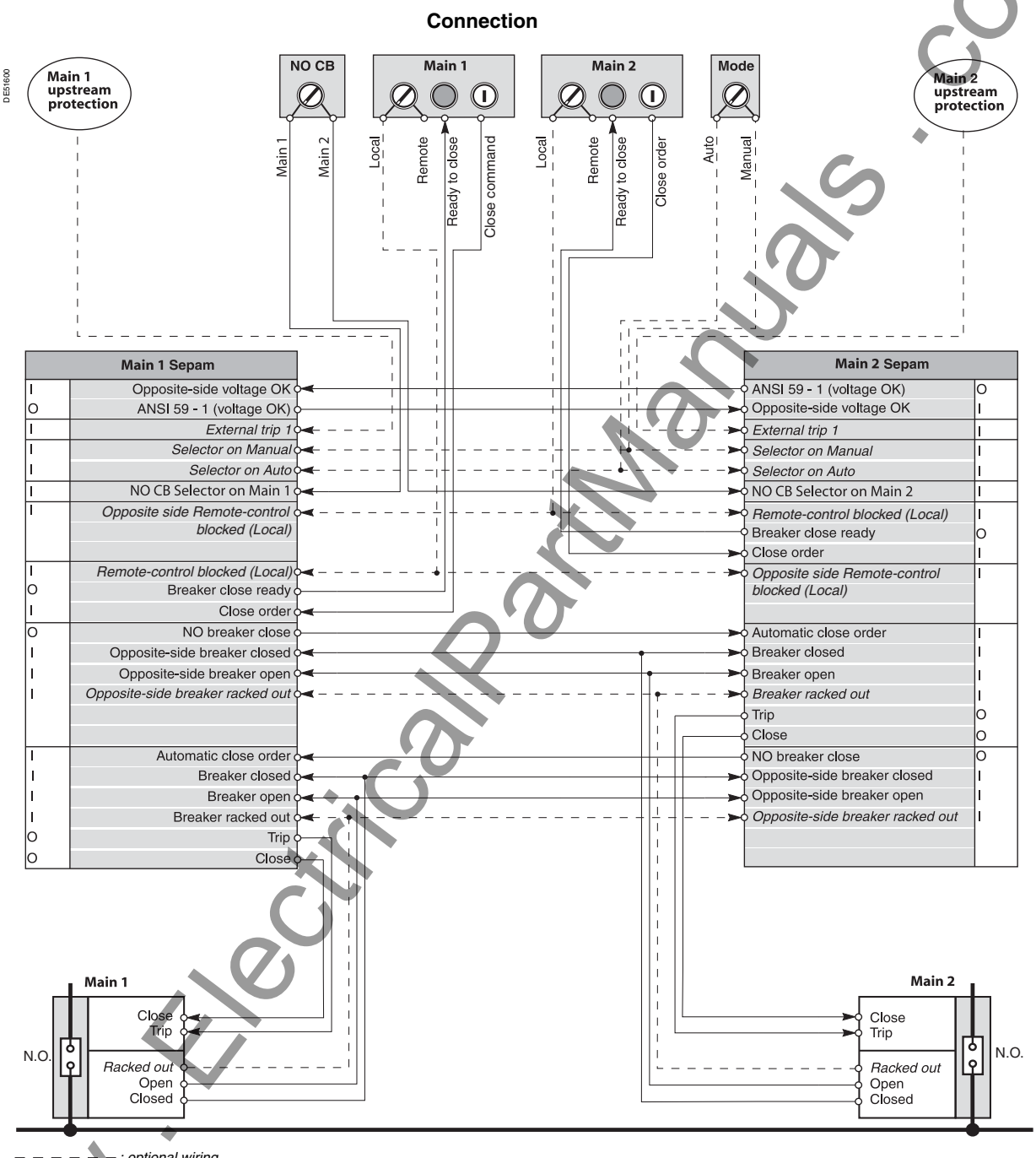
Block Diagram



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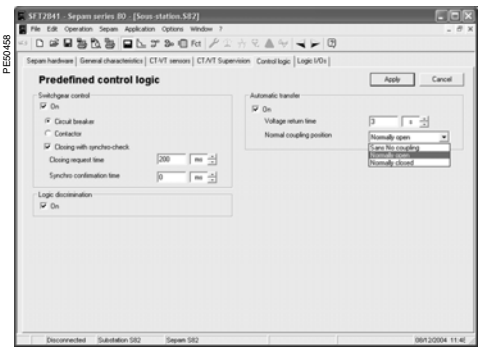
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Connection



– – – – – – – : optional wiring.

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SFT2841: parameter setting of predefined control logic

Parameter Setting: Predefined Control Functions

The Automatic transfer function is set up with the Switchgear control function in the "Control logic" tab of the SFT2841 software.

Switchgear Control Function

- activating the Switchgear control function
- activating the Sync-check function if necessary

Automatic Transfer Function

- activating the Automatic transfer function and adjustment of associated parameters:
  - voltage return time Tr (typically 3 seconds)
  - normal breaker position: tie open

VT Supervision Function

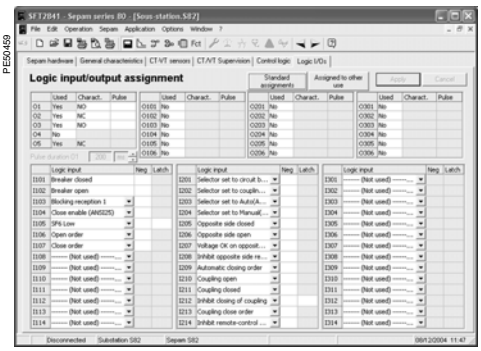
Activate the VT supervision (ANSI 60FL, if necessary.

Protection Function Setting

Protection Functions	Use	Setting Information
Phase undervoltage (ANSI 27) Unit 1	Initialization of automatic transfer on detection of voltage loss.	Voltage set point: 60% V_{LL}Np Delay: 300 msec
Phase overcurrent (ANSI 50/51) Unit 1, instantaneous output	Detection of downstream phase fault, to block automatic transfer.	To be set according to coordination study (the most sensitive set point).
Ground fault (ANSI 50N/51N) Unit 1, instantaneous output	Detection of downstream ground fault, to block automatic transfer.	To be set according to coordination study (the most sensitive set point).
Phase overvoltage (ANSI 59) Unit 1	Detection of phase voltage upstream of the circuit breaker. To be assigned to a Sepam™ logic output in the control matrix.	Voltage set point: 90% V_{LL}Np Delay: 3 sec
Optional Protection Functions	**Use**	**Setting information**
Remnant undervoltage (ANSI 27R) Unit 1	Detection of no remnant voltage on the bus to which the motors are connected.	Voltage set point: 30% V_{LL}Np Delay: 100 msec

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SFT2841: standard assignment of the inputs required for the AT function

Logic Input Assignment

The logic inputs required for the AT function are assigned in the SFT2841 "Logic I/Os" screen.

The "Standard assignments" button suggests an assignment of the main inputs required for the AT function. The other inputs are assigned manually.

Logic Output Assignment in the Control Matrix

The assignment of the logic outputs required for the AT function takes place in two steps:

1. declaring the required logic outputs "Used", indicating the control mode of each output, in the SFT2841 "Logic I/Os" screen
2. assigning each predefined output associated with the AT function to a Sepam™ logic output in the SFT2841 "Control matrix" screen.

The predefined outputs associated with the AT function are as follows:

"Protection" Button	Description	Use
59 - 1	Delayed output of the Phase overvoltage function (ANSI 59) Unit 1	Indication for the opposite side Sepam™: the voltage is OK upstream of the incoming circuit breaker.
"Logic" Button	**Description**	**Use**
NO circuit breaker closing	Predefined output V_CLOSE_NO_ORD of the AT function	Automatic closing command of opposite side circuit breaker.
Breaker closing ready	Predefined output V_CLOSE_EN of the AT function	LED indication: the return to normal conditions are met (neglecting the sync-check)

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Automatic Transfer "Main-Main" Characteristics

Setting				
Activity				
Setting range	On / Off			
Voltage Return Time				
Setting range	0 to 300 s			
Accuracy (1)	±2% or from –10 msec to +25 msec			
Resolution	10 msec or 1 digit			
Normal Tie Breaker Position				
Setting range	No tie / Normally open / Normally closed			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Transfer command on fault	V_TRANS_ON_FLT	■	■	
Transfer off command	V_TRANS_STOP	■	■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Automatic transfer on	V_TRANSF_ON		■	
Tripping by 2/3 or 1/2 logic	V_2/3_TRIPPING		■	■
Tripping by automatic transfer	V_AT_TRIPPING		■	■
NO circuit breaker closing	V_CLOSE_NO_ORD		■	■
Breaker closing ready	V_CLOSE_EN		■	■

***(1)** Under reference conditions (IEC 60255-6).*

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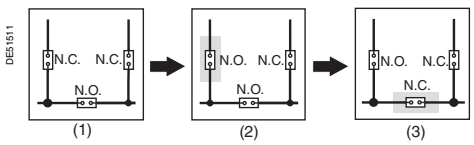
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Automatic Transfer "Main-Tie-Main" Operation

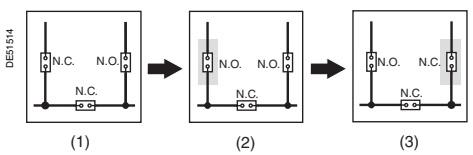
Definition

The "Main-Tie-Main" (M-T-M) transfer is automatic and is suitable for substations with bus supplied by two mains and with a tie (M-T-M). Automatic transfer is made up of two functions:

1 automatic transfer with bus supply interruption
2 voluntary return to normal without bus supply interruption.



Automatic transfer with normally open tie
(1) Normal condition
(2) Transfer condition
(3) Transferred condition



Automatic transfer with normally closed tie
(1) Normal condition
(2) Transfer condition
(3) Transferred condition

Automatic Transfer with Supply Interruption

Description

This function transfers bus supply from one source to the other after detecting a voltage loss or a fault that is upstream of the source.

Automatic source transfer takes place in two steps:

1 tripping the circuit breaker triggered by the detection of the loss of voltage or an external trip command (trip command from upstream protection unit): loss of bus supply
2 closing the normally open circuit breaker to resupply the bus. According to the parameter setting, the normally open circuit breaker may be one of the following:
- the tie circuit breaker, when the tie is normally open
- the opposite side circuit breaker, when the tie is normally closed.

When motors are connected to the bus, it is necessary to check for remnant voltage on the bus using the remnant undervoltage function (ANSI 27R).

Mandatory Transfer Conditions

These conditions are always required to enable transfer:
- the incoming circuit breaker is closed
- according to the tie setup:
  - the opposite side circuit breaker is closed and the tie circuit breaker is open, when the tie is normally open
  - or the opposite side circuit breaker is open and the tie circuit breaker is closed, when tie breaker is normally closed
- no phase-to-phase fault detected by the main on the bus or downstream
- no phase-to-ground fault detected by the main on the bus or downstream
- voltage OK on the opposite main.

Optional Transfer Conditions

These conditions are required when the associated optional functions are enabled:
- the "Auto / Manual" selector is in the Auto position
- the three "Local / Remote" selectors are in the Remote position
- the three circuit breakers are racked in
- no VT fault detected by the VT Supervision function (ANSI 60FL), to avoid transfer on the loss of voltage transformers
- no blocking transfer by V_TRANS_STOP by logic equations or by Logipam.

Initializing Transfer

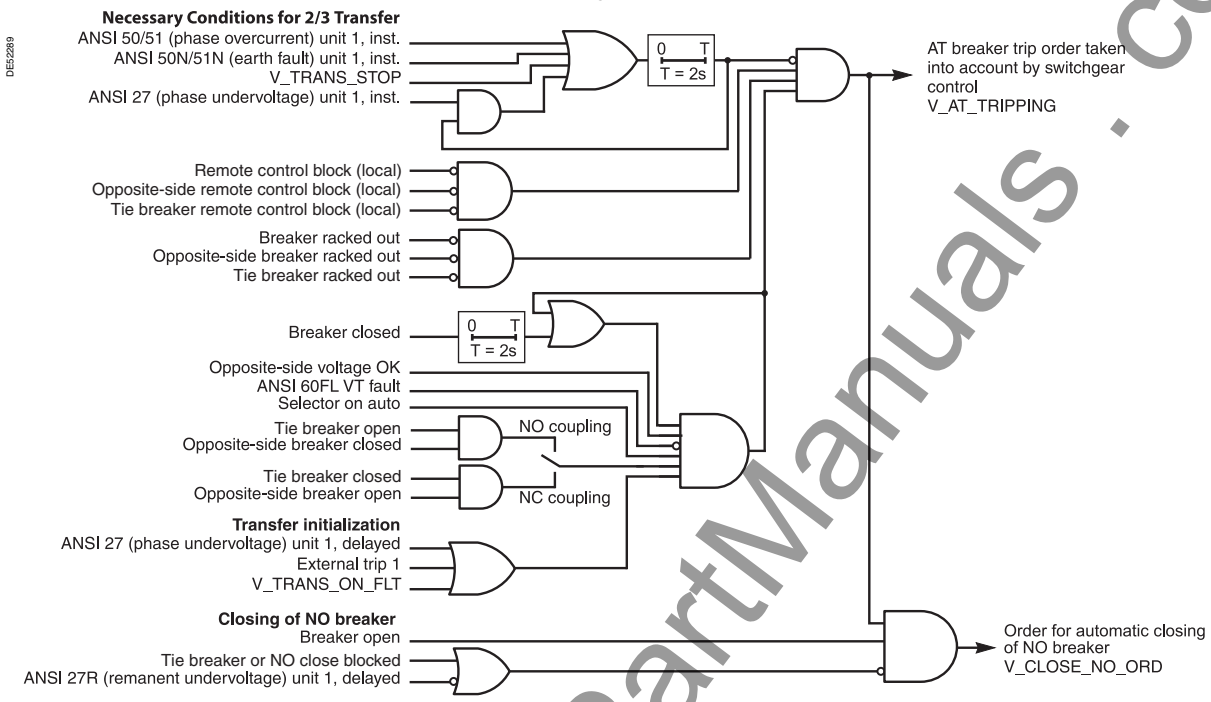
Any of the following events can trigger automatic transfer:
- loss of voltage detected on the main by the Phase undervoltage function (ANSI 27)
- or the detection of a fault by the protection units upstream of the main, with a tripping command on the "External tripping 1" logic input
- or V_TRANS_ON_FLT, initialization of transfer by logic equations or by Logipam.

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Automatic Transfer "Main-Tie-Main" Operation

Block Diagram



Closing a Normally Open Circuit Breaker

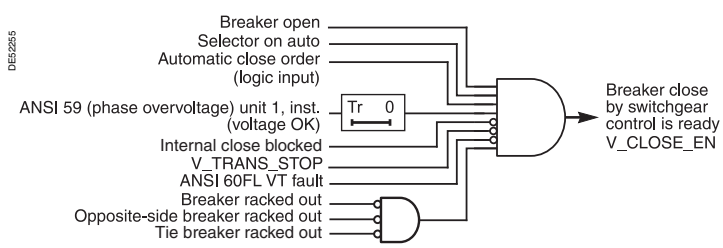
The following conditions must be met to close the normally open circuit breaker:

- the incoming circuit breaker is open
- no normally open circuit breaker block close conditions
- no remnant voltage on the bus (checking necessary when motors are connected to the bus)

If the normally open circuit breaker is the opposite side circuit breaker, the NO circuit breaker closing command is transmitted by a Sepam™ logic output to a logic input of the opposite side Sepam™ where it is evaluated by the Switchgear control function (see block diagram below).

If the normally open circuit breaker is the tie circuit breaker, the NO circuit breaker closing command is transmitted by a Sepam™ logic output to close the circuit breaker directly, without any intermediary.

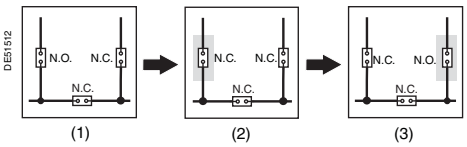
Block Diagram (Opposite Side Sepam™)



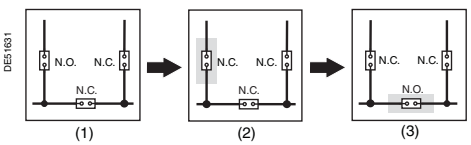
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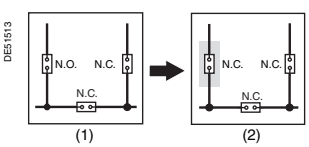
Automatic Transfer "Main-Tie-Main" Operation



Voluntary return to normal with normally closed tie
(1) Transferred condition
(2) Closed Transition
(3) Return to normal condition



Voluntary return to normal with normally open tie
(1) Transferred condition
(2) Closed transition
(3) Return to normal condition



Closing the Open Circuit Breaker
(1) One Main open
(2) Two Mains closed

Voluntary Return to Normal without Interruption

Description

The voluntary return to normal without interruption involves two separate control functions:

1 closing the open circuit breaker with or without sync-check. The three circuit breakers are closed
2 opening the normally open circuit breaker (designated by the "NO circuit breaker" selector).

These two functions may also be used to transfer the bus supply source without any interruption.

Mandatory Transfer Conditions

These conditions are required to enable transfer:

- the incoming circuit breaker is open
- the opposite side circuit breaker and the tie circuit breaker are closed
- The voltage is OK upstream of the incoming circuit breaker. This voltage is detected either by function ANSI 59, or by a processing operation in Logipam using V_TRANS_V_EN.

Optional Transfer Conditions

These conditions are required when the associated optional functions are enabled:

- the "Auto / Manual" selector is in the Manual position
- the three "Local / Remote" selectors are in the Local position
- the three circuit breakers are racked in
- no VT fault detected by the VT Supervision function (ANSI 60FL), to avoid transfer on the loss of voltage transformers
- no blocking of transfer by V_TRANS_STOP by logic equations or by Logipam.

Initializating the Return to Normal

- voluntary incoming circuit breaker close command.

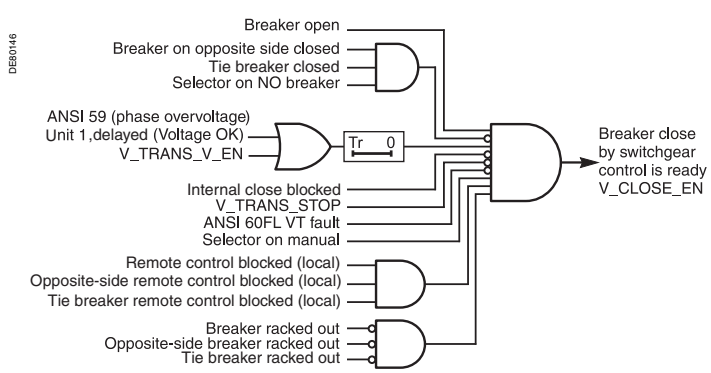
Closing the Open Circuit Breaker

Description

Circuit breaker closing is ensured by the Switchgear control function, with or without sync-check.

The AT function checks that all the required conditions are met and indicates to the user that the return to normal is possible.

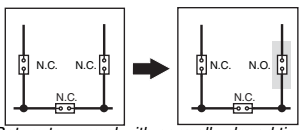
Block Diagram



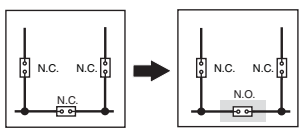
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DE51529



Return to normal with normally closed tie



Return to normal with normally open tie

DE51589

Opening the Normally Open Circuit Breaker

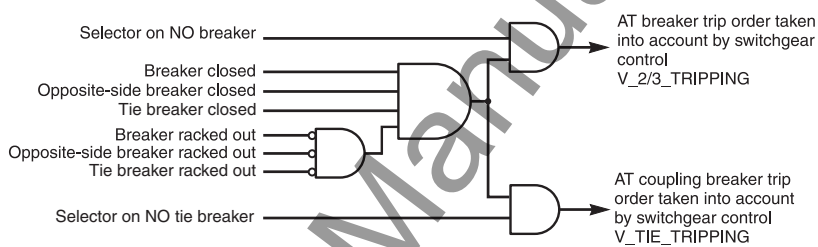
Description

This function controls the opening of the circuit breaker that is designated "normally open" by the position of the "NO circuit breaker" selector, when the three circuit breakers are closed.

For all automatic control sequences that put the two sources in parallel, it guarantees, that only two of the three circuit breakers are closed at the end of the transfer.

The open command is taken into account by the Switchgear control function.

Block Diagram



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Automatic Transfer "Main-Tie-Main" Operation

Closing Tie

Description

The voluntary closing of the tie circuit breaker without interruption involves two separate control functions:

1 closing the tie circuit breaker regardless of sync-check. The three circuit breakers are closed.

2 opening the normally open circuit breaker, designated by the "NO circuit breaker" selector.

Mandatory Transfer Conditions

These conditions are required to enable transfer:

- the opposite side voltage is OK
- the following conditions are not fulfilled simultaneously:
  - the main circuit breaker is closed
  - the opposite side circuit breaker is closed
  - the tie breaker is the normally open circuit breaker (NO tie).

Optional Transfer Conditions

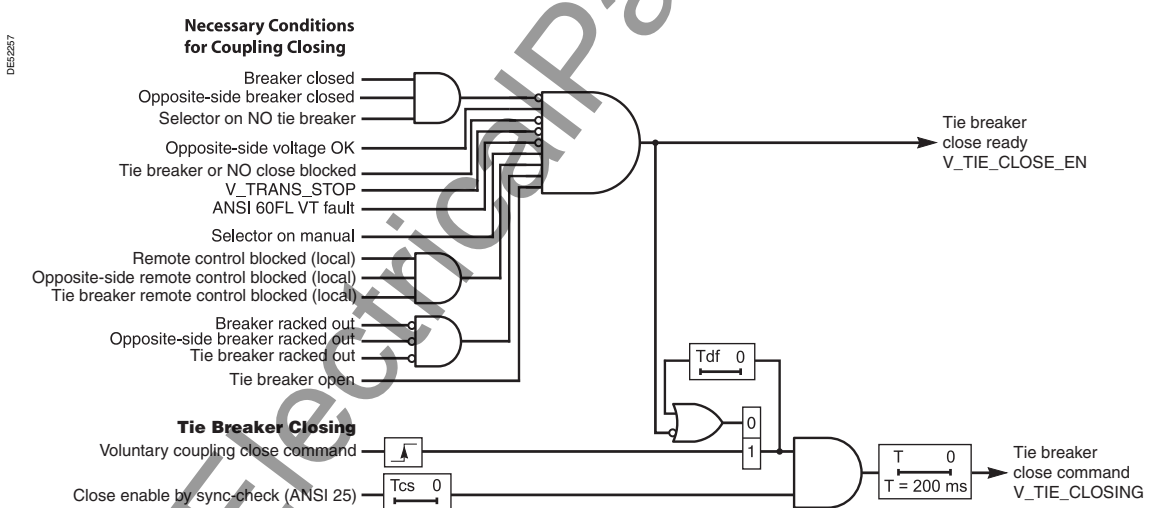
These conditions are required when the associated optional functions are enabled:

- the "Auto / Manual" selector is in the Manual position
- the three "Local / Remote" selectors are in the Local position
- the three circuit breakers are racked in
- no VT fault detected by the VT Supervision function (ANSI 60FL), to avoid transfer on the loss of voltage transformers
- no blocking transfer by V_TRANS_STOP by logic equations or by Logipam.

Initializing Tie Closing

Voluntary tie close command.

Block Diagram

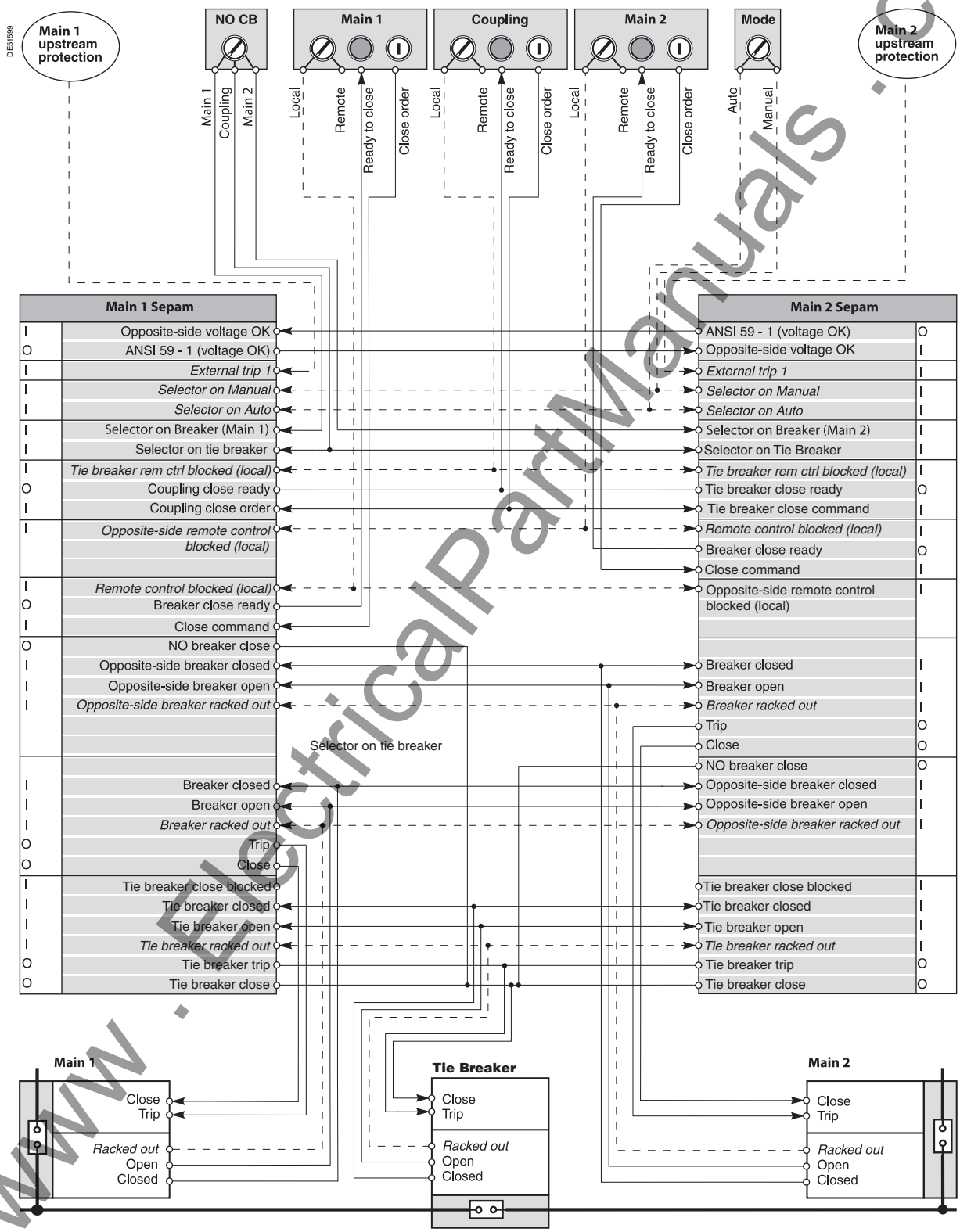


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Automatic Transfer "Main-Tie-Main" Implementation

Connection for Normally Open Tie

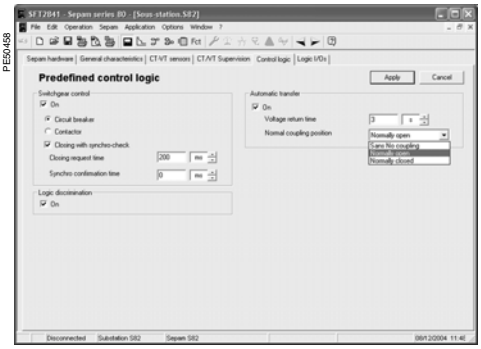


– – – – – – : optional wiring

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Automatic Transfer "Main-Tie-Main" Implementation



SFT2841: parameter setting of predefined control logic

Parameter Setting of Predefined Control Functions

The Automatic transfer function is set up at the same time as the Switchgear control function in the "Control logic" tab of the SFT2841 software.

Switchgear Control Function

- activation of the Switchgear control function
- activation of the Sync-check function if necessary.

Automatic Transfer Function

- activation of the Automatic transfer function and adjustment of associated parameters:
  - voltage return time Tr (typically 3 sec)
  - normal tie position: normally open or normally closed, according to the network operating mode.

VT Supervision Function

The VT supervision (ANSI 60FL) is to be activated if necessary.

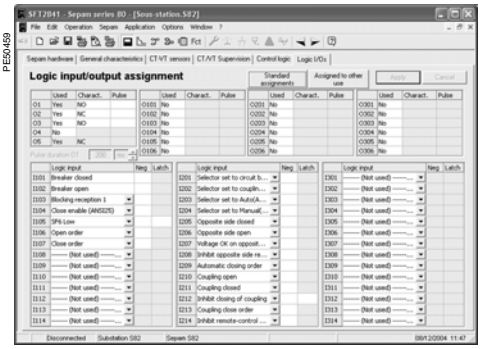
Protection Function Setting

Protection Functions	Use	Setting Information
Phase undervoltage (ANSI 27) Unit 1	Initialization of automatic transfer on detection of voltage loss.	Voltage set point: 60% V_{LL}Np Delay: 300 msec
Phase overcurrent (ANSI 50/51) Unit 1, instantaneous output	Detection of downstream phase fault, to block automatic transfer.	To be set according to coordination study (the most sensitive set point).
Ground fault (ANSI 50N/51N) Unit 1, instantaneous output	Detection of downstream ground fault, to block automatic transfer.	To be set according to coordination study (the most sensitive set point).
Phase overvoltage (ANSI 59) Unit 1	Detection of phase voltage upstream of the circuit breaker. To be assigned to a Sepam™ logic output in the control matrix.	Voltage set point: 90% V_{LL}Np Delay: 3 sec
Optional Protection Functions	**Use**	**Setting Information**
Remnant undervoltage (ANSI 27R) Unit 1	Detection of no remnant voltage on the bus to which the motors are connected.	Voltage set point: 30% V_{LL}Np Delay: 100 msec

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Automatic Transfer "Main-Tie-Main" Implementation



SFT2841: standard assignment of the inputs required for the AT function

Logic Input Assignment

The logic inputs required for the "AT" function are assigned in the SFT2841 "Logic I/Os" screen.

The "Standard assignments" button suggests an assignment of the main inputs required for the "AT" function. The other inputs are assigned manually.

Logic Output Assignment in the Control Matrix

The assignment of the logic outputs required for the AT function takes place in two steps:

1. declaring the required logic outputs "Used", indicating the control mode of each output, in the SFT2841 "Logic I/Os" screen
2. assigning each predefined output associated with the AT function to a Sepam™ logic output in the SFT2841 "Control matrix" screen.

The predefined outputs associated with the AT function are as follows:

"Protection" button	Description	Use
59 - 1	Delayed output of the Phase overvoltage function (ANSI 59) Unit 1	Indication for the opposite side Sepam™: voltage OK upstream of the incoming circuit breaker.
"Logic" button	**Description**	**Use**
NO circuit breaker closing	Predefined output V_CLOSE_NO_ORD of the AT function	Automatic closing command of normally open circuit breaker.
Tie closing	Predefined output V_TIE_CLOSING of the AT function	Tie close command.
Tie tripping	Predefined output V_TIE_OPENING of the AT function	Tie open command.
Breaker closing ready	Predefined output V_CLOSE_EN of the AT function	LED indication: the return to normal conditions are met. (neglecting the sync-check)
Tie closing ready	Predefined output V_TIE_CLOSE_EN of the AT function	LED indication: the tie close conditions are met. (neglecting the sync-check)

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Automatic Transfer "Main-Tie-Main" Characteristics

Setting				
Activity				
Setting range	On / Off			
Voltage Return Time				
Setting range	0 to 300 s			
Accuracy (1)	±2% or from –10 ms to +25 ms			
Resolution	10 ms or 1 digit			
Normal Tie Position				
Setting range	No tie / Normally open / Normally closed			
Inputs				
Designation	**Syntax**	**Equations**	**Logipam**	
Transfer command on fault	V_TRANS_ON_FLT	■	■	
Transfer off command	V_TRANS_STOP	■	■	
Voltage OK upstream of the incoming circuit breaker	V_TRANS _ V_EN		■	
Outputs				
Designation	**Syntax**	**Equations**	**Logipam**	**Matrix**
Automatic transfer on	V_TRANSF_ON		■	
Tripping by 2/3 or 1/2 logic	V_2/3_TRIPPING		■	■
Tripping by automatic transfer	V_AT_TRIPPING		■	■
NO circuit breaker closing	V_CLOSE_NO_ORD		■	■
Breaker closing ready	V_CLOSE_EN		■	■
Tie tripping	V_TIE_OPENING		■	■
Tie closing ready	V_TIE_CLOSE_EN		■	■
Tie closing	V_TIE_CLOSING		■	■
Tie closing with sync-check failed	V_TIESYNCFAIL		■	■

(1) *Under reference conditions (IEC 60255-6).*

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Local Indication
ANSI Code 30

Operation

Events may be displayed locally on the front panel of Sepam™ by:
- a message on the display
- switching on of one of the 9 yellow LEDs.

Message Type Indication

Predefined Messages

All messages connected to the standard Sepam™ functions are predefined and available in two language versions:
- in English, factory-set messages (not modifiable)
- in the local language, according to the version delivered.

The language version is chosen when Sepam™ parameters are set.

The messages are visible on the Sepam™ display and on the SFT2841 Alarms screen.
The number and type of predefined messages depend on the type of Sepam™. The table below gives the complete list of all predefined messages.

Functions			UK English	US English
Control and Monitoring	**ANSI Code**			
External trip (1 to 3)			EXT. TRIP (1 to 3)	EXTERNAL TRIP (1 to 3)
Buchholz trip			BUCHH/GAS TRIP	BUCHH/GAS TRIP
Buchholz alarm			BUCHHOLZ ALARM	BUCHHOLZ ALARM
Thermostat trip			THERMOS^T. TRIP	THERMOS^T. TRIP
Thermostat alarm			THERMOS^T. ALARM	THERMOS^T. ALARM
Pressure trip			PRESSURE TRIP	PRESSURE TRIP
Pressure alarm			PRESSURE ALARM	PRESSURE ALARM
Thermistor trip			THERMISTOR TRIP	THERMISTOR TRIP
Thermistor alarm			THERMISTOR AL.	THERMISTOR AL.
Control fault			CONTROL FAULT	CB CNTRL FAULT
Load shedding			LOAD SHEDDING	LOAD SHEDDING
Genset shutdown			GENSET SHUTDOWN	GENSET SHUTDOWN
De-excitation			DE-EXCITATION	DE-EXCITATION
Tripping command by automatic transfer			AUTO TRANSFER	AUTO TRANSFER
Diagnosis	**ANSI Code**			
SF6 fault			SF6 LOW	SF6 LOW
MET1482 No 1 RTD fault			RTD'S FAULT MET1 (1)	RTD'S FAULT NO. 1 (1)
MET1482 No 2 RTD fault			RTD'S FAULT MET2 (1)	RTD'S FAULT NO. 2 (1)
VT supervision	60FL	Phase VT supervision	VT FAULT	VT FAULT
		Residual VT supervision	VT FAULT Vo	VT FAULT Vr
CT supervision	60	Main CT supervision	CT FAULT	CT FAULT
		Additional CT supervision	CT' FAULT	CT' FAULT
Trip circuit supervision (TCS) fault or mismatching of open/closed position contacts	74		TRIP CIRCUIT	TRIP CKT FAULT
Closing circuit fault			CLOSE CIRCUIT	CLOSE CIRCUIT
Capacitor step matching fault			COMP. FLT. STP (1 to 4)	BANK. FLT. STP (1 to 4)
Cumulative breaking current monitoring			ΣI^2BREAKING >>	ΣI^2BREAKING >>
Battery monitoring			BATTERY LOW (1)	BATTERY LOW (1)
Auxiliary power supply monitoring		Low threshold	LOW POWER SUP.	LOW POWER SUP.
		High threshold	HIGH POWER SUP.	HIGH POWER SUP.

(1) *RTD FAULT, BATTERY LOW messages: refer to the maintenance chapter.*
(2) *With indication of the faulty phase.*
(3) *With indication of the faulty phase, when used with phase-to-neutral voltage.*

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Local Indication
ANSI Code 30

Functions			UK English	US English
Protection	**ANSI Code**			
Overspeed	12		OVERSPEED	OVERSPEED
Underspeed	14		UNDERSPEED	UNDERSPEED
Underimpedance	21B		UNDERIMPEDANCE	UNDERIMPEDANCE
Overexcitation (V/Hz)	24		OVER-FLUXING	OVER EXCITATION
Sync-check	25	Sync-checked close request in process	SYNC.IN PROCESS	SYNC.IN PROCESS
		Sync-checked close request successful	SYNC. OK	SYNC. OK
		Closing failed, out-of-sync	SYNC. FAILURE	SYNC. FAILURE
		Closing failed, out-of-sync, cause dU	SYNC. FAILED dU	SYNC. FAILED dV
		Closing failed, out-of-sync, cause dPHI	SYNC. FAILED dPhi	SYNC. FAILED dPhi
		Closing failed, out-of-sync, cause dF	SYNC. FAILED dF	SYNC. FAILED df
		Stop closing with sync-check	STOP SYNC.	STOP SYNC.
		Tie closing with sync-check failed	TIE SYNC. FAILED	TIE SYNC. FAILED
Undervoltage	27		UNDERVOLTAGE (1)	UNDERVOLTAGE (1)
Positive sequence undervoltage	27D	Positive sequence undervoltage	UNDERVOLTAGE.PS	UNDERVOLTAGE.PS
		Reverse rotation	ROTATION -	REV ROTATION -
Third harmonic undervoltage	27TN/64G2		100% STATOR	100% STATOR GROUND
Active overpower	32P		OVER P	OVER POWER
Reactive overpower	32Q		OVER Q	EXCESS OVER VAR
Phase undercurrent	37		UNDER CURRENT	UNDERCURRENT
Phase underpower	37P		UNDER POWER	UNDER POWER
Temperature monitoring	38/49T	Alarm	OVER TEMP. ALM	OVER TEMP. ALM
		Tripping	OVER TEMP. TRIP	OVER TEMP. TRIP
Field loss	40		FIELD LOSS	LOSS OF FIELD
Negative sequence / unbalance	46		UNBALANCE I	CURRENT UNBAL
Negative sequence overvoltage	47		UNBALANCE U	VOLTAGE UNBAL
Excessive starting time, locked rotor	48/51LR	Excessive starting time	LONG START	LONG START
		Locked rotor in normal operation	ROTOR BLOCKING	JAMMED / STALL
		Locked rotor on start	LOCKED ROT^{OR}	ST^{RT} LOCKED ROT^{R}
Thermal overload	49RMS	Alarm	THERMAL ALARM	THERMAL ALARM
		Tripping	THERMAL TRIP	THERMAL TRIP
		Block closing	START INHIBIT	BLOCKED START
Breaker failure	50BF		BREAKER FAILURE	BREAKER FAILURE
Inadvertent energization	50/27		INADV. ENERGIZ.	INADV. ENERGIZ.
Phase overcurrent	50/51		PHASE FAULT (2)	PHASE FAULT (2)
Ground fault	50N/51N		EARTH FAULT	GROUND FAULT
Voltage-restrained overcurrent	50V/51V		O/C V REST (2)	O/C V REST (2)
Capacitor bank unbalance	51C		UNBAL. STP (1 to 4)	UNBAL. STEP (1 to 4)
Overvoltage	59		OVERVOLTAGE (1)	OVERVOLTAGE (1)
Neutral voltage displacement	59N		Vo FAULT	Vr FAULT
Restricted ground fault	64REF		RESTRIC. EARTH FAULT	RESTRIC. GROUND FAULT
Starts per hour	66		START INHIBIT	BLOCKED START
Directional phase overcurrent	67		DIR. PHASE FAULT (2)	DIR. PHASE FAULT (2)
Directional ground fault	67N/67NC		DIR. EARTH FAULT	DIR. GROUND FAULT
Pole slip	78PS		POLE SLIP	POLE SLIP
Recloser	79	Cycle x	CYCLE (1 to 4) (3)	SHOT (1 to 4) (3)
		Reclosing successful	CLEARED FAULT	CLEARED FAULT
		Permanent trip	FINAL TRIP	FINAL TRIP
Overfrequency	81H		OVER FREQ.	OVER FREQ.
Underfrequency	81L		UNDER FREQ.	UNDER FREQ.
Rate of change of frequency	81R		ROCOF	df/dt
Machine differential	87M		DIFFERENTIAL	DIFFERENTIAL
Transformer differential	87T		DIFFERENTIAL	DIFFERENTIAL

(1) *With indication of the faulty phase, when used with phase-to-neutral voltage.*
(2) *With indication of the faulty phase.*
(3) *With indication of the protection unit that has initiated the cycle (phase fault, ground fault, ...).*

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Personalized User Messages

An additional 100 messages can be created using the SFT2841 software. The user can link a message to a logic input, to the result of a logic equation, or to replace a predefined message by a user message.

User Message Editor in SFT2841

A user message editor is included in the SFT2841 software and can be accessed from the control matrix screen while in the connected or disconnected mode. To access the message editor follow these steps:

1 display the "Event" tab on the screen: the user messages appear
2 double-click on one of the messages displayed to activate the user message editor.

User Message Editor Functions

The Message Editor allows the user to perform the following tasks:

- create and modify user messages in US English or the local language
  - by text input or importing of an existing bitmap file (*.bmp) or by point to point drawing
- delete user messages
- assign predefined or user messages to an event defined in the control matrix:
  - from the control matrix screen, "Events" tab, double-click on the event to be linked to a new message
  - select the new predefined or user message from the messages presented
  - "assign" it to the event.

The same message may be assigned to several events, with no limitations.

Message Display in SFT2841

- The predefined messages are stored in Sepam™'s memory and are displayed in connected mode. In disconnected mode, the last messages stored in Sepam™ connected mode are displayed.
- The user messages are saved with the other Sepam™ parameters and protection settings and are displayed in connected and disconnected modes.

Message Processing on the Sepam™ Display

When an event occurs, the related message appears on the Sepam™ display.

The user presses the **clear** key to clear the message and enable normal consultation of all the display.

The user must press the reset key to acknowledge latched events (e.g. protection outputs).

The list of messages remains accessible in the alarm history (⚠ key), in which the last 16 messages are stored. The last 250 messages may be consulted with the SFT2841 software.

To delete the messages stored in the alarm history:

- display the alarm history on the display
- press the **clear** key.

LED Indication

The 9 yellow LEDs on the front of Sepam™ are assigned by default to the following events:

LED	Event	Name on Label on Front Panel
LED 1	Trip protection 50/51 unit 1	I>51
LED 2	Trip protection 50/51 unit 2	I>>51
LED 3	Trip protection 50N/51N unit 1	Io > 51N
LED 4	Trip protection 50N/51N unit 2	Io >> 51N
LED 5		Ext
LED 6		
LED 7	Circuit breaker open (Ia02)	0 Off
LED 8	Circuit breaker closed (Ia01)	I On
LED 9	Trip by circuit breaker control	Trip

The default parameter setting can be personalized using the SFT2841 software. LEDs are assigned to events in the "LEDs" tab of the control matrix screen. Editing and printing of personalized labels are proposed in the general characteristics screen.

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Local Control


PE50486

Local control using the mimic-based UMI

Description

Switchgear can be controlled locally using Sepam™ Series 80 units equipped with the mimic-based UMI. The control functions available are:

- selecting the Sepam™ control mode
- viewing device status on the animated mimic diagram
- local control of the opening and closing of all Sepam™ controlled devices

Selecting the Sepam™ Control Mode

A key-switch on the front of the mimic-based UMI is used to select the Sepam™ control mode. Three modes are available: Remote, Local, or Test.

In **Remote** mode, remote control commands are taken into account. Local control commands are disabled, with the exception of the circuit breaker open command. Remote mode is indicated by the variable V_MIMIC_REMOTE = 1.

In **Local** mode, remote control commands are disabled, with the exception of the circuit breaker open command. Local control commands are enabled. Local mode is indicated by the variable V_MIMIC_LOCAL = 1.

Test mode should be selected for tests on equipment, as in during preventive maintenance operations. All functions enabled in Local mode are available in Test mode. No time-tagged events are sent by the communication link. Test mode is indicated by the variable V_MIMIC_TEST = 1.

The Logipam programming software can be used to customize control-mode processing.

Mimic Diagram and Symbols

A mimic diagram or single-line diagram is a simplified diagram of an electrical installation. It is made up of a fixed background on which symbols and measurements are placed.

The mimic diagram editor integrated in the SFT2841 software can be used to personalize and setup mimic diagrams.

The symbols that make up the mimic-diagram constitute the interface between the mimic-based UMI and the other Sepam™ control functions.

There are three types of symbols:

- **fixed symbol**: represents the electrotechnical devices that are neither animated or controlled, e.g. a transformer
- **animated symbol** with one or two inputs: represents the electrotechnical devices that change on the mimic diagram, depending on the symbol inputs, but cannot be controlled via the Sepam™ mimic-based UMI.
  This type of symbol is used for switch-disconnectors without remote control, for example.
- **controlled symbol** with one or two inputs/outputs: represents the electrotechnical devices that change on the mimic diagram, depending on the symbol inputs, and can be controlled via the Sepam™ mimic-based UMI.

  This type of symbol is used for circuit breakers, for example. The symbol outputs are used to control the electrotechnical device:
  - directly via the Sepam™ logic outputs
  - by the switchgear control function
  - by logic equations or the Logipam program.

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Symbol Animation

Symbols change, depending on the value of their inputs. A graphic symbol represents each state. Animation occurs automatically by changing the symbol each time the state changes.

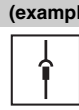
The symbol inputs must be assigned directly to the Sepam™ inputs to indicate the position of the symbolized switchgear.

Animated Symbols with One Input

"Animated -1 input" and "Controlled -1 input/output" symbols are animated symbols with one input. The value of the input determines the state of the symbol:

- input set to 0 = inactive
- input set to 1 = active

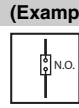
This type of symbol is used for simple presentation of information, for example the racked out position of a circuit breaker.

Symbol Inputs	Symbol State	Graphic Representation (example)
Input = 0	Inactive	
Input = 1	Active	

Animated Symbols with Two Inputs

"Animated - 2 inputs" and "Controlled - 2 inputs/outputs" symbols are animated symbols with two inputs, one open and the other closed. This is the most common situation in representing switchgear positions.

The symbol has three states,or graphic representations: open, closed, and unknown. The latter occurs when the inputs are not matched. In this case it is impossible to determine the position of the switchgear.

Symbol Inputs	Symbol State	Graphic Representation (Example)
Input 1 (open) = 1 Input 2 (closed) = 0	Open	
Input 1 (open) = 0 Input 2 (closed) = 1	Closed	
Input 1 (open) = 0 Input 2 (closed) = 0	Unknown	
Input 1 (open) = 1 Input 2 (closed) = 1	Unknown	

Local Control Using a Symbol

"Controlled - 1 input/output" and "Controlled - 2 inputs/outputs" symbols are used to control the switchgear corresponding to the symbol via the Sepam™ mimic-based UMI.

Control Symbols with Two Outputs

"Controlled - 2 inputs/outputs" symbols have two control outputs for opening and closing of the symbolized device. An command on the mimic-based UMI sends a 300 ms pulse on the controlled output.

Control Symbols with One Output

"Controlled - 1 input/output" symbols have one control output. The output remains in the last state to which it was commanded. A new command results in a change in the output state.

Blocking Commands

"Controlled - 1 input/output" and "Controlled - 2 inputs/outputs" symbols have two block inputs that, when set to 1, block opening and closing commands. This makes it possible to create interlocking systems or other command-disabling systems that are taken into account by the UMI.

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Symbol Inputs/Outputs

Depending on the desired operation of the mimic-based UMI, Sepam™ variables must be assigned to the inputs of animated symbols and the inputs/outputs of controlled symbols.

Sepam™ Variables Assigned to Symbol Inputs

Sepam™ Variables		Name	Use
Logic inputs		Ixxx	Symbol animation directly based on device positions
Outputs of predefined functions	Switchgear control	V_BLOCK_CLOSE	Circuit-breaker operation disabled
	Position of key on the front panel of Sepam™	V_MIMIC_LOCAL, V_MIMIC_REMOTE, V_MIMIC_TEST	■ Representation of key position ■ Operation disabled depending on the control mode
	Logic equations or Logipam program	V_MIMIC_IN_1 to V_MIMIC_IN_16	■ Representation of Sepam™ internal status conditions ■ Cases where operation is disabled

Sepam™ Variables to be Assigned to Symbol Outputs

Sepam™ Variables		Name	Use
Logic outputs		Oxxx	Direct control of devices
Inputs of predefined functions	Switchgear control	V_MIMIC_CLOSE_CB V_MIMIC_OPEN_CB	Circuit-breaker control using the switchgear-control function via the mimic-based UMI
	Logic equations or Logipam program	V_MIMIC_OUT1 to V_MIMIC_OUT16	Command processing by logic functions: interlocking, command sequence, etc.

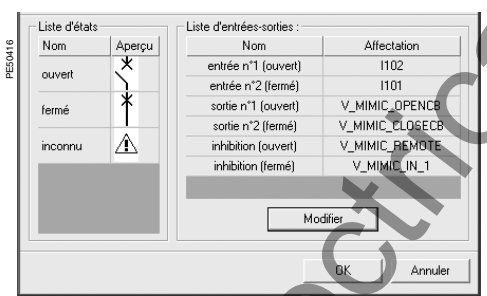
Block Diagram

The block diagrams below present the functions ensured by the controlled symbols, based on two examples.

Voluntary user control commands (selection of the device to be controlled in the mimic diagram and action on a control key) are represented in the block diagrams by the following icons:

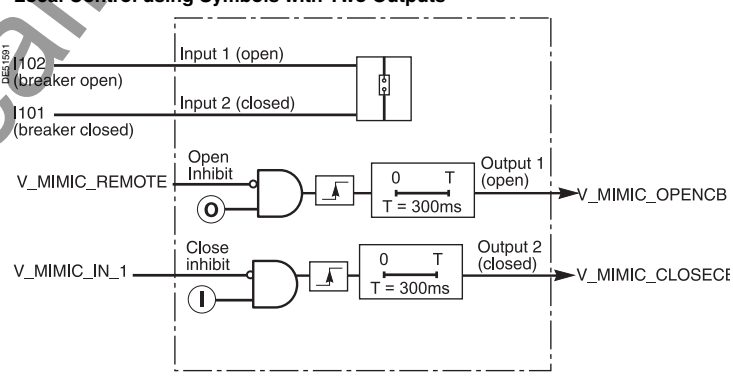
(O) : open command

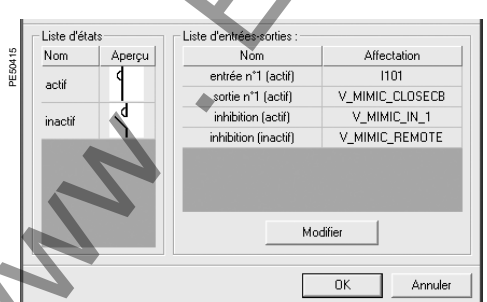
(I) : close command



SFT2841: example of the logic input / output assignment of a symbol with two outputs.

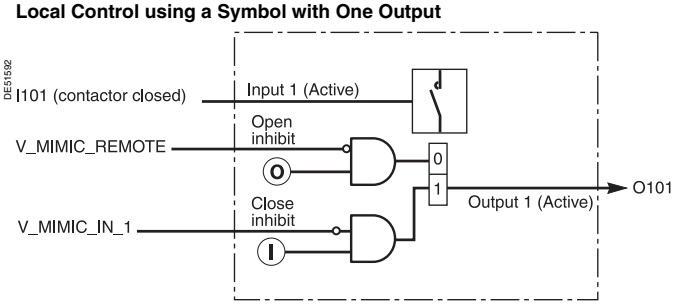
Local Control using Symbols with Two Outputs





SFT2841: example of the logic input / output assignment of a symbol with one output.

Local Control using a Symbol with One Output



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Control Matrix

Description

The control matrix is used for assigning the logic outputs and LEDs to data produced by the protection functions, control logic, and logic inputs.

Each column creates a logic OR between all the lines selected. The matrix can also be used to display the alarms associated with the data. It guarantees the consistency of the parameter setting with the predefined functions.

The following data are managed in the control matrix and can be set using the SFT2841 software tool.

Control Matrix Inputs

"Protection" Button	Meaning	Comments
All application protection functions	Protection tripping output and additional outputs when applicable	
"Inputs" Button		
Logic inputs I101 to I114	According to configuration	If first MES120 module is configured
Logic inputs I201 to I214	According to configuration	If second MES120 module is configured
Logic inputs I301 to I314	According to configuration	If third MES120 module is configured
"Equations" Button	**Meaning**	**Comments**
V1 to V20	Logic equation editor outputs	
"Logipam" Button	**Meaning**	**Comments**
MAT001 to MAT128	Logipam output variables to the control matrix	Only the variables actually used in the Logipam program are displayed
"Logic" Button	**Meaning**	**Comments**
Switchgear Control		
Closing	Closing by switchgear control function	By default on O3. Only available if switchgear control is in circuit breaker mode
Tripping	Tripping by switchgear control function	Forced on O1, if switchgear control is in circuit breaker mode
Block closing	Block by switchgear control function	By default on O2. Only available if switchgear control is in circuit breaker mode
Contactor control	Contactor control	Forced on O1, if switchgear control is in circuit breaker mode
Pick-up	Logic OR of the instantaneous output of all protection units with the exception of protection units 38/49T, 48/51LR, 49 RMS, 64G2/27TN, 66.	
Drop-out	A protection unit time delay counter has not yet gone back to 0.	
Zone Selective Interlocking		
Zone selective Interlocking trip	Tripping command sent by zone selective interlocking function	Only when zone selective interlocking function is used without switchgear control function
Blocking send 1	Sending of blocking signal to next Sepam™ in zone selective interlocking chain 1	By default on O102.
Blocking send 2	Sending of blocking signal to next Sepam™ in zone selective interlocking chain 2	By default on O103
Motor/Generator Control		
Load shedding	Sending of a load shedding command	Motor application
Genset shutdown	Sending of a prime mover shutdown command	Generator application
De-excitation	Sending of a de-excitation command	Generator application
Recloser		
Recloser in service	The recloser is in service	
Reclosing successful	The recloser has successfuly reclosed	Pulse type output
Permanent trip	The circuit breaker is permanently open after the reclosing cycles	Pulse type output
Recloser ready	The recloser is ready to operate	
Recloser step 1	Step 1 in progress	
Recloser step 2	Step 2 in progress	
Recloser step 3	Step 3 in progress	
Recloser step 4	Step 4 in progress	
Closing by recloser	A closing command is given by the recloser	

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Control Matrix

"Logic" Button	Meaning	
Diagnosis		
TCS fault	Trip circuit fault	
CCS fault	Closing circuit fault	
TC / breaker position discrepancy	Discrepancy between the last state commanded by the remote monitoring and control system and the position of the circuit breaker	
Breaker monitoring	A circuit breaker or contactor open or close command has not been executed	
Reverse phase rotation	Reverse voltage rotation due to a wiring error	
Additional-phase reverse rotation	Reverse rotation of additional phase voltages due to a wiring error	
Disturbance recording blocked	Disturbance recording blocked	
Cumulative breaking current monitoring	Overshooting of the cumulative breaking current set point	
Low auxiliary voltage threshold	The auxiliary voltage is below the low threshold	
High auxiliary voltage threshold	The auxiliary voltage is above the high threshold	
Low battery fault	Battery low or absent	
MET1482 No 1 fault MET1482 No 2 fault	Hardware problem on an MET 1482 module (module 1 or 2) or on an RTD	
Watchdog	Monitoring of Sepam™ operation	Always on O5 if used
CT Supervision		
Main CT fault	I current input CT fault	
Additional CT fault	I' current input CT fault	
VT Supervision		
Main VT fault, phase channel	V voltage input phase VT fault	
Main VT fault, residual channel	Vr voltage input residual VT fault	
Additional VT fault, phase channel	V' voltage input phase VT fault	
Additional VT fault, residual channel	V'r voltage input residual VT fault	
Sync-Check		
Closing with sync-check	Circuit breaker close request with sync-check by the ANSI 25 function has been initiated	Switchgear control with sync-check function
Closing with sync-check completed	Breaker closing with sync-check by the ANSI 25 function successful	Switchgear control with sync-check function
Closing failed, out-of-sync	Synchronism conditions too short to enable breaker closing	Switchgear control with sync-check function
Closing failed, out-of-sync, cause dU	Breaker closing blocked because sources are out-of-sync due to an excessive voltage difference	Switchgear control with sync-check function
Closing failed, out-of-sync, cause dPHI	Breaker closing blocked because sources are out-of-sync due to an excessive phase difference	Switchgear control with sync-check function
Closing failed, out-of-sync, cause dF	Breaker closing blocked because sources are out-of-sync due to an excessive frequency difference	Switchgear control with sync-check function
Stop closing with sync-check	A sync-checked circuit breaker close request has been interrupted	Switchgear control with sync-check function
Automatic Transfer		
Tie closing with sync-check failed	The tie close request initiated by automatic transfer has failed because the sources are out-of-sync	
Tripping by automatic transfer	Breaker tripping initiated by automatic transfer (tripping is performed by the switchgear control function)	
Tripping by 2/3 or 1/2 logic	Breaker tripping initiated by 2/3 or 1/2 logic (tripping is performed by the switchgear control function)	
NO circuit breaker closing	Normally open circuit breaker close command for automatic transfer function	
Breaker closing ready	Indication that breaker closing is possible to return to normal operation	
Tie closing	Tie closing command for automatic transfer function	
Tie closing ready	Indication that tie breaker closing is possible to return to normal operation	
Tie Breaker tripping	Tie tripping command for automatic transfer function	
Control of Capacitor Banks		
Tripping of capacitor step x	Capacitor step x tripping output	
Closing of capacitor step x	Capacitor step x closing output	
Capacitor step x position fault	Capacitor step x positions mismatched	
Automatic capacitor step control	Capacitor steps in automatic control mode	
Manual capacitor step control	Capacitor steps in manual control mode	

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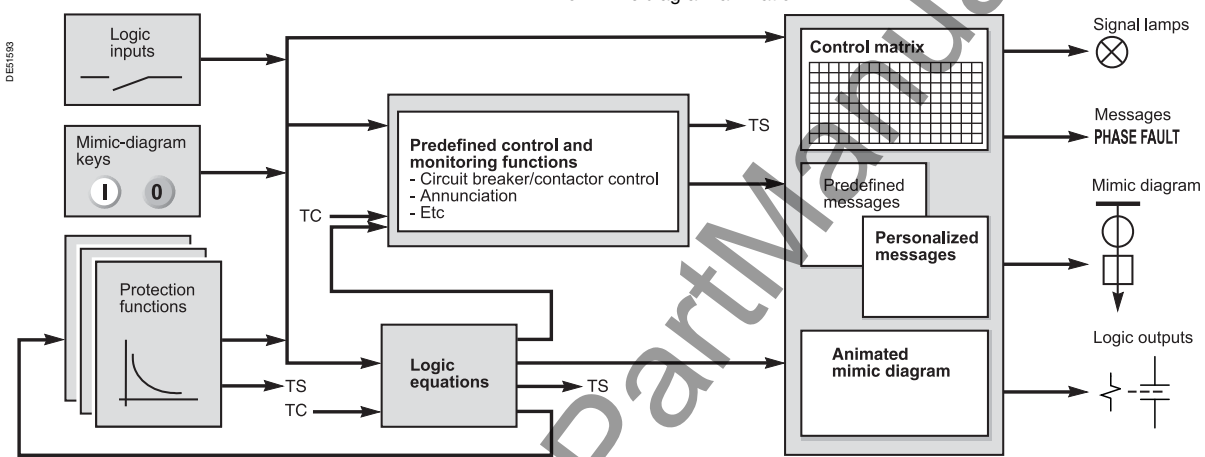
Logic Equations

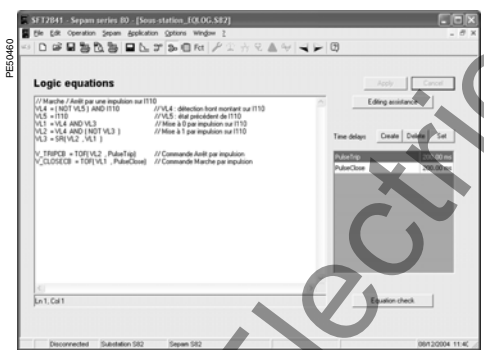
Adaptation of the predefined control and monitoring functions by the addition of simple logic functions.

Use

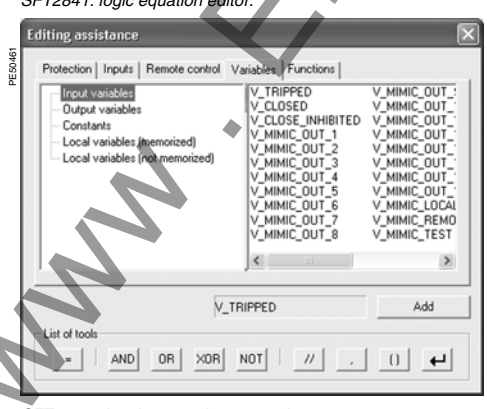
This function can be used to configure simple logic functions by combining data received from the protection functions, logic inputs, remote control commands, or the mimic-based UMI.
By using logic operators (AND, OR, XOR, NOT) and timers, new processing operations and indications may be added to the existing ones.
The logic functions produce outputs that can be used:

- in the matrix to control output relays, switch on a LED, or display new messages
- in the protection functions to create, for example, new block or reset conditions
- in the main predefined control and monitoring functions to complete processing operations or add new cases of tripping or genset shutdown, for example
- for mimic diagram animation.





SFT2841: logic equation editor.



SFT2841: data input assistance tool.

Logic Function Configuration

Logic functions are entered in text format in the SFT2841 equation editor. Each line includes a logic operation, the result of which is assigned to a variable.

Example:

Va = P5051_2_3 OR Ia02.

The variable Va is assigned the result of the logic OR operation involving the value from protection function 50/51 and logic input Ia02. The variables may be used for other operations or as outputs to produce actions in the control matrix, protection functions or predefined control and monitoring functions.

A program is a series of lines executed sequentially every 14 ms. A data input assistance tool provides quick access to each equation editor operator and variables.

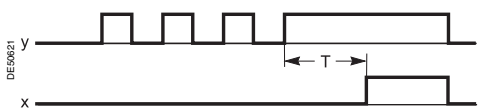
Description of Operations

Operators

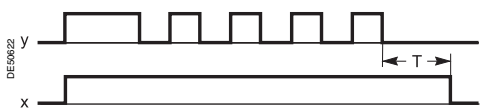
- **=**: assignment of a result
  Vb = VL3 //Vb is assigned the value of VL3
- **NOT**: logic inversion
  VL1 = NOT VL2 // VL1 is assigned the opposite logic state of VL2
- **OR**: logic OR
  Va = VL3 OR I103 // Va is assigned state 1 if VL3 or I103 are in state 1
- **AND**: logic AND
  VV3 = VL2 AND VVa // VV3 is assigned state 1 if VL2 and VV1 are in state 1
- **XOR**: exclusive OR
  V3 = VL1 XOR VL2 // V3 is assigned state 1 if only one of the variables VL1 or VL2 is in state 1.
  This is equivalent to **V3 = (Va AND (NOT Vb)) OR (Vb AND (NOT Va))**
- **//**: commentary
  The characters on the right are not processed
- **(,)**: the operations may be grouped between brackets to indicate the order in which they are carried out
  V1 = (VL3 OR VL2) AND I213.

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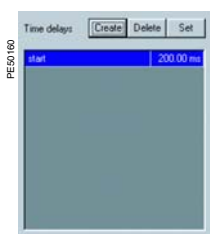
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*x = **TON**(y, t).*



*x = **TOF**(y, t).*



SFT2841: timer editor.

Functions

- x = **SR**(y, z): bistable with priority to Set
  x is set to 1 when y is equal to 1
  x is set to 0 when z is equal to 1 (and y is equal to 0)
  otherwise x is not changed.

V1 = SR(I104, I105) // I104 sets V1 to 1, I105 sets V1 to 0

- **LATCH**(x, y, …): latching of variables x, y, ...

The variables are maintained constantly at "1" after being initially set. They are reset to "0" when Sepam™ is reset (reset button, external input or remote control command).

The LATCH function accepts as many parameters as the number of variables that the user wishes to latch. It applies to the entire program, whatever the position of LATCH in the program. For easier reading, it is advisable to put it at the beginning of the program.

LATCH(V1, VL2, VV3) // V1, VL2 and VV3 are latched. Once they are set to 1, only a Sepam™ reset can set them back to 0

- x = **TON**(y, t): "on" delay timer

The variable x goes to 1 t ms after variable y goes to 1.

V1 = TON(I102.2000) // used to filter input I102 which must be present for // 2 s to be taken into account in V1

- x = **TOF**(y, t) : "off" delay timer.

The variable x goes to 0 t ms after variable y goes to 0).

VL2 = TOF(VL1, 100) // VL2 stays at 1 for 100 ms after VL1 // goes back to 0

- x = **PULSE**(s, i, n): time-tagger

Used to generate n periodic pulses, separated by an interval i as of the starting time s
s is expressed in hours:minutes:seconds
i is expressed in hours:minutes:seconds
n is a whole number (n = -1: repeated until the end of the day).

V1 = PULSE (8:30:00, 1:0:0, 4) will generate 4 pulses at 1-hour intervals at 8 h 30, 9 h 30, 10 h 30 and 11 h 30. This will be repeated every 24 hours.
The pulses last for a 14 ms cycle. V1 is assigned the value of 1 during the cycle.
If necessary, V1 may be extended using the **TOF, SR** or **LATCH** functions.

Timer values

A timer editor is used to give a name and value to each timer. The name may then be used in the **TON** and **TOF** functions. The timer value may therefore be adjusted without changing the program content.

V1 = TON (VL1, start) // start set to 200 ms in the timer editor.

Maximum number of functions

The number of time delays (**TON**, **TOF**) and pulse commands (**PULSE**) is globalized and may not be more than 16.

There is no limitation for the **SR** and **LATCH** functions.

Description of Variables

- **input variables**: come from the protection functions, logic inputs or predefined control functions. They may only appear on the right of the = sign
- **output variables**: produced by the equation editor to generate actions in the matrix, protection functions or predefined control functions
- **local variables**: intended for intermediary calculations and are not available outside the logic equation editor.

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Logic Equations

Input vVariables		
Type	**Syntax**	**Example / Meaning**
Logic inputs	Ixxx	I101: input 1 of MES120 No 1 module I312 : input 12 of MES120 No 3 module
Protection function outputs	Pnnnn_x_y nnnn: ANSI code x: unit y: data	P50/51_2_1 : Protection 50/51, unit 2, delayed output. The protection function output data numbers are given in the characteristics of each function and may be accessed using the data input assistance tool.
Remote control commands	TC1 to TC64	Pulse type value (duration of one 14 ms cycle) of remote control commands received
Predefined control function outputs	V_TRIPPED	Tripping command present at switchgear control function output
	V_BLOCK_CLOSE	Block closing command present at switchgear control function output
	V_CLOSED	Closing command present at switchgear control function output
Mimic-based UMI outputs	V_MIMIC_OUT_1 to V_MIMIC_OUT_16	Variables that may be assigned to the mimic diagram symbol outputs and that change values when control commands are transmitted from the mimic-based UMI
	V_MIMIC_LOCAL V_MIMIC_TEST, V_MIMIC_REMOTE	Position of the key on the mimic-based UMI
Output Variables		
Type	**Syntax**	**Example / Meaning**
Outputs to matrix	V1 to V20	They may initiate LEDs, logic outputs or messages in the matrix.
Protection function inputs	Pnnnn_x_y nnn: ANSI code x: unit y: data	P50N/51N_6_113: Protection 50N/51N, unit 6, block command. The protection function output data numbers are given in the characteristics of each function and may be accessed using the data input assistance tool.
Predefined control function inputs	V_TRIPCB	Tripping of circuit breaker (contactor) by the switchgear control function. Used to adapt tripping and recloser activation conditions.
	V_BLOCKCLOSE	Block circuit breaker (contactor) closing by the switchgear control function. Used to add circuit breaker (contactor) block closing conditions.
	V_CLOSECB	Closing of circuit breaker (contactor) by the switchgear control function. Used to generate a circuit breaker (contactor) close command based on a particular condition.
	V_SHUTDOWN	Shutdown of genset prime mover. Used to adapt cases of genset shutdown
	V_DE_EXCITATION	Generator de-excitation Used to adapt cases requiring generator de-excitation
	V_FLAGREC	Data saved in disturbance recording. Used to save a specific logic state in addition to those already present in disturbance recording.
	V_RESET	Sepam™ reset
	V_CLEAR	Clearing of alarms present
	V_BLOCK_RESET_LOCAL	Block Sepam™ reset by UMI Reset key.
	V_CLOSE_NOCTRL	Breaking device closing enabled without sync-check. Used to adapt the Switchgear control function
	V_TRIP_STP1 to V_TRIP_STP4	Tripping of capacitor steps 1 to 4. Used to adapt the Capacitor step control function
	V_CLOSE_STP1 to V_CLOSE_STP4	Closing of capacitor steps 1 to 4. Used to adapt the Capacitor step control function
	V_TRANS_ON_FLT	Automatic transfer command on fault. Used to adapt automatic transfer
	V_TRANS_STOP	Stopping automatic transfer Used to adapt automatic transfer
Local Variables, Constants		
Type	**Syntax**	**Example / Meaning**
Local variables stored	VL1 to VL31	The values of these variables are saved in the event of an auxiliary power outage and are restored when Sepam™ starts again.
Local variables not stored	VV1 to VV31	The values of these variables are not saved in the event of an auxiliary power outage. They are assigned the value of 0 when Sepam™ starts.
Constants	K_1, K_0	Value not modifiable K_1: always 1 K_0 : always 0

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Processing in the Event of Auxiliary Power Outage
All the variables, with the exception of the variables VVx, are saved in the event of a Sepam™ auxiliary power outage. The states of the variables are restored when the power is recovered, allowing the states produced by **LATCH**, **SR** or **PULSE** type memory operators to be saved.

Special Cases

- brackets must be used in expressions that comprise different **OR, AND, XOR or NOT** operators:
  - **V1 = VL1 AND I102 OR P27/27S_1_1. //** expression incorrect
  - **V1 = (VL1 AND I102) OR P27/27S_1_1. //** expression correct
  - **V1 = VL1 OR I102 OR P27/27S_1_1. //** expression correct
- protection input/output variables (Pnnn_x_y) may not be used in the **LATCH** function
- function parameters may not be expressions:
  - **VL3 = TON ((V1 AND V3), 300) //** expression incorrect
  - VL4 = V1 AND V3
  - **VL3 = TON (VL4, 300) //** correct.

Use Limit
The number of operators and functions **(OR, AND, XOR, NOT, =, TON, TOF, SR, PULSE** is limited to 200.

Examples of Applications

The following are some application examples.

1 ***Latching the recloser permanent trip signal***. By default, this signal is of the pulse type at the recloser output. If required by operating conditions, it may be latched as follows:
LATCH (V1) // V1 may be latched
V1 = P79_1_204 // recloser "permanent trip" output.
V1 may then control a LED or output relay in the matrix.

2 ***Latching an LED without latching the protection function***. Certain operating conditions call for the latching of indications on the front panel of Sepam™, without latching of the tripping output O1.
LATCH (V1, V2) // V1 and V2 may be latched
V1 = P50/51_1_1 OR P50/51_3_1 // tripping, units 1 and 3 of protection 50/51
V2 = P50/51_2_1 OR P50/51_4_1 // tripping, units 2 and 4 of protection 50/51
V1 and V2 must be configured in the matrix to control 2 front panel LEDs.

3 ***Circuit breaker tripping if input I113 is present for more than 300 ms***.
V_TRIPCB = TON (I113, 300).

4 ***Live line work (example 1).*** If work is underway with power on (indicated by input I205), the relay behavior is to be changed as follows:
a) circuit breaker tripping by the instantaneous output of protection 50/51 unit 1 or 50N/51N unit 1 AND if input I205 is present:
V_TRIPCB = (P50/51_1_1 OR P50N/51N_1_1) AND I205
b) Block recloser:
P79_1_113 = I205

5 ***Live line work (example 2).*** The user wishes to block protection functions 50N/51N and 46 by an input I204:
P50N/51N_1_113 = I204
P46_1_113 = I204

6 ***Validation of a 50N/51N protection function by logic input I210.*** A 50N/51N protection function with a very low threshold must only initiate tripping of the circuit breaker if it is validated by an input. The input comes from a relay which gives a very accurate measurement of the neutral point current:
V_TRIPCB = P50N/51N_1_3 AND I210

7 ***Block circuit breaker closing if thermal alarm thresholds are overrun.*** The temperature protection function 38/49T supplies 16 alarm bits. If one of the first three bits is activated (1 state), the user wishes to block circuit breaker closing
V_BLOCKCLOSE = P38/49T_1_10 OR P38/49T_2_10 OR P38/49T_3_10

8 Remote control command to block protection 50/51 unit 1.
VL1=SR(TC63,TC64) // TC63 set block, TC64 reset blocking
P50/51_1_113 = VL1 // VL1 is stored in the event of an auxiliary power outage.

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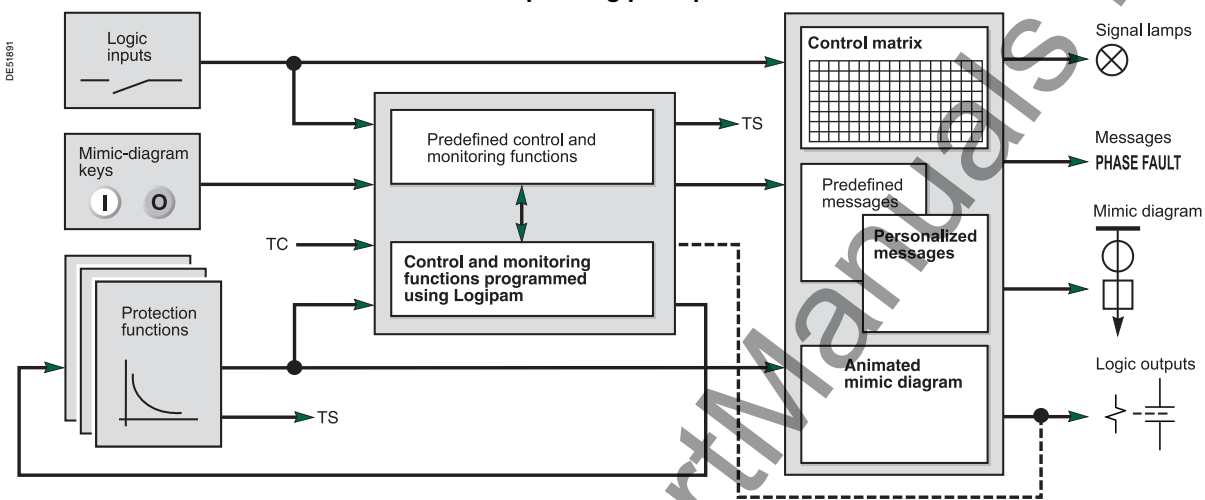
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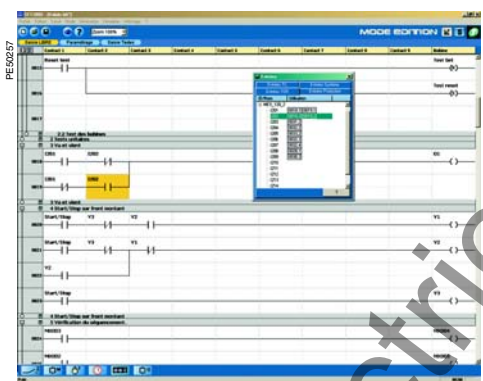
Customized Functions Using Logipam

The SFT2885 programming software (Logipam) can be used to enhance Sepam™ by programming specific control and monitoring functions.

Only the Sepam™ Series 80 with a cartridge containing the Logipam SFT080 option can run the control and monitoring functions programmed by Logipam.

Operating principle





SFT2885: Logipam programming software.

Logipam Programming Software

The Logipam SFT2885 programming software can be used to:
- adapt predefined control and monitoring functions
- program specific control and monitoring functions, either to replace the predefined versions or to create completely new functions, to provide all the functions required by the application.

It consists of:
- a ladder-language program editor used to address all Sepam™ data and to program complex control functions
- a simulator for complete program debugging
- a code generator to run the program on Sepam™.

The ladder-language program and the data used can be documented and a complete file can be printed.

Offering more possibilities than the logic-equation editor, Logipam can be used to create the following functions :
- specific automatic transfer functions
- motor starting sequences.

The functions programmed by Logipam cannot be combined with functions adapted by the logic-equation editor in a given Sepam™.

The Logipam program uses the input data from:
- protection functions
- logic inputs
- remote control commands
- local control commands transmitted by the mimic-based UMI.

The result of Logipam processing can be:
- assigned to a logic output, directly or via the control matrix
- assigned to a LED or message via the control matrix
- transmitted by the communication link, as a new remote indication
- used by the predefined control and monitoring functions
- used to block or reset a protection function.

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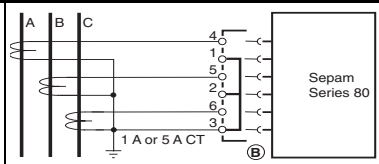
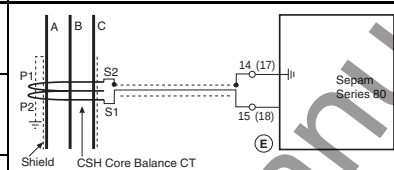
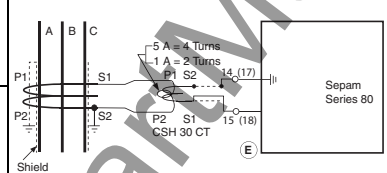
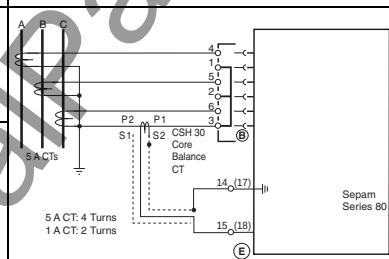
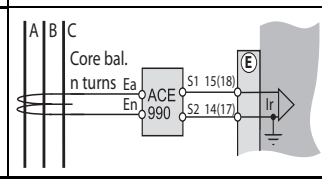
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Ground Fault Current
Measurement Method Summary without Neutral

Method Number	Measurement Method	Setting Range	Zero Sequence CT	Connections	Residual Current Setting	Remark
1A (applies for LPCT also)	Internal Phase Current Summation	DT=0.1 to 15 Inr IDMT=0.1 to Inr	None		"3I Sum"	Sepam Series 80 Considers INr=IN
2A	Specific CSH Zero Sequence CT On 2 A Input Rating	DT=0.2 A to 30 A IDMT=0.2 A to 2 A	CSH 120 CSH 200		"2 A Rated CSH" (2 A Core Bal. CT)	Sepam Series 80 Considers INr=2 A
3A	Specific CSH Zero Sequence CT on 5 A Input Rating	DT=0.5A to 75A IDMT=0.5A to 7.5A	CSH 120 CSH 200		"5 A Rated CSH" (5 A zero sequence CT)	Ino=5A
4A	Specific CSH Zero Sequence CT On 20 A Input Rating	DT=2 A to 300 A IDMT=2 A to 20 A	CSH 120 CSH 200		"20 A Rated CSH (20 A Core Bal. CT)	Sepam Series 80 Considers INr=20 A
5A*	Standard 1A or 5A CT	DT=0.1 to 15 Inr IDMT=0.1 to Inr	1 A/5 A CT Zero Sequence CT + CSH 30 Aux CT as interface		"1 A CT + CSH" or 5 ACT + CSH	Primary Rated Current: 1 A to 6.25 kA, INr=IN
5A (Sensitive)	Standard 5A or 1A CT	DT=0.1 to 15 Inr IDMT=0.1 to Inr	5 A/1 A CT Zero Sequence CT + CSH 30 Aux CT as interface		"5 A CT + CSH" (or 1 A CT + CSH) "sensitivity X10	Primary Rated Current: 1 A to 6.25 kA, INr=IN/10
6A*	External Sum of Phase CT Secondaries (1 A or 5 A)	DT=0.1 to 15 Inr IDMT=0.1 to Inr	CSH 30 Zero Sequence CT as Interface		"1 A CT + CSH" or "5 A CT + CSH"	Set Sepam Series 80 For INr=IN (Primary Rated Current: 1 A to 6.25 kA)
6A (Sensitive)	External Sum of Phase CT Secondaries (1 A or 5 A)	DT=0.1 to 15 Inr IDMT=0.1 to Inr	CSH 30 Zero Sequence CT as Interface		"1 A CT + CSH (or 5 A CT + CSH) sensitivity X10	INr=IN/10 (Ipri=1 A to 6.25 kA)
7A	Standard 1 A CT or 5 A CT	DT=0.1 to 15 Inr IDMT=0.1 to Inr	1 A/5 A Zero Sequence CT + ACE 990		5 A CT + ACE 1 A CT + ACE	INr=k x N N=CT turns .00578 ≤ K ≤ .26316

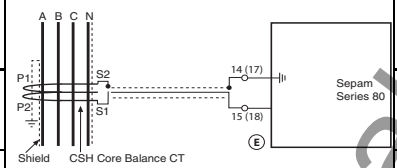
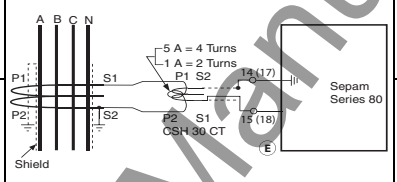
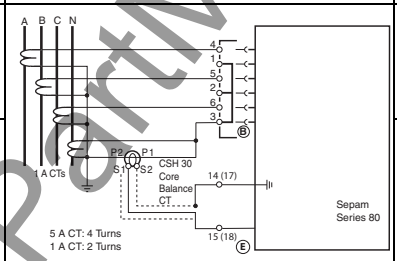
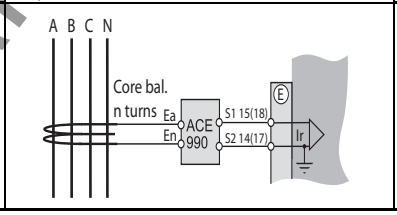
***See alternate CSH30 secondary connection in the Sepam Series 80 *Installation, Use, Commissioning and Maintenance* manual.**

Note: *INr should be thought of as a relay input port for ground fault protection. This port can accept residually connected phase ct's and therefore measure positive, negative and zero sequence components. This port can also accept a zero sequence ct which measures only true zero sequence (no positive or negative sequence). So the port name INr is just that a port name. What kind of current (positive, negative or zero sequence) depends on the type of CTs used)*

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Ground Fault Current
Measurement Method Summary with Neutral

Method Number	Measurement Method	Setting Range	Zero Sequence CT	Connections	Residual Current Setting	Remark
2B	Specific CSH Zero Sequence CT On 2 A Input Rating	DT=0.2 A to 30 A IDMT=0.2 A to 2 A	CSH 120 CSH 200		"2 A Rated CSH" (2 A Core Bal. CT)	Sepam Series 80 Considers INr=2 A
3B	Specific CSH Zero Sequence CT on 5 A Input Rating	DT=0.5A to 75A IDMT=0.5A to 7.5A	CSH 120 CSH 200		"5 A Rated CSH" (5 A zero sequence CT)	INr=5A
4B	Specific CSH Zero Sequence CT On 20 A Input Rating	DT=2 A to 300 A IDMT=2 A to 20 A	CSH 120 CSH 200		"20 A Rated CSH (20 A Core Bal. CT)	Sepam Series 80 Considers INr=20 A
5B*	Standard 1 A CT or 5 A CT	DT=0.1 to 15 INr IDMT=0.1 to INr	1 A/5 A CT Zero Sequence CT + CSH 30 Aux CT as interface		"1 A CT + CSH" or 5 ACT + CSH	Primary Rated Current: 1 A to 6.25 kA, INr=IN
5B (Sensitive)	Standard 5 A CT or 1 A CT	DT=0.1 to 15 INr IDMT=0.1 to INr	5 A/1 A CT Zero Sequence CT + CSH 30 Aux CT as interface		"5 A CT + CSH" (or 1 A CT + CSH) "sensitivity X10	Primary Rated Current: 1 A to 6.25 kA, INr=IN/10
6B*	External Sum of Phase CT Secondaries (1 A or 5 A)	DT=0.1 to 15 INr IDMT=0.1 to INr	CSH 30 Zero Sequence CT as Interface		"1 A CT + CSH" or "5 A CT + CSH"	Set Sepam Series 80 For INr=IN (Primary Rated Current: 1A to 6.25 kA)
6B (Sensitive)	External Sum of Phase CT Secondaries (1 A or 5 A)	DT=0.1 to 15 INr IDMT=0.1 to INr	CSH 30 Zero Sequence CT as Interface		"1 A CT + CSH (or 5 A CT + CSH) sensitivity X10	INr=IN/10 (Ipri=1 A to 6.25 kA)
7B	Standard 1 A CT or 5 A CT	DT=0.1 to 15 INr IDMT=0.1 to INr	1 A/5 A Zero Sequence CT + ACE 990		5 A CT + ACE 1 A CT + ACE	INr=k x N N=CT turns .00578 ≤ K ≤ .26316

***See alternate CSH30 secondary connection in the Sepam Series 80 *Installation, Use, Commissioning and Maintenance* manual.**

Note: *INr should be thought of as a relay input port for ground fault protection. This port can accept residually connected phase ct's and therefore measure positive, negative and zero sequence components. This port can also accept a zero sequence ct which measures only true zero sequence (no positive or negative sequence). So the port name INr is just that a port name. What kind of current (positive, negative or zero sequence) depends on the type of CT's used)*

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Setting Coding

Data Format

All the settings are transmitted in 32-bit signed 2's complement integer format.

Coding of Tripping and Timer Hold Curves

The numbers correspond to the setting columns in the lists of settings.

(1) Tripping Curves

0 = definite time
1 = inverse9 = IEC VIT/B
2 = long time inverse10 = IEC EIT/C
3 = very inverse11 = IEEE Mod. inverse
4 = extremely inverse12 = IEEE very inverse
5 = ultra inverse13 = IEEE extr. inverse
6 = RI14 = IAC inverse
7 = IEC SIT/A15 = IAC very inverse
8 = IEC LTI/B16 = IAC extr. inverse
24 = Customized curve

(2) Tripping Curves

0 = definite11 = IEEE moderately inverse
7 = IEC inverse / A12 = IEEE very inverse
8 = IEC long time inverse / B13 = IEEE extremely inverse
9 = IEC very inverse / B17 = Specific Schneider curve
10 = IEC extremely inverse / C20 = RI^2

(3) Timer Hold Curves

0 = definite time
1 = IDMT

Common Protection Settings

All protection functions have the following settings at the head of the table.

Setting	Data	Format/Unit
1	Latching	0: no 1: yes
2	Program logic	see details
3	Activity	0: Off 1: On
4	Measurement origin	0: mainsee note 1: additional

Details on program-logic field

Bit	*31*	*30*	*....*	*4*	*3*	*2*	*1*	*0*
						DES	AGR	CDC

CDC= 1: the protection function takes part in circuit-breaker/contactor control
= 0: the protection function does not take part
AGR= 1: the protection function takes part in genset shutdown
= 0: the protection function does not take part
DES= 1: the protection function takes part in de-excitation
= 0: the protection function does not take part
When a common protection setting is not applicable to a particular protection function, it is signaled "reserved" in the table for the function.

Nota : *there are a few special cases of coding for the measurement-origin field, listed below.*

Value	50N/51N	67N	59N
0	IrΣ	IrΣ	Vr
1	Ir	Ir	$V_{Ln}t$
2	I'r	I'r	
3	I'rΣ		

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Protection Settings

They are organized according to **increasing ANSI codes**.

ANSI 12 - Overspeed

Function number: 72xx
Unit 1: xx = 01 to unit 2: xx = 02

Setting	Data	Format/Unit
1 to 3	Common settings	
4	Reserved	
5	Set point	%
6	Tripping time delay	10 ms

ANSI 14 - Underspeed

Function number: 77xx
Unit 1: xx = 01 to unit 2: xx = 02

Setting	Data	Format/Unit
1 to 3	Common settings	
4	Reserved	
5	Set point	%
6	Tripping time delay	10 ms

ANSI 21B - Underimpedance

Function number: 7401

Setting	Data	Format/Unit
1 to 3	Common settings	
4	Reserved	
5	Zs set point	mΩ
6	Tripping time delay	10 ms

ANSI 24 - Overexcitation (V/Hz)

Function number: 75xx
Unit 1: xx = 01 to unit 2: xx = 02

Setting	Data	Format/Unit
1 to 3	Common settings	
4	Reserved	
5	VT connection	0: delta 1: wye
6	Tripping curve	0 = definite21 = Type A 22 = Type B23 = Type C
7	Voltage/frequency threshold	0.01 pu
8	Tripping time delay	10 ms

ANSI 27 - Undervoltage

Function number: 32xx
Unit 1: xx = 01 to unit 4: xx = 04

Setting	Data	Format/Unit
1 to 4	Common settings	
5	Tripping curve	0: definite 19: IDMT
6	Voltage mode	0: phase-to-neutral 1: phase-to-phase
7	Threshold voltage	% $V_{LL}p$
8	Tripping time delay	10 ms

ANSI 27D - Positive Sequence Undervoltage

Function number: 38xx
Unit 1: xx = 01 to unit 2: xx = 02

Setting	Data	Format/Unit
1 to 4	Common settings	
5	Threshold voltage	% $V_{LL}p$
6	Tripping time delay	10 ms

ANSI 27R - Remanent Undervoltage

Function number: 35xx
Unit 1: xx = 01 to unit 2: xx = 02

Setting	Data	Format/Unit
1 to 4	Common settings	
5	Threshold voltage	% $V_{LL}p$
6	Tripping time delay	10 ms

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ANSI 32P - Directional Active Overpower

Function number: 53xx
Unit 1: xx = 01 to unit 2: xx = 02

Setting	Data	Format/Unit
1 to 3	Common settings	
4	Reserved	
5	Access	0: reverse power 1: overpower
6	Ps set point	100 W
7	Tripping time delay	10 ms

ANSI 32Q - Directional Reactive Overpower

Function number: 5401

Setting	Data	Format/Unit
1 to 3	Common settings	
4	Reserved	
5	Access	0: reverse power 1: overpower
6	Qs set point	100 var
7	Tripping time delay	10 ms

ANSI 37 - Phase Undercurrent

Function number: 2201

Setting	Data	Format/Unit
1 to 3	Common settings	
4	Reserved	
5	Threshold current	0.1 A
6	Tripping time delay	10 ms

ANSI 37P - Directional Active Underpower

Function number: 55xx
Unit 1: xx = 01 to unit 2: xx = 02

Setting	Data	Format/Unit
1 to 3	Common settings	
4	Reserved	
5	Access	0: drawn 1: supplied
6	Ps set point	100 W
7	Tripping time delay	10 ms

ANSI 38/49T - Temperature Monitoring

Function number: 46xx
Unit 1: xx = 01 to unit 16: xx = 16

Setting	Data	Format/Unit
1 to 3	Common settings	
4	Reserved	
5	Ts1 alarm set point	°C
6	Ts2 alarm set point	°C

ANSI 40 - Field Loss (Underimpedance)

Function number: 7001

Setting	Data	Format/Unit
1 to 3	Common settings	
4	Reserved	
5	Xa resistance	1 mΩ
6	Xb resistance	1 mΩ
7	Xc resistance	1 mΩ
8	Tripping time delay circle 1	10 ms
9	Tripping time delay circle Xd	10 ms

ANSI 46 - Negative Sequence / Unbalance

Function number: 45xx
Unit 1: xx = 01 to unit 2: xx = 02

Setting	Data	Format/Unit
1 to 4	Common settings	
5	Tripping curve	②
6	Threshold current	% IB
7	Tripping time delay	10 ms
8	K setting	1 to 100

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ANSI 47 - Negative Sequence Overvoltage

Function number: 40xx
Unit 1: xx = 01 to unit 2: xx = 02

Setting	Data	Format/Unit
1 to 4	Common settings	
5	Threshold voltage	% $V_{LL}p$
6	Tripping time delay	10 ms

ANSI 48/51LR - Locked Rotor / Excessive Starting Time

Function number: 4401

Setting	Data	Format/Unit
1 to 3	Common settings	
4	Reserved	
5	Threshold current	% IB
6	"ST" excessive starting time	10 ms
7	"LT" locked rotor time	10 ms
8	"LTS" locked on start time	10 ms

ANSI 49RMS - Thermal Overload for Cables and Machines

Function number: 4301

Setting	Data	Format/Unit
1 to 4	Common settings	
5	Negative sequence factor (K)	0: none (0)1: low (2.25) 2: medium (4.5)3: high (9)
6	Is set point (shift group 1/group 2)	% IB
7	Ambient temperature taken into account	0: no 1: yes
8	Maximum equipment temperature	°C
9	Additional settings taken into account (group 2)	0: no 1: yes
10	Learnt cooling time constant (T2 learnt) taken into account	0: no 1: yes
11	Group 1 - thermal alarm set point	%
12	Group 1 - thermal tripping set point	%
13	Group 1 - heating time constant	min.
14	Group 1 - cooling time constant	min.
15	Group 1 - initial heat rise	%
16	Group 2 - thermal alarm set point	%
17	Group 2 - thermal tripping set point	%
18	Group 2 - heating time constant	min.
9	Group 2 - cooling time constant	min.
20	Group 2 - initial heat rise	%
21	Group 2 - base current for group 2	0.1 A
22	Current threshold	0.1 A
23	Associated time constant	min.

Nota : *parameters 1 to 21 concern the machine thermal overload, the common protection settings and parameters 22 and 23 concern the cable thermal overload.*

ANSI 50/27 - Inadvertent Energization

Function number: 7301

Setting	Data	Format/Unit
1 to 3	Common settings	
4	Reserved	
5	Is set point	0.1 A
6	Vs set point	% $V_{LL}p$
7	T1 time	10 ms
8	T2 time	10 ms
9	Use of breaker-position inputs	0: no 1: yes

ANSI 50BF - Breaker Failure

Function number: 9801

Setting	Data	Format/Unit
1	Common settings	
2	Reserved	
3	Common settings	
4	Reserved	
5	Use of breaker closed input	0: no 1: yes
6	Is set point	0.1 A
7	Time	10 ms

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ANSI 50/51 - Phase Overcurrent

Function number: 01xx
Unit 1: xx = 01 to unit 8: xx = 08

Setting	Data	Format/Unit
1 to 4	Common settings	
5	Confirmation	0 = none 1 = neg. seq. overvoltage 2 = undervoltage
6	Group A - tripping curve	①
7	Group A - Is threshold current	0.1 A
8	Group A - tripping time delay	10 ms
9	Group A - timer hold curve	③
10	Group A - timer hold	10 ms
11	Group B - tripping curve	①
12	Group B - Is threshold current	0.1 A
13	Group B - tripping time delay	10 ms
14	Group B - timer hold curve	③
15	Group B - timer hold	10 ms

ANSI 50N/51N - Ground Fault

Function number: 06xx
Unit 1: xx = 01 to unit 8: xx = 08

Setting	Data	Format/Unit
1 to 4	Common settings	
5	Group A - tripping curve	①
6	Group A – Isr threshold current	0.1 A
7	Group A - tripping time delay	10 ms
8	Group A - timer hold curve	③
9	Group A - timer hold	10 ms
10	Group A - H2 restraint	0: yes 1: no
11	Group B - tripping curve	①
12	Group B - threshold current	0.1 A
13	Group B - tripping time delay	10 ms
14	Group B - timer hold curve	③
15	Group B - timer hold	10 ms
16	Group B - H2 restraint	0: yes 1: no

ANSI 50V/51V - Voltage-Restrained Overcurrent

Function number: 19xx
Unit 1: xx = 01 to unit 2: xx = 02

Setting	Data	Format/Unit
1 to 4	Common settings	
5	Tripping curve	①
6	Threshold current	0.1 A
7	Tripping time delay	10 ms
8	Timer hold curve	③
9	Timer hold	10 ms

ANSI 59 - Overvoltage

Function number: 28xx
Unit 1: xx = 01 to unit 4: xx = 04

Setting	Data	Format/Unit
1 to 4	Common settings	
5	Voltage mode	0: phase-to-neutral 1: phase-to-phase
6	Threshold voltage	% V_{LL}p
7	Tripping time delay	10 ms

ANSI 59N - Neutral Voltage Displacement

Function number: 39xx
Unit 1: xx = 01 to unit 2: xx = 02

Setting	Data	Format/Unit
1 to 4	Common settings	
5	Tripping curve	0: definite 19: IDMT
6	Threshold voltage	% V_{LL}p
7	Tripping time delay	10 ms

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ANSI 27TN/64G2 - Third Harmonic Undervoltage

Function number: 71xx
Unit 1: xx = 01 to unit 2: xx = 02

Setting	Data	Format/Unit
1 to 3	Common settings	
4	Reserved	
5	Access	0: adaptive 1: fixed
6	Vs set point	0.1% $V_{LL}tp$
7	Min. Ss set point	% Sb
8	Min. Vs set point	% $V_{LL}p$
9	K set point	0.01
10	Tripping time delay	10 ms

ANSI 64 REF - Restricted Ground Fault Differential

Function number: 64xx
Unit 1: xx = 01 to unit 2: xx = 02

Setting	Data	Format/Unit
1 to 4	Common settings	
5	Threshold current	0.1 A

ANSI 66 - Starts per Hour

Function number: 4201

Setting	Data	Format/Unit
1	Common settings	
2	Reserved	
3	Common settings	
4	Reserved	
5	Period of time	Hours
6	Total number of starts	1
7	Number of consecutive hot starts	1
8	Number of consecutive cold starts	1
9	Time delay between stop and start	min.

ANSI 67 - Directional Phase Overcurrent

Function number: 52xx
Unit 1: xx = 01 to unit 2: xx = 02

Setting	Data	Format/Unit
1 to 3	Common settings	
4	Reserved	
5	Group A - direction	0: line1: bus
6	Group A - characteristic angle	3: 30°4: 45°5: 60°
7	Group A - tripping logic	0: 1/31: 2/3
8	Group A - tripping curve	①
9	Group A - Is threshold current	0.1 A
10	Group A - tripping time delay	10 ms
11	Group A - timer hold curve	③
12	Group A - timer hold	10 ms
13	Group B - direction	0: line1: bus
14	Group B - characteristic angle	3: 30°4: 45°5: 60°
15	Group B - tripping logic	0: 1/31: 2/3
16	Group B - tripping curve	①
17	Group B - Is threshold current	0.1 A
18	Group B - tripping time delay	10 ms
19	Group B - timer hold curve	③
20	Group B - timer hold	10 ms

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ANSI 67N/67NC - Directional Ground Fault

Function number: 50xx
Unit 1: xx = 01 to unit 2: xx = 02

Setting	Data	Format/Unit
1 to 4	Common settings	
5	Access	0: projection 1: directional
6	Group A - direction	0: line1: bus
7	Group A - characteristic angle	0: -45°1: 0°2: 15° 3: 30°4: 45°5: 60° 6: 90°
8	Group A - sector	2: sector 763: sector 83 4: sector 86
9	Group A - tripping curve	①
10	Group A – Isr threshold current	0.1 A
11	Group A - tripping time delay	10 ms
12	Group A – Vsr threshold current	% V_{LL}p
13	Group A - timer hold curve	③
14	Group A - timer hold	10 ms
15	Group A - memory time	10 ms
16	Group A - memory voltage	% V_{LL}p
17	Group B - direction	0: line1: bus
18	Group B - angle	Same as group A
19	Group B - sector	Same as group A
20	Group B - tripping curve	①
21	Group B - Isr threshold current	0.1 A
22	Group B - tripping time delay	10 ms
23	Group B - Vsr threshold current	% V_{LL}p
24	Group B - timer hold curve	③
25	Group B - timer hold	10 ms
26	Group B - memory time	10 ms
27	Group B - memory voltage	% V_{LL}p

ANSI 78PS - Pole Slip

Function number: 7601

Setting	Data	Format/Unit
1 to 3	Common settings	
4	Reserved	
5	Access	0: equal-area criterion 1: power-swing criterion 2: both criteria
6	T area	10 ms
7	Max. number of power swings	1 to 30
8	Max. time between power swings	10 ms

ANSI 81H - Overfrequency

Function number: 57xx
Unit 1: xx = 01 to unit 2: xx = 02

Setting	Data	Format/Unit
1 to 4	Common settings	
5	Frequency threshold	0.1 Hz
6	Tripping time delay	10 ms
7	Reserved	
8	Vs set point	% V_{LL}p

ANSI 81L - Underfrequency

Function number: 56xx
Unit 1: xx = 01 to unit 4: xx = 04

Setting	Data	Format/Unit
1 to 4	Common settings	
5	Frequency threshold	0.1 Hz
6	Tripping time delay	10 ms
7	Restraint	0: no 1: yes
8	Vs set point	% V_{LL}p
9	BLOCK set point for frequency variation	Hz/s

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ANSI 87M - Machine Differential

Function number: 6201

Setting	Data	Format/Unit
1 to 3	Common settings	
4	Reserved	
5	Ids threshold current	1 A
6	Restraint on CT loss	0: no 1: yes

ANSI 87T - Transformer and Transformer-Machine Unit Differential

Function number: 6001

Setting	Data	Format/Unit
1 to 3	Common settings	
4	Reserved	
5	Ids set point	%
6	Id/It set point	%
7	Restraint on CT loss	0: no 1: yes
8	Test mode	0: no 1: yes

Other Function Settings

ANSI 60 - CT Supervision

Function number: 2601: CT supervision
2602: Supervision additional CTs

Setting	Data	Format/Unit
1	Reserved	
2	Reserved	
3	Common settings	
4	Reserved	
5	Action on 21G, 46, 40, 51N, 32P, 37P, 32Q, 78PS and 64REF functions	0: none 1: block
6	Tripping time delay	10 ms

ANSI 60FL - VT Supervision

Function number: 2701: VT supervision
2702: reserved

Setting	Data	Format/Unit
1	Reserved	
2	Reserved	
3	Common settings	
4	Reserved	
5	Use breaker-position or voltage-presence criterion	1: circuit breaker 2: voltage
6	Check loss of 3 V/2 V_{LL}	0: no 1: yes
7	Test current	0: no 1: yes
8	Use V2, I2 criterion	0: no 1: yes
9	Action on 21G, 27/27S, 27D, 27TN, 32P, 32Q, 37P, 40, 47, 50/27, 51V, 59, 59N and 78PS functions	0: none 1: block
10	Action on 67 function	0: non directional 1: block
11	Action on 67N function	0: non directional 1: block
12	V2 tripping set point	%
13	I2 tripping set point	%
14	3 V/ 2 V_{LL} loss time	10 ms
15	V2, I2 criterion time	10 ms

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ANSI 79 - Recloser

Function number: 1701

Setting	Data	Format/Unit
1	Reserved	
2	Reserved	
3	Common settings	
4	Reserved	
5	Number of shots	0 to 4
6	Reclaim time	10 ms
7	Safety time until ready	10 ms
8	Maximum additional dead time	0: no 1: yes
9	Maximum wait time	10 ms
10	Step 1 activation mode	see note
11	Step 2, 3, 4 activation mode	see note
12	Step 1 dead time	10 ms
13	Step 2 dead time	10 ms
14	Step 3 dead time	10 ms
15	Step 4 dead time	10 ms

Nota : *The activation of each of the cycles is coded as follows:*

Bit	Activation by (if bit set to 1) / Non activation by (if bit set to 0)
0	Instantaneous protection 50/51 unit 1
1	Delayed protection 50/51 unit 1
2	Instantaneous protection 50/51 unit 2
3	Delayed protection 50/51 unit 2
4	Instantaneous protection 50/51 unit 3
5	Delayed protection 50/51 unit 3
6	Instantaneous protection 50/51 unit 4
7	Delayed protection 50/51 unit 4
8	Instantaneous protection 50N/51N unit 1
9	Delayed protection 50N/51N unit 1
10	Instantaneous protection 50N/51N unit 2
11	Delayed protection 50N/51N unit 2
12	Instantaneous protection 50N/51N unit 3
13	Delayed protection 50N/51N unit 3
14	Instantaneous protection 50N/51N unit 4
15	Delayed protection 50N/51N unit 4
16	Instantaneous protection 67N unit 1
17	Delayed protection 67N unit 1
18	Instantaneous protection 67N unit 2
19	Delayed protection 67N unit 2
20	Instantaneous protection 67 unit 1
21	Delayed protection 67 unit 1
22	Instantaneous protection 67 unit 2
23	Delayed protection 67 unit 2
24	Instantaneous V_DECL logical equation

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Function Settings
General &
Application-Specific Parameters

General Parameters

These settings are read accessible only.
Function number: D002

Setting	Data	Format/Unit
1	Working language	1: English 2: other
2	Rated frequency	50, 60 (Hz)
3	Active group of settings	1: group A 2: group B 3: selection by logic input 4: selection by remote control
4	Demand-value integration period	5, 10, 15, 30, 60 minutes
5	Type of cubicle	1: main 2: feeder
6	Active-energy increment	100 to 5000000 (W)
7	Reactive-energy increment	100 to 5000000 (var)
8	Phase-rotation direction	1: direction 123 2: direction 132
9	Temperature unit	1: °C 2: °F
10	Remote-setting authorization	1: no 2: yes
11	Time synchronization mode	1: COM1 port 2: COM2 port 3: input I103 5: none
12	Remote-control mode	1: SBO mode 2: direct mode
13	Reserved	
14	Monitoring of auxiliary power	1: inactive 2: active
15	Rated auxiliary voltage	24 to 250 (V DC)
16	Aux. voltage alarm low set point	% rated Vaux, min. 20 V
17	Aux. voltage alarm high set point	% rated Vaux, max. 275 V
18	Logic inputs ignored on loss of Vaux	1: inactive 2: active
19	Base current Ib	0.2 to 1.3 In (A)
20	Rated current In	1 to 6250 A
21	Number of phase CTs	1: 2 CTs 2: 3 CTs
22	Phase CT rating	1: 1 A 2: 5 A3: LPCT
23	Rated residual current Inr	10 to 62500 (dA)
24	Residual current measurement mode	1: CSH 2 A 3: CSH 20 A 4: CSH + CT 1 A 6: CSH + CT 5 A 8: ACE990 range 1 9: ACE990 range 2 11: not measured
25	Reserved	
26	Rated primary voltage $V_{LL}p$	220 to 250000 (V)
27	Rated secondary voltage $V_{LL}s$	100, 110, 115, 120, 200, 230 (V)
28	VT wiring	1: 3 V_{Ln}, 2: 2 V_{LL}, 3: 1 V_{LL}, 4: 1 V_{Ln}
29	Residual voltage mode	1: none 2: Σ3V 3: VT $V_{LL}s/\sqrt{3}$ 4: VT $V_{LL}s/3$
30	Neutral-point residual voltage measurement	1: none 2: present
31	Neutral-point rated voltage $V_{LL}p$	220 to 250000 (V)
32	Neutral-point rated voltage $V_{LL}s$	57 V to 133 V
33	Reserved	
34	Reserved	
35	Additional rated current I'n	1 to 6250 A
36	Number of additional phase CTs	1: 2 CTs 2: 3 CTs3: none
37	Additional phase CT rating	1: 1 A 2: 5 A3: LPCT
38	Additional rated residual current I'Nr	10 to 62500 (dA)
39	Additional residual current measurement mode	Idem 24
40	Reserved	
41	Reserved	
42	Reserved	
43	Reserved	
44	Reserved	
45	Reserved	
46	Reserved	
47	Reserved	
48	Reserved	

Application-Specific Parameters

These settings are read accessible only.
Function number: D003

Setting	Data	Format/Unit
1	Transformer presence	1: no 2: yes
2	Voltage winding 1 $V_{LL}1$	220 to 250000 V
3	Voltage winding 2 $V_{LL}2$	220 to 440000 V
4	Power S	100 to 999000 kVA
5	Vector shift	0 to 11
6	Rated motor speed	100 to 3600 rpm
7	Number of pulses per rotation	1 to 1800
8	Zero speed threshold	5 to 20%

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Schneider Electric USA
295 Tech Park Drive, Suite 100
LaVergne, TN 37086
Tel : 1-888-SquareD (1-888-778-2733)
www.us.squared.com

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