PowerLogic™ P5

Protection Relay

User Manual

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General information

Legal notice

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Contact information

35 rue Joseph Monier
92500 Rueil-Malmaison
FRANCE
Phone: +33 (0) 1 41 29 70 00
Fax: +33 (0) 1 41 29 71 00
www.se.com

Purpose

This user manual is intended for electrical power engineering experts, OEMs, system integrators, communication specialists, and general users of the PowerLogic™ P5 protection and control relays.
The complete manual is arranged as follows:

- Preliminary sections, with the details of the manual (how to use it, glossary) and technical data.
- Functions of the protection relay.
  Explanations, diagrams and settings of the protection, control, monitoring and maintenance, measurement, recording and programmable logic functions are detailed in these sections.
- Installation and commissioning.
- Local control panel use, troubleshooting and maintenance instructions.

The following documents complete this manual:

- Quick Start Guide, delivered in the relay package, summarises instructions for installation.
- Communication Manual, for the understanding and the setup of the communication protocols with PowerLogic P5.
- Application Book, for the understanding of specific applications and describing how the PowerLogic P5 protection and control relay functionality can be expanded.

All above documents are accessible at se.com under this link:https://www.se.com/ww/en/product-range/62400-powerlogic-p5-protection-relays/?parent-subcategory-id=86796&filter=business-6-medium-voltage-distribution-and-grid-automation#documents

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Safety information and password protection

Important information

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 manual or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.



The addition of this symbol to a "Danger" or "Warning" safety label indicates that an electrical hazard exists which will result in death or serious injury if the instructions are not followed.



This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

⚠⚠DANGER

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

Failure to follow these instructions will result in death or serious injury.

⚠WARNING

WARNING indicates a potentially hazardous situation which, if not avoided, can result in death or serious injury.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

⚠CAUTION

CAUTION indicates a potentially hazardous situation which, if not avoided, can result in minor or moderate injury, or equipment damage.

Failure to follow these instructions can result in injury or equipment damage.

NOTICE

NOTICE is used to address practices not related to physical injury.

Failure to follow these instructions can result in equipment damage.

Abbreviations

Table 1 - Abbreviations used in the manual

Acronyms	Indication
Ø	Diameter
AC, DC	Alternating Current, Direct Current
ACSI	Abstract Communication Service Interface
AI, AO	Analogue Input, Analogue Output: used in connection with the number of input and output contacts within the relay and - when necessary - with the slot letter.
CAE	EcoStruxure Cybersecurity Admin Expert
CB	Circuit Breaker
CS	CyberSecurity
CID	Configured IED Description
CT	Current Transformer
CTS	Current Transformer Supervision
DCD	Device Capabilities Description
DI, DO	Digital Input, Digital Output: used in connection with the number of inputs and output contacts within the relay and - when necessary - with the slot letter.
DG	Distributed Generation
DIN rail	Standard metal rail used to mount equipment inside ar rack (DIN for Deutsches Institut für Normung)
DMS	Distribution Management System
EMC	Electromagnetic Compatibility
ETH	Ethernet Module
f	frequency
FC	Function Code
FO	Fibre Optic
G_D	Threshold of independent time operation.
GOOSE	Generic Object Oriented Substation Events: in IEC 61850, type of generic substation event, for a peer-to-peer communication over Ethernet.
HMI	Human Machine Interface
HSR	High availability Seamless Redundancy
ICD	IED Capability Description
ICT	Inductive Current Transformer
IEC	International Electrotechnical Commission prepares and publishes international standards for electrical and electronics technology.
IED	Intelligent Electronic Device
IN.CSH	Measured neutral current from CSH core-balance CT
IN.CSH.nom	Neutral CSH CT primary nominal
IN.calc	Calculated neutral current from 3 phase currents
IN.meas	Measured neutral current from standard 1A/5A current inputs
IN.nom	Standard neutral CT primary nominal
IN.sens	Measured neutral current from sensitive 1A input
IN.sens.nom	Sensitive neutral CT primary nominal
IVT	Inductive Voltage Transformer
I/O	Input/Output (e.g. 6I/4O: 6 inputs, 4 outputs): used in connection with the number of inputs and output contacts within the relay.

Table 1 - Abbreviations used in the manual (Continued)

Acronyms	Indication
In	Phase CT primary nominal
Inom	Phase CT primary nominal
IRIG-B	Inter-Range Instrumentation Group time code B: standard for time transfer
LC	"Lucent Connector": type of optical connector
LED	Light Emitting Diode
LPCT	Low Power Current Transformer
LPIT	Low Power Instrument Transformer
LPVT	Low Power Voltage Transformer
LV, MV	Low Voltage, Medium Voltage
max.	Maximum
NERC	North American Electric Reliability Corporation
NI	Network Input
P2P	Peer-to-Peer
PCT	Protective Conductor Terminal (earth/ground)
PLC	Programmable Logic Controller
POC	Primary Operating Current
PRP	Parallel Redundancy Protocol
Pnom	Active nominal power
pu	Base unit which equals to primary nominal value
QR code	Quick Response code: two-dimensional barcode.
RBAC	Role Based Access Control: provides a restricting access to authorised users only (Cybersecurity).
RCA	Relay Characteristic Angle
Ref	Reference
REF	Restricted Earth Fault
RH	Relative Humidity
RJ45	Standardised type of connector (eight-wire connector) used for Ethernet networking (Registered Jack)
RMS	Root Mean Square
RoCoF	Rate of Change of Frequency
RS485 (or EIA-485)	Standard defining the electrical characteristics of a serial communication interface.
RSTP	Rapid Spanning Tree Protocol: communication protocol
RTC	Real Time Clock
RTD	Resistance Temperature Detector
RTU	Remote Terminal Unit
SCADA	Supervisory Control And Data Acquisition
SFP	Small Form-factor Pluggable
SFTP/FTP	Secured File Transfer Protocol/File Transfer Protocol
SOL	Selective Overcurrent Logic
SRL	Serial Module
ST (BFOC)	Straight Tip (Bayonet Fibre Optic Connector): type of optical connector
Snom	Apparent nominal power

Table 1 - Abbreviations used in the manual (Continued)

Acronyms	Indication
THD	Total Harmonic Distortion
TLS	Transport Layer Security
TP	Time Protocol: communication protocol
UFLS	Underfrequency Load Shedding
Un	Phase VT primary nominal
USB	Universal Serial Bus
VI	Virtual Input
VN.calc	Calculated neutral voltage from 3 phase voltages
VN.meas	Measured neutral voltage from neutral voltage input
VO	Virtual Output
VT	Voltage Transformer
VTS	Voltage Transformer Supervision
VA.nom	Nominal auxiliary voltage
Vnom	VT primary nominal (PP)
Vnom/√3	VT primary nominal (PN)

Range description

PowerLogic P5 is a family of digital protection and control relays for medium voltage distribution networks dedicated to:

- Buildings and Industry:
  - Data centers
  - Retails
  - Hotels
  - Health care
  - Education and research
  - Transportation
  - Industrial buildings
- Utilities: energy distribution
- Large sites:
  - Oil and Gas
  - Mining
  - Mineral and Metals
  - Water

PowerLogic P5 protection and control relays are based on proven technology concepts developed in close cooperation with customers and available in two sizes.

- The PowerLogic P5x20 is housed in 20TE casing. It offers up to 16 digital inputs and up to 9 output contacts, one Ethernet and one serial communication port[1]. P5x20 can realize feeder, motor or transformer applications with Universal model (P5U20) and voltage/frequency applications with Voltage model (P5V20).
- The PowerLogic P5x30 is housed in 30TE casing. It offers up to 40 digital inputs and up to 16 output contacts, two Ethernet and one serial communication port[2]. P5x30 can realize feeder (P5F30), motor (P5M30) and transformer differential (P5T30) applications. PowerLogic P5x30 offers in-built arc flash protection.

PowerLogic P5 protection relays have been designed around user-friendliness, a feature which is proven in our customer reports day after day.

- A complete set of protection functions, related to the application
- Optional arc detection (for PowerLogic P5x30) by point sensors
- Dedicated circuit breaker control with Mimic, push buttons, programmable function keys, customisable LEDs and alarm
- Multilingual local panel display for customised messaging
- eSetup Easergy Pro software for setting parameters, configuring and network fault simulation
- Both serial and Ethernet communication, including redundancy and precision time synchronisation
- Compliant with IEC 61850 edition 1 and 2 standard
- Cybersecurity functionalities
- Back-up memory for fast and easy replacement
- Withdrawability for maintenance

Easergy to PowerLogic renaming

Schneider Electric, driven by its “Customer First” Core Value is fully committed to easing the customer experience with our portfolio on all fronts. With this core mission in mind, the decision of optimizing the number of brands has been taken across the entire digital Schneider Electric portfolio, to provide a more cohesive and consistent presentation of our offers across different Divisions, bringing a

1. Maximum configuration is 16DI/7DO+WD or 9DI/8DO+WD depending on the boards selected.
2. Maximum configuration is 40DI/15DO+WD or 19DI/18DO+WD depending on the boards selected.

simpler and customer-centric approach, that will facilitate the navigation through all the breadth and depth of our offers and that will be a key enabler for an optimised digitization experience.

This brand optimization initiative affects Protection & Control portfolio including Easergy P5 protection and control relays. The Easergy P5 has been renamed to PowerLogic P5. It is essential to emphasize that this renaming change exclusively affects the brand name of the products and will have absolutely no consequence on the current performances, specifications, characteristics, and/or quality of the product, which remain totally unaffected by this brand name migration.

During the brand transition project, it may happen that the application of this change to different parts of the offer goes effective with different time schedules. There is absolutely no difference between Easergy and PowerLogic branded P5 products and accessories. Easergy accessories can be used with PowerLogic P5 product as long as the commercial reference is matching. The commercial references have not changed along with renaming of the offer. eSetup Easergy Pro and CET850 remain the software to configure PowerLogic P5 protection and control relays.

Introduction

Selection guide by application

Table 2 - PowerLogic P5 protection relay selection guide

		PowerLogic P5x20			PowerLogic P5x30		
							
Voltage		-		P5V20	-		-
Feeder		P5U20		-	P5F30		-
Transformer					-		P5T30
Motor					P5M30		-
Characteristics							
Analogue inputs	Phase current	1/5A CT (x3)	LPCT (x3)	-	1/5A CT (x3)	LPCT (x3)	1/5A CT (x6)
	Neutral current	1/5A CT & 1A CT or CSH	CSH	-	1/5A CT & 1A CT or CSH	CSH	1/5A CT (x2)
	Voltage	-	LPVT (x4)[3]	VT (x4)	VT (x4)	LPVT (x4)[3]	VT (x1)
Arc-flash sensor inputs		-			0 to 6 point sensors		
Digital	Inputs	4 to 16			4 to 40		
	Outputs	3 to 8 + watchdog			3 to 18 + watchdog		
Temperature sensor inputs		0 to 16 (external modules)		-	0 to 16 (external modules)		
Front ports	Mini-USB port for configuration tool	■			■		
	USB port for USB key	■			■		
Communication							
Rear ports	Extension port with backup memory	■			■		
	Serial port	■			■		
	Ethernet port	■			■		
	2nd Ethernet port	-			■		
Protocols	IEC 61850 Ed.1 and Ed.2	■			■		
	IEC 60870-5-103	■			■		
	IEC 60870-5-101	■			■		
	DNP3 serial and Ethernet	■			■		
	Modbus slave serial and Ethernet	■			■		
	Modbus master	■			■		
	EtherNet/IP	■			■		
	Digital CB	■			■		

3. Resistive divider or capacitive divider LPVTs can be connected to the PowerLogic P5 protection relay.

Table 2 - PowerLogic P5 protection relay selection guide (Continued)

		PowerLogic P5x20	PowerLogic P5x30
Redundancy protocols	RSTP	■	■
	PRP	■	■
	HSR	■	■
Time synchronisation	Pulse, IRIG-B	■	■
	SNTP, PTP IEEE 1588-2008 / IEC 61588:2009	■	■
Others			
Control		6 controlled + 2 monitored objects	
Logic	Matrix	■	
	Logic equations	■	
	Advanced logic compliant IEC 61131-3 and IEC 61499	■	
Cybersecurity		RBAC according to IEC 62351 standard IEC 62443-4 Security Level 1	
Withdrawability		■	

Function table

Table 3 - PowerLogic P5 protection relay function selection table

	IEC 61850 Logical node[4]	ANSI code	P5U20 CT variant	P5U20 LPCT/ LPVT variant	P5V20 VT variant	P5F30 CT/VT variant LPCT/ LPVT variant	P5M30 CT/VT variant LPCT/ LPVT variant	P5T30 CT/VT variant
Protection functions								
Non-directional/directional phase overcurrent[5]	P5OC**PTOC**x	50/51/67	6[6]	6	-	6	6	6
Non-directional/directional earth/ ground fault overcurrent[7]	P5DEFU**PTOC**x [8] P5DEF**PTOC**x	50N/ 51N/ 67N	6	6	-	6	6	6
Wattmetric earth/ground fault	P5EF**PDOP**x	32N	-	-	-	2	2	-
Transient intermittent earth/ground fault	P5IOIO**PTEF**1	67NI	-	-	-	1	-	-
Capacitor bank unbalance	P5CAP**PTOC**x	51C	2	-	-	2	-	-
Negative sequence overcurrent	P5NEG**PTOC**x	46	2	2	-	2	2	2
Unbalance overcurrent, broken conductor	P5UIBC**PTOC**1	46BC	2	2	-	2	2	2
Cold load pick up (CLPU)	P5CLP**PIOC**1		1	1	-	1	1	-
Selective overcurrent logic (SOL)	P5SOL**PIOC**1	68	1	1	-	1	1	
Switch On To fault (SOTF)	P5SOTF**PIOC**1	50HS	1	1	-	1	1	-
5th harmonic detection	P5HAR5**PTOC**1	68H5	1	1	-	1	1	-
Circuit breaker failure	P5CBFP**PIOC**x	50BF	1	1	1	1	1	2
Directional power	P5REVP**PDOP**1 P5REVP**PDOP**2	32	-	2	-	2	2	-
Fault locator	P5FL**RFLO**1	21FL	-	-	-	1	-	-
Auto-Recloser	P5AR**RREC**1	79	1	1	-	1	-	-
Arc-flash protection	P5ARCM**PIOC**x	50ARC	-	-	-	8	8	8
Thermal overload protection for motor	P5THM**PTTR**1	49M	1	1	-	-	1	-
Thermal overload protection for feeder	P5THF**PTTR**1	49F	1	1	-	1	-	1
Temperature monitoring	P5RTD**GAPC**x	38	16	16	-	16	16	16
Phase undercurrent	P5UC**PTUC**x	37	1	1	-	1	1	-
Motor start-up supervision, locked rotor	P5STAL**PMSS**1 P5LR**PMSS**1	48/51LR	1	1	-	-	1	-
Motor restart inhibition	P5FST**PMRI**1	66	1	1	-	-	1	-
Motor speed detection[9]	P5MSPD**PMSS**1		1	1	-	-	1	-
Motor overspeed[9]	P5MOT**POVS**x	12	2	2	-	-	2	-
Motor underspeed[9]	P5MOT**PZSU**x	14	2	2	-	-	2	-
Motor Anti-backspin ABS[9]	P5MABS**PMSS**1	ABS	1	1	-	-	1	-
Emergency restart	P5EMG**PMSS**1		1	1	-	-	1	-
Inrush detection	P5ID**PHAR**1	68H2	1	1	-	1	1	2

4. The x at the end of the logical node name in this column corresponds to the number of the stages of protection functions and the number of the objects for control and monitoring functions.
5. Only non-directional phase overcurrent is available in P5U20 and P5T30.
6. Non-directional only
7. Only non-directional earth/ground fault overcurrent is available in P5U20.
8. Dedicated for P5U20.
9. This protection function is only available when 12I4O module is fitted in the PowerLogic P5 protection relay.

Table 3 - PowerLogic P5 protection relay function selection table (Continued)

	IEC 61850 Logical node[10]	ANSI code	P5U20 CT variant	P5U20 LPCT/ LPVT variant	P5V20 VT variant	P5F30 CT/VT variant LPCT/ LPVT variant	P5M30 CT/VT variant LPCT/ LPVT variant	P5T30 CT/VT variant
Overvoltage	P5OV**PTOV**x	59	-	3	3	3	3	-
Undervoltage	P5UV**PTUV**x	27	-	3	3	3	3	-
Positive sequence undervoltage	P5UVPS**PTUV**x	27P	-	-	2	-	2	-
Capacitor overvoltage	P5CAP**PTOV**1	59C	1	-	-	1	-	-
Neutral overvoltage	P5UO**PTOV**x	59N	-	3	3	3	3	3
Overfrequency	P5OF**PTOF**x	81O	-	2	2	2	2	-
Underfrequency	P5UF**PTUF**x	81U	-	8	8	8	8	-
Rate of Change of Frequency (RoCoF)	P5DFDT**PFRC**x	81R/ 81FR	-	9	9	9	-	-
Synchro-check	P5**RSYN**1	25	-	-	1	1	-	-
Lockout relay		86	1	1	1	1	1	1
Programmable stages	P5PS**GAPC**x	99	8	8	8	8	8	8
Programmable curves			3	3	3	3	3	3
Negative sequence overvoltage	P5NEG**PTOV**x	47	-	2	2	2	2	-
Neutral admittance	P5EF**PADM**x	21YN	-	-	-	2	2	-
Restricted earth fault (low impedance)	P5REF**PDIF**1	64REF	1[11]	-	-	1[11]	1[11]	2[11]
Restricted earth fault with external connection (high-impedance)		87N	A[11]	-	-	A[11 12]	A[11 12]	A[11 12]
High impedance busbar differential		87BB	A[11 12]	-	-	A[11 12]	A[11 12]	A[11 12]
Transformer differential protection (2-winding transformer differential)		87T	-	-	-	-	-	1
Transformer overfluxing protection	P5TVF**PVPH**x	24	-	-	-	-	-	3
Voltage-controlled overcurrent		51V	A[12]	A[12]	-	A[12]	A[12]	-
Setting groups			4	4	4	4	4	4
Monitoring functions								
CT supervision	P5CTS**GGIO**1	60	1	1	-	1	1	2
VT supervision	P5VTS**GGIO**1	60	-	1	1	1	1	-
Trip circuit supervision		74	1	1	1	1	1	2
Transformer monitoring	P5TRF**SIML**x	26/63	-	-	-	-	-	2
Circuit breaker monitoring	P5CBWA**GGIO**1		1	1	-	1	1	1
Relay monitoring			■	■	■	■	■	■
Digital Circuit Breaker	P5BMM**GGIO**1	■	■	■	■	■	■	■
Control functions								
Switchgear control and monitoring	P5OBJ**CSWI**x		6	6	6	6	6	6
Switchgear monitoring only	P5OBJ**CSWI**x		2	2	2	2	2	2
Programmable switchgear interlocking			■	■	■	■	■	■

10. The x at the end of the logical node name in this column corresponds to the number of the stages of protection functions and the number of the objects for control and monitoring functions.
11. Only available with conventional (phase or neutral) CTs.
12. Function can be realized by application guidelines.

Table 3 - PowerLogic P5 protection relay function selection table (Continued)

	IEC 61850 Logical node[13]	ANSI code	P5U20 CT variant	P5U20 LPCT/ LPVT variant	P5V20 VT variant	P5F30 CT/VT variant LPCT/ LPVT variant	P5M30 CT/VT variant LPCT/ LPVT variant	P5T30 CT/VT variant
Local control on single-line diagram			■	■	■	■	■	■
Local control with O/I keys			■	■	■	■	■	■
Local/remote function			■	■	■	■	■	■
Function keys			1	1	1	7	7	7
Custom logic (logic equations)			■	■	■	■	■	■
Advanced logic engine			■	■	■	■	■	■
Control with EcoStruxure Power Device (smartphone, tablet application)			■	■	■	■	■	■
Logs and Records								
Sequence of event record			■	■	■	■	■	■
Last fault record			■	■	■	■	■	■
Disturbance record	P5DR**RDRE**1		■	■	■	■	■	■
Tripping context record			■	■	■	■	■	■
Relay maintenance data log			■	■	■	■	■	■
Security data log			■	■	■	■	■	■
Measurement								
RMS current values	P5RMSA**MMXU**1		■	■	-	■	■	■
RMS voltage values	P5RMSV**MMXU**1		-	■	■	■	■	■[14]
RMS active, reactive and apparent power	P5RMSP**MMXU**1		-	■	-	■	■	-
Frequency	P5VECA**MMXU**x		■	■	■	■	■	■
Fundamental frequency current values			■	■	-	■	■	■
Fundamental frequency voltage values	P5VECV**MMXU**1		-	■	■	■	■	■[14]
Fundamental frequency active, reactive and apparent power values			-	■	-	■	■	-
Power factor	P5VECP**MMXU**1		-	■	-	■	■	-
Phase differential currents			-	-	-	-	-	■
Phase bias currents			-	-	-	-	-	■
Active and reactive energy values			-	■	-	■	■	-
Demand values: phase currents			■	■	-	■	■	■
Demand values: active, reactive, apparent power and power factor			-	■	-	■	■	-
Maximum demand values: phase currents			■	■	-	■	■	■
Minimum and maximum demand values: RMS phase currents			■	■	-	■	■	■
Minimum and maximum demand values: active, reactive, apparent power and power factor	P5SRD**MMXU**x		-	■	-	■	■	-

13. The x at the end of the logical node name in this column corresponds to the number of the stages of protection functions and the number of the objects for control and monitoring functions.
14. For 1 voltage.

Table 3 - PowerLogic P5 protection relay function selection table (Continued)

	IEC 61850 Logical node[15]	ANSI code	P5U20 CT variant	P5U20 LPCT/ LPVT variant	P5V20 VT variant	P5F30 CT/VT variant LPCT/ LPVT variant	P5M30 CT/VT variant LPCT/ LPVT variant	P5T30 CT/VT variant
Minimum and maximum demand values over the last 31 days and 12 months: active, reactive and apparent power			-	■	-	■	■	-
Minimum and maximum values: currents			■	■	-	■	■	■
Minimum and maximum values: voltages			-	■	■	■	■	■[16]
Minimum and maximum values: frequency			■	■	■	■	■	■
Minimum and maximum values: active, reactive, apparent power and power factor			-	■	-	■	■	-
Harmonic values of phase current and THD	P5HI**MHAI**1 P5THDI**MHAI**1		■	■	-	■	■	■
Harmonic values of voltage and THD	P5HU**MHAI**1 P5THDU**MHAI**1		-	■	■	■	■	■[16]
Voltage sags and swells			-	■	■	■	■	■[16]

15. The x at the end of the logical node name in this column corresponds to the number of the stages of protection functions and the number of the objects for control and monitoring functions.
16. For 1 voltage.

Technical characteristics

Table 4 - PowerLogic P5 protection relay technical characteristics

Characteristic	Value	
	PowerLogic P5x20	PowerLogic P5x30
Power system frequency		
Rated frequency	50 Hz or 60 Hz	
Power supply		
Operating range	DC: 24 to 250 V DC, ±20% AC: 100 to 230 V AC, ±20%	DC: 48 to 250 V DC, ±20% AC: 100 to 230 V AC, ±20% Optional: DC: 24 to 48 V DC, ±20%
AC frequency operating range	50 Hz, ±10%; 60 Hz, ±10%	
Maximum continuous withstand	300 V DC max, 276 V AC max	
Inrush current for start-up	I < 3 A , t < 5 ms, 100 V AC I < 5 A , t < 6 ms, 230 V AC I < 4 A, t < 6 ms, 48 V DC I < 8 A, t < 4 ms, 250 V DC	
Burden DC	Quiescent stage: 4 W, maximum load: 6 W at 48 V DC Quiescent stage: 4 W, maximum load: 6 W at 250 V DC	Quiescent stage: 8 W, maximum load: 11 W at 48 V DC Quiescent stage: 8 W, maximum load: 11 W at 250 V DC
Burden AC	Quiescent stage: 10 VA, maximum: 15 VA at 230 V AC Quiescent stage: 8 VA, maximum: 10 VA at 100 V AC	Quiescent stage: 20 VA, maximum: 22 VA at 230 V AC Quiescent stage: 13 VA, maximum: 15 VA at 100 V AC
RTC retention time		
RTC retention time	1 month typical[17]	
Phase CT inputs		
CT rated primary current	10 A to 20 kA	
CT secondary phase current	1 A or 5 A	
Linear range	60 x CT rated current	
Thermal withstand	Continuous: 20 A; 1 s: 500 A	
Input impedance	< 0.003 Ω	
Burden	< 0.02 VA at 1 A; < 0.5 VA at 5 A	
LPCT inputs		
Nominal current	2.5 A to 20 kA	
LPCT rated primary current	10 A to 5 kA	
LPCT rated secondary voltage	22.5 mV	
Current factor	0.25; 0.50; 1.00; 1.25; 1.33; 2.00; 2.50; 3.20; 4.00; 5.00; 6.30; 6.66; 10; 16; 20; 25; 31.5	
Linear range	45 x Nominal current	
Standard earth/ground fault CT inputs		
CT rated primary current	1 A to 20 kA	
CT rated earth/ground fault current	1 A, 2 A or 5 A	
Linear range	30 x CT rated current	
Thermal withstand	Continuous: 20 A; 1 s: 500 A	

17. This value can be impacted by high temperature exposition during a long time.

Table 4 - PowerLogic P5 protection relay technical characteristics (Continued)

Characteristic	Value	
	PowerLogic P5x20	PowerLogic P5x30
Input impedance	< 0.02 Ω (not connected)	
Burden	< 0.02 VA at 1 A; < 0.08 VA at 2 A; < 0.5 VA at 5 A	
CSH core balance inputs		
CSH rated primary current	2 A or 20 A	
CT ratio	1/470	
Linear range	42.5 x rated primary current	
Thermal input withstand	Continuous: 300 A (primary); 1 s: 18 kA (primary)	
Input impedance	< 0.02 Ω (not connected) < 4 Ω between CSH120, CSH200, CSH300 or GO 110 and the PowerLogic P5 protection relay	
Burden	< 10 mVA at 0.1 A; < 50 mVA at 5 A	
CSH30 core balance inputs		
CT ratio	1/1000; 5/1000	
Burden	< 10 mVA at 0.1 A; < 50 mVA at 5 A	
VT inputs		
VT rated primary voltage	100 V to 500 kV	
VT rated secondary rated range	25 V to 250 V	
Voltage withstand	Continuous: 276 V AC	
Input impedance	> 100 kΩ	
Rated frequency	50 Hz and 60 Hz	
Burden	< 0.05 VA at 75 V; < 0.5 VA at 200 V	
LPVT inputs		
Nominal voltage	18.75 V to 500 kV	
LPVT rated primary voltage	75 V to 500 kV	
LPVT rated secondary voltage	3.25 V / √3	
Voltage factor	0.25 to 1.5	
Digital inputs		
Operating nominal voltage	24 V DC to 250 V DC 90 V AC to 230 V AC	
Voltage threshold	40% to 80% of nominal voltage	
Voltage withstand	300 V DC / 275 V AC	
Common mode insulation	Basic insulation 2500 V DC 1 min	
Reset threshold	20% to 60% of nominal voltage	
Voltage threshold resolution	1%	
Debounce filter[18]	Settable: 0 ms to 100 ms (Default value: 10 ms)	
Threshold accuracy	± 10% of nominal voltage or ± 2 V	
Max. current	< 2 mA	
Input current	Nominal voltage: 24 V to 110 V Inrush: 9.0 mA last 10 ms Continuous: 2.1 mA	
	Nominal voltage: 110.1 V to 220 V Inrush: 4.5 mA last 10 ms	

18. A setting below 10 ms can be used for testing only. It is not recommended during operation.

Table 4 - PowerLogic P5 protection relay technical characteristics (Continued)

Characteristic	Value	
	PowerLogic P5x20	PowerLogic P5x30
	Continuous: 1.3 mA	
Maximum activation time	DC < 1 ms AC < 20 ms	
Reset time	< 0.5 ms	
Debounce time	Adjustable (by software) from 1 ms up to 20 ms, with 1 ms steps	
Burden	< 0.5 W in DC < 0.5 VA in AC	
Control relay outputs **PowerLogic P5x20 power supply DO1 - DO2 - DO3 Slot B** **PowerLogic P5x30 power supply DO2 - DO3 Slot B** **PowerLogic P5x20 5I5O module DO1 - DO2 - DO3 Slot C** **PowerLogic P5x30 5I5O module DO1 - DO2 - DO3 Slot C, D, E** **PowerLogic P5x30 arc-flash module DO1 - DO2 Slot D, E**		
According to IEC 60255-1 and IEC 61810-1		
Contact rated voltage	250 V DC or 230 V AC, 50/60 Hz	
Continuous current	8 A	
Short duration carry current	30 A for 3 s	
Making capacity	10000 operations 1000 W with L/R = 40 ms, 250 V DC 2000 VA 230 V AC Duty cycle 1 s ON, 9 s OFF	
Breaking capacity	10000 operations 50 W with L/R = 40 ms, 250 V DC 2000 VA 230 V AC Duty cycle 1 s ON, 9 s OFF	
Dielectric withstand across normally open contacts	1 kV rms AC for 1 minute	
According to IEEE C37.90 standard		
Make and carry	2000 operations make and carry 30 A DC Duty cycle 200 ms ON, 15 s OFF (current is interrupted by independent means at the end of each ON cycle)	
Dielectric withstand across normally open contacts	1.5 kV rms AC for 1 minute	
Other characteristics		
Making capacity	2000 operations 5 A DC with L/R = 50 ms Duty cycle 1 s ON, 9 s OFF	
Breaking capacity	10000 operations 0.25 A DC with L/R = 50 ms Duty cycle 1 s ON, 9 s OFF	
Short duration making capacity	20 A for 0.5 s; 30 A for 0.2 s	
Minimum making current	10 mA with 50 mW minimum	
Closing/opening time	7 ms (typical value), 3.5 ms + 3.5 ms for contact bounce, resistive load	
Contact material	Ag alloy	
Number of operations unloaded	100000	

Table 4 - PowerLogic P5 protection relay technical characteristics (Continued)

Characteristic	Value	
	PowerLogic P5x20	PowerLogic P5x30
High speed, high break control relay output PowerLogic P5x30 power supply DO1 Slot B PowerLogic P5x20 5I5O module DO4 - DO5 Slot C PowerLogic P5x30 5I5O module DO4 - DO5 Slot C, D, E		
According to IEC 60255-1 and IEC 61810-1		
Contact rated voltage	250 V DC or 230 V AC, 50/60 Hz	
Continuous current	10 A	
Short duration carry current	30 A for 3 s	
Making and breaking capacity	10000 operations 2500 W with L/R = 40 ms 250 V DC 2300 VA 230 V AC Duty cycle 1 s ON, 9 s OFF	
Dielectric withstand across normally open contacts	None – due to Solid State Devices across normally open contact	
According to IEEE C37.90 standard		
Make and carry	2000 operations make and carry 30 A DC Duty cycle 200 ms ON, 15 s OFF (current is interrupted by independent means at the end of each ON cycle)	
Dielectric withstand across normally open contacts	None – due to Solid State Devices across normally open contact	
Other characteristics		
Making capacity	2000 operations 5 A DC with L/R = 50 ms	
Breaking capacity	10000 operations 0.25 A DC with L/R = 50 ms	
Short duration making capacity	20 A for 0.5 s; 30 A for 0.2 s	
Minimum making current	10 mA with 50 mW minimum	
Closing time	1 ms (typical value) for the high-speed contact relay DO1 (PowerLogic P5x30)	
Opening time	20 ms (typical value), resistive load	
Contact material	Ag alloy	
Number of operations unloaded	100000	

Table 4 - PowerLogic P5 protection relay technical characteristics (Continued)

Characteristic	Value	
	PowerLogic P5x20	PowerLogic P5x30
Signalling relay outputs Watchdog power supply, Slot B PowerLogic P5x20 6I4O/12I4O module all DOs Slot C PowerLogic P5x30 6I4O/12I4O module all DOs Slot C, D, E PowerLogic P5x30 arc-flash module DO3 Slot D, E		
According to IEC 60255-1 and IEC 61810-1		
Contact rated voltage	250 V DC or 230 V AC, 50/60 Hz	
Continuous current	2 A	
Short duration carry current	30 A for 200 ms	
Making capacity	10000 operations 1000 W with L/R = 40 ms 250 V DC 1150 VA 230 V AC Duty cycle 1 s ON, 9 s OFF	
Breaking capacity	10000 operations 30 W with L/R = 40 ms 250 V DC 1150 VA 230 V AC Duty cycle 1 s ON, 9 s OFF	
Dielectric withstand across normally open contacts	1 kV rms AC for 1 minute	
Other characteristics		
Making and breaking capacity	10000 operations 1 A DC with L/R = 20 ms	
Minimum making current	10 mA with 50 mW minimum	
Closing/opening time	7 ms (typical value) 3.5 ms + 3.5 ms for contact bounce, resistive load	
Contact material	Ag alloy	
Number of operations unloaded	100000	
Size and weight		
Size (Width x Height x Depth)	102/180/224 mm (4.01/7.08/ 8.82 in)	152.4/180/224 mm (6/7.08/8.82 in)
Weight	≤ 2.5 kg (5.51 lb)	≤ 3.3 kg (7.28 lb)

NOTE:

Control relay outputs, both conventional hinged-armature relays and high speed, high break outputs, should be used for operating the open (trip) and close control circuits of the CB and for circuits with similar high requirements regarding make, carry and break currents.

It is worthy to note,

- the signaling of the raising edge (“make”) with high speed output is at least 5 ms faster than with conventional hinged-armature relay output;
- the signaling of the falling edge (“break”) with high speed output is at maximum 15 ms slower than with conventional hinged-armature relay output.

Such differences also need to be considered in the set up of protection scheme timing.

Signalling relay outputs should be used for conventional transfer of digital data to other secondary equipment or control systems, where requirements for make, carry and break of currents are low. Also, such outputs are often wired with common return, to allow more output signals with a given (limited) number of terminal contacts.

Environmental characteristics

⚠WARNING

UNEXPECTED OPERATION

Install PowerLogic P5 according to the environmental characteristics described in the table below.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

According to the informative annex of IEC 60255-1 standard edition 2, all the environmental tests are performed at the minimum settings which helps ensure the robustness of the PowerLogic P5 protection relay.

The digital inputs have been tested with 10 ms of debounce filter.

Table 5 - PowerLogic P5 protection relay environmental characteristics

Characteristic	Description/Value		
Power Supply			
Characteristics	**Standard**	**Level/Class**	**Value**
Voltage dips (DC)	IEC 61000-4-29 GOST 30804.4		500 ms voltage dips 0%, 250 V DC and above, Criteria A; 150 ms voltage dips 0%, 110 V DC; 100 ms voltage dips 0%, 48 V DC; 50 ms voltage dips 0%, 24 V DC
Ripple (DC)	IEC 61000-4-17		15%; 100 Hz / 120 Hz, Criteria A
Voltage dips (AC)	IEC 61000-4-11 GOST 30804.4		Criteria A, 30 cycles, voltage dips 0%, 230 V AC; 10 cycles, voltage dips 0%, 110 V AC
Product Safety			
Insulation Characteristics	**Standard**		**Value**
Insulation resistance	IEC 60255-27		> 100 MΩ at 500 V DC Using only electronic/brushless insulation tester.
Protection class	IEC 60255-27	Class I	
Creepage distances and clearances	IEC 60255-27		Pollution degree 2, Overvoltage category III
High voltages withstand (dielectric)	IEC 60255-27		2 kV rms AC, 1 min: between all case terminals connected together, and the case earth/ground; 2 kV rms AC, 1 min: between all terminals of independent circuits; 1 kV rms AC for 1 min: across normally open control and signalling contacts; 1.5 kV DC for 1 min; communication port; None for High Speed, High Break control relay output due to solid state devices across normally open contact.
	IEEE C37.90		1.5 kV rms AC for 1 min: across open tripping contacts
Impulse voltage	IEC 60255-27		5 kV, 1.2/50 µs, 0.5 J between all terminals of independent circuits, and all terminals and case earth/ground.

Table 5 - PowerLogic P5 protection relay environmental characteristics (Continued)

Characteristic	Description/Value		
Electromagnetic Compatibility			
Characteristics	**Standard**	**Level/Class**	**Value**
Emission test			
Radiated disturbances	CISPR32 CISPR11 IEC 60255-26 GOST-30805.22	Class A	
	IACS-E10		For equipment installed in the general power distribution zone.
Conducted disturbances	CISPR32 IEC 60255-26 GOST-30805.22	Class A	
	IACS-E10		For equipment installed in the general power distribution zone.
Radiated disturbances immunity tests			
Radiated radio frequency fields	IEC 61000-4-3	Level 3	10 V/m, 80 MHz to 6 GHz, 80% AM (1 kHz)
	ANSI C37.90.2		20 V/m, 80 MHz to 1GHz, 80% AM (1 kHz)
	GOST R 50746		10 V/m, 80 MHz to 1 GHz AM 80% (1 kHz and pulse 200 Hz) 30 V/m, 800 MHz to 960 MHz/1.4 GHz to 6 GHz
	IACS E10	Level 3	10 V/m, 100 kHz and 1 MHz, 2 s
Electrostatic discharges	IEC 61000-4-2	Level 4	15 kV air, 8 kV contact
	ANSI C37.90.3		15 kV air, 8 kV contact
Magnetic field at power frequency	IEC 61000-4-8	Level 5	100 A/m continuous; 1000 A/m, 1 to 3 s
Pulse magnetic fields	IEC 61000-4-9	Level 5	1000 A/m
Oscillatory magnetic fields	IEC 61000-4-10	Level 5	100 A/m, 100 kHz and 1 MHz
Conducted Radio Frequency disturbances			
Conducted Radio Frequency disturbance	IEC 61000-4-6	Level 3	10 V rms common mode, 0.15 MHz to 80 MHz, 80% AM (1 kHz)
Fast transient bursts[19]	IEC 61000-4-4	Level 4	4 kV common mode, 5 kHz, 100 kHz
	ANSI C37.90.1		4 kV, 5 kHz, common mode and transversal mode
	IACS E10		2 kV power supply, 1 kV digital I/O, 5 min, 5 kHz
Slow damped oscillatory waves	IEC 61000-4-18	Level 3	2.5 kV common mode 1 kV differential mode, 100 kHz, 1 MHz
	ANSI C37.90.1		2.5 kV, 1 MHz, common mode and transversal mode
	IEC 61000-4-12 GOST 30804.4.12	Level 3	2 kV common mode; 1 kV, differential mode, 100 kHz, Source impedance: 12 Ω
Fast damped oscillatory waves	IEC 61000-4-18	Level 3	2 kV common mode, 3 MHz, 10 MHz, 30 MHz
Conducted disturbances 0 to 150 kHz	IEC 60255-26	Zone A	150 V rms, differential mode; 300 V rms, common mode.
	GOST 51317.4.6	Level 3	Continuous: 30 V rms Short: 300 V rms 5 Hz – 150 kHz: 30 V rms
Surges[20]	IEC 61000-4-5	Level 4	4 kV, common mode; 2 kV, differential mode

19. ANSI C37.90.1 test passed with 20 ms of digital inputs debounce filter.
20. When protection function 50N/51N/50G/51G/67N is used and IN is measured with CSH core balance CT, it is recommended to use operation time of 50 ms at the lowest pickup value setting.

Table 5 - PowerLogic P5 protection relay environmental characteristics (Continued)

Characteristic	Description/Value		
Harmonics and inter-harmonics (AC)	IEC 61000-4-13	Level 3	Criteria A
Power voltage fluctuation (AC)	IEC 61000-4-14	Level x Level 3	±ΔU 15% for (Un, Un – 10 %Un, Un + 10 %Un) ±ΔU 12% (Un, Un – 10 %Un, Un + 10 %Un)
Environmental conditions			
Operation			
Characteristics	**Standard**	**Test Method**	**Value**
Exposure to cold	IEC 60068-2-1	Ad	-40°C (-40°F), 96 hours.
Exposure to dry heat	IEC 60068-2-2	Bd	+70°C (+158°F), 96 hours; +85°C (+185°F), 16 hours
Exposure to damp heat	IEC 60068-2-78	Cab	40 °C (+104 °F), 93% ± 3% RH, 56 days, without condensation
Temperature variation	IEC 60068-2-14	Nc	-40°C to +70°C (-40°F to +158°F), 10°C/min (18°F/min) 96 hours
Damp heat cyclic test	IEC 60068-2-30	Db Variant 1	55°C (131 °F), 93% ± 3% RH and 25°C (77 °F), 97% -2% +3% RH, with condensation, 6 cycles (12 h + 12 h)
Storage			
Exposure to cold	IEC 60068-2-1	Ab	-40°C (-40°F), 96 hours
Exposure to dry heat	IEC 60068-2-2	Bb	+85°C (+185°F), 96 hours
Exposure to damp heat	IEC 60068-2-78	Cab	40 °C (+104°F), 93% ± 3% RH, 21 days
Temperature variation	IEC 60068-2-14	Nc	-40°C to +70°C (-40°F to +158°F) transfer time: 10°C/min (18°F/min), 96 hours
Corrosive atmosphere			
Salt mist	IEC 60068-2-52	Kb Severity 1	4 spraying periods of 2 hours with a storage of 7 days after each
2 Gas	IEC 60068-2-60	Ke	+25°C (+77°F), 75% RH, 21 days, method 1: 0.5 ppm SO_2; 0.1 ppm H_2S.
4 Gas	IEC 60068-2-60	Ke	+25°C (+77°F), 75% RH, 21 days, method 4: 0.11 ppm SO_2; 0.071 ppm H_2S; 0.034 ppm Cl_2, 0.26 ppm NO_2. (according to IEC 60721-3-3:2002 3C2 environment)
Mechanical Robustness			
Characteristics	**Standard**	**Level**	**Value**
In operation (flush mounted case with REL51032: panel mounting kit with flush mounting accessory)			
Vibrations	IEC 60255-21-1	Class 2	1 Gn, 10 Hz to 150 Hz
	GOST 17516.1		0.015 mm peak, 0.5 Hz to 57.6 Hz 1 Gn, 57.6 Hz to 150 Hz
	IACS E10		2 Hz to 13.2 Hz - amplitude ±1mm 13.2 Hz to 100 Hz - acceleration ±0.75 Gn
Shocks	IEC 60255-21-2	Class 2	10 Gn, 11 ms
Earthquakes	IEC 60255-21-3	Class 2	2 Gn horizontal; 1 Gn vertical
Storage (flush mounted case with REL51032: panel mounting kit with flush mounting accessory)			
Vibration	IEC 60255-21-1	Class 2	2 Gn, 10 Hz to 150 Hz
	GOST 17516.1		2 Gn, 0.5 Hz to 150 Hz
Shocks	IEC 60255-21-2	Class 2	30 Gn, 11 ms
Bumps	IEC 60255-21-2	Class 2	20 Gn, 16 ms

Table 5 - PowerLogic P5 protection relay environmental characteristics (Continued)

Characteristic	Description/Value		
Enclosure			
Local panel	IEC 62262	IK07	Degree of protection against mechanical impacts
	IEC 60529	IP54	Front panel
		IP54	Mounted in panel with flush mounting accessory
		IP41	Mounted in panel without accessory
	NEMA	Type 12	
Rear panel	IEC 60529	IP10	Area with ring terminal connection (analogue inputs)
Fire resistance			
Flammability	IEC 60695-11-10		class V-1 minimum
Packaging			
Resistance to shocks by free fall (with packaging)	IEC 60068-2-31		1 m (3.28 ft)
Cybersecurity			
Certification	Achilles	Level I	Certification number: 453–071119
		Level II[21]	Certification number: 500–101420
	IEC 62443-4-1		Security for industrial automation and control systems: Secure product development life-cycle requirements.
	IEC 62443-4-2 Security Level 1 (SL 1)[22]		Security for industrial automation and control systems: Technical security requirements for IACS components.
Certification/declaration			
CE European Commission's directives	EN/IEC 60255-26		Electromagnetic Compatibility (EMC) directive 2014/30/EU
	EN 60255-27/IEC 60255-27		Electrical Equipment (Safety) directive 2014/35/EU
	EN IEC 63000/IEC 63000		Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (ROHS) directive 2015/863/EU
	ETSI EN 300 328 (V2.2.2)		Radio Equipment Directive 2014/53/UE
	ETSI EN 301 489-1 (V2.2.3)		
	ETSI EN 301 489-17 (V3.2.4)		
c UL us UL Standards	UL 508 ANSI/IEEE C37.90 CAN/CSA C22.2 No.14		File E354250, NRGU
EAC Eurasian Customs Union	EAЭC RU C-FR.HA46.B.05269/22		Hardware variants with P5xxx-xxxx-xxxx-xxxH
UK CA United Kingdom regulations	BS EN 60255-26/IEC 60255-26		Electromagnetic Compatibility (EMC) regulations SI 2016 No. 1091
	BS EN 60255-27/IEC 60255-27		Electrical Equipment (Safety) regulations SI 2016 No. 1101
	BS EN IEC 63000/IEC 63000		Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (ROHS) regulations SI 2012 No. 3032
	ETSI EN 300 328 (V2.2.2)		Radio Equipment Regulations SI 2017 No. 1206
	ETSI EN 301 489-1 (V2.2.3)		
	ETSI EN 301 489-17 (V3.2.4)		

21. EtherNet/IP protocol is not included in Level II certification.
22. PowerLogic P5 with Advanced Cybersecurity level (P5xxx-xxxx-xxxxx-xxxBx or P5xxx-xxxx-xxxxx-xxxDx) and Cybersecurity Admin Expert (CAE) is certified.

Installation

Safety instructions

This page contains important safety instructions that must be followed precisely before attempting to install, repair, service or maintain electrical equipment. Carefully read and follow the safety instructions described below. Only qualified personnel, equipped with appropriate individual protection equipment, may work on or operate the equipment. Qualified personnel are:

- Familiar with the installation, commissioning, and operation of the equipment and of the system to which it is being connected.
- Able to safely perform switching operations in accordance with accepted safety engineering practices and are authorised to energise and de-energise equipment and to isolate, earth/ground, and label it.
- Trained in the care and use of safety apparatus in accordance with safety engineering practices.
- Trained in emergency procedures (for example, first aid).

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Turn off all power supplying the protection relay and the equipment in which it is installed before working on it.
- Always use a properly rated voltage sensing device to confirm that power is off.
- Apply appropriate personal protective equipment and follow safe electrical work practices. See local regulation.
- Do not install this product in ATEX class 0, 1 and 2 areas.

Failure to follow these instructions will result in death or serious injury.

⚠DANGER

FIRE HAZARD

If you are authorised to withdraw the relay:

- Disconnect the power supply before removing or replacing a module or the withdrawable part of the protection relay.
- Never touch electronic parts (electrostatic discharge).
- Before replacing the withdrawable part, clean all debris and contaminants from the case, the withdrawable part, and the connectors.
- Apply proper tightening torque to all wire connections.

Failure to follow these instructions will result in death or serious injury.

⚠WARNING

UNEXPECTED OPERATION

Do not energise the primary circuit before this protection relay is properly configured.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

Protection Class I equipment

Before energising the equipment it must be earthed/grounded using the protective conductor terminal, if provided, or the appropriate termination of the supply plug in the case of plug connected equipment.

The protective conductor (earth/ground) connection must not be removed since the protection against electric shock provided by the equipment would be lost.

When the protective (earth/ground) conductor terminal (PCT) is also used to terminate cable shields, etc., it is essential that the integrity of the protective (earth/ground) conductor is checked after the addition or removal of such functional earth/ground connections. For M4 stud PCTs the integrity of the protective (earth/ground) connections should be ensured by use of a locknut or similar.

The recommended minimum protective conductor (earth/ground) wire size is 2.5 mm² (AWG 14) (3.3 mm² (AWG 12) for North America) unless otherwise stated in the technical data section of the equipment documentation, or otherwise required by local or country wiring regulations.

The protective conductor (earth/ground) connection must be low-inductance and as short as possible.

All connections to the equipment must have a defined potential. Connections that are pre-wired, but not used, should preferably be grounded when digital inputs and output relays are isolated. When digital inputs and output relays are connected to common potential, the pre-wired but unused connections should be connected to the common potential of the grouped connections.

Transport, handling and storage

Transport

In its original packing, a protection relay can be shipped to any destination by all usual means of transport.

If installed in a cubicle, the protection relay can be transported by all usual means of transport in the customary conditions used for cubicles. Storage conditions should be taken into consideration for a long period of transport.

Handling

Protective relays, although generally of robust construction, require careful handling: handle the PowerLogic P5 protection relays in their original packing in order to help protect it against damage.

If installed in a cubicle: should the protection relay fall out of a cubicle, check its condition by visual inspection and energising.

Storage

NOTICE

WATER DAMAGE

- Do not expose the products to sustained humidity during storage.
- Electrically energise the products within three months of unpacking.
- Where electrical equipment is being installed, allow sufficient time for acclimatisation to the ambient temperature of the environment before powering on.
- Supply power to the protection relay every two years for at least one hour.

Failure to follow these instructions can reduce the product life span.

If PowerLogic P5 protection relays are not to be installed immediately upon receipt, they should be stored in a place free from dust, humidity and moisture in their original packaging. PowerLogic P5 can be stored in its original packaging, in an appropriate location for several years:

- Temperature between -25°C and +70°C (between -13°F and +158°F)
- Humidity < 90%

Care should be taken on subsequent unpacking so that any dust collected on the carton does not fall inside. In locations of high humidity, the carton and packing may become impregnated with moisture and the de-humidifier crystals will lose their efficiency.

Periodic, yearly checking of the environment and the packaging condition is recommended: the relay should be powered on for one hour every two years.

Once the protection relay has been unpacked, it should be energised as soon as possible in an appropriate environment in term of temperature, humidity and pollution.

If protection relay is installed in a cubicle, keep the cubicle protection packing as long as possible. The protection relay, like all electronic units, should not be stored in a damp environment for more than a month. The protection relay should be energised as quickly as possible. If this is not possible, the cubicle reheating system should be activated.

Unpacking

Equipment receipt

NOTICE

PRODUCT TAMPERING

Our products leave our factory in closed, sealed original packaging. At delivery, if the packaging is opened or the seal is broken, Schneider Electric must be informed.

Failure to follow these instructions can result in compromised confidentiality and authenticity of the information contained in the products.

A PowerLogic P5 protection relay is shipped in a cardboard box which helps protect it against any shocks received in transport.

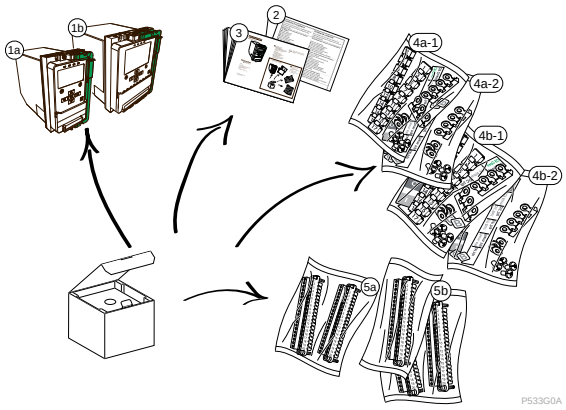
Protection relays that are supplied unmounted and not intended for immediate installation should be returned to their protective plastic bags and delivery carton.

Package contents

Each PowerLogic P5 protection relay is delivered in an independent package containing:

- A PowerLogic P5 protection relay
  - **1a**: PowerLogic P5x20
  - **1b**: PowerLogic P5x30
- A certificate of conformity ②
- An installation sheet providing main information about installation and use ③
- One plastic bag including a set of labels and stickers, and the cabling kit for connector A
  - **4a-1**: pack for PowerLogic P5x20 of CT/VT analogue input type
  - **4a-2**: pack for PowerLogic P5U20 of LPCT/LPVT analogue input type
  - **4b-1**: pack for PowerLogic P5x30 of CT/VT analogue input type
  - **4b-2**: pack for PowerLogic P5x30 of LPCT/LPVT analogue input type
- One plastic bag including one to four rear connectors
  - **5a**: pack for PowerLogic P5x20
  - **5b**: pack for PowerLogic P5x30

Figure 1 - PowerLogic P5 package contents

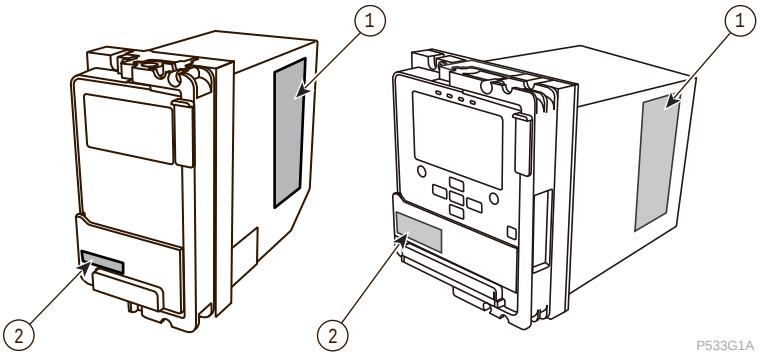


Accessories, such as the mounting accessory with panel mounting kit, communication modules and cables can be delivered in a separate package.

Equipment identification

Different kinds of labels and stickers are used on the PowerLogic P5 protection relay to identify its model type and its different components.

Figure 2 - Label examples on the PowerLogic P5 protection relay



① Rear panel connection instructions label

② Reference label

Reference label

The reference label contains the commercial reference, the serial number, the power supply voltage of the relay and a QR code. The QR code can be used to access the specific product website through **mySchneider** App (available in App Store and Google Store) to get basic product documents and product life cycle documents like Certificate of Conformity and Test.

Figure 3 - Reference label on PowerLogic P5x20

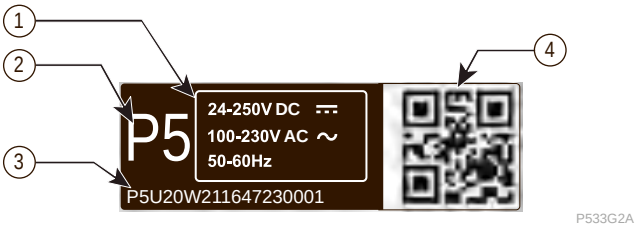


Figure 4 - Reference label on PowerLogic P5x30



① Power supply voltage (Optional 24–48 V DC for PowerLogic P5x30)

② Reference

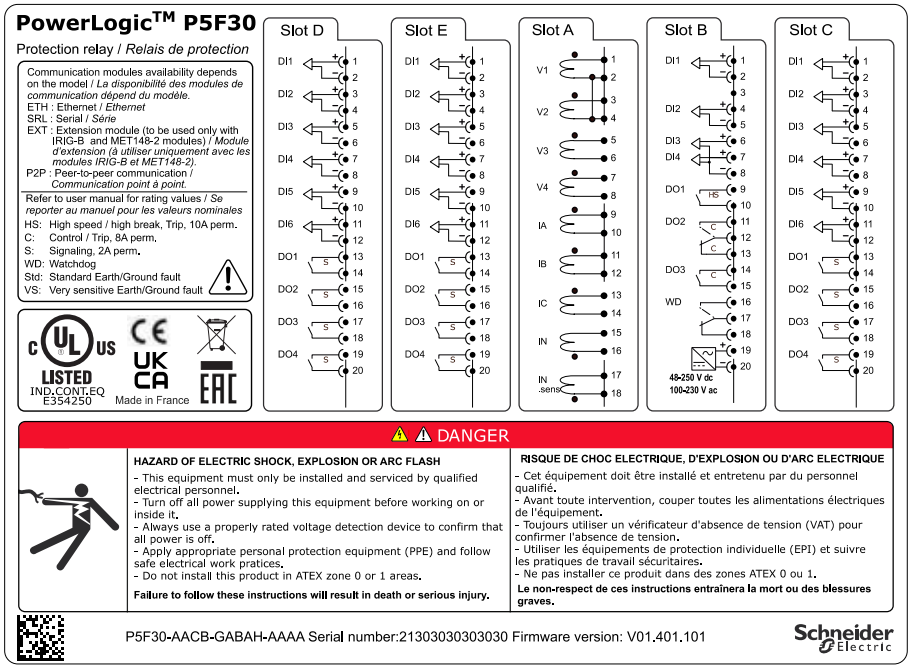
③ Serial number

④ Access to product website

Rear panel connection instructions label

The rear panel connection label contains the designation of the rear panel terminals together with instructions for installing and wiring the protection relay.

Figure 5 - Example rear panel connection instructions label



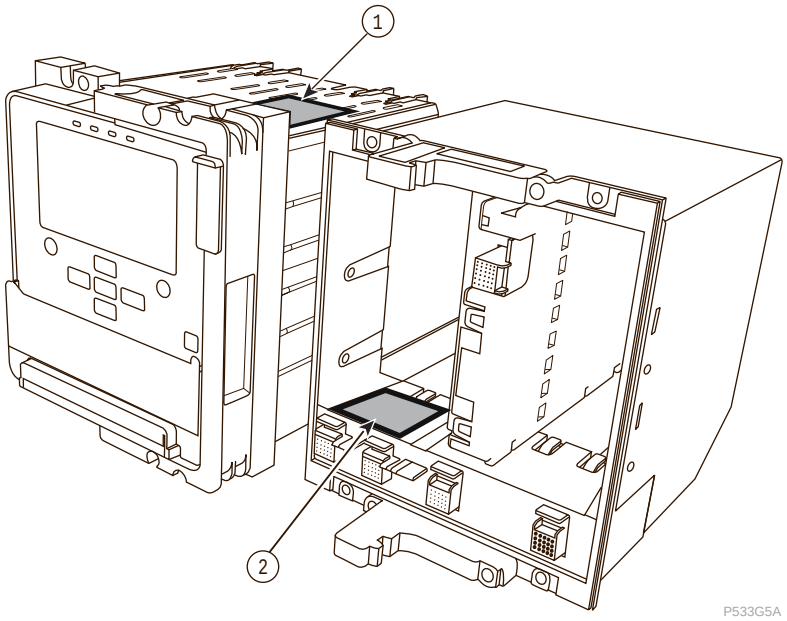
As built configuration

The information about model number, serial number and firmware number can be found on the bottom side of rear panel connection instructions label, as shown above. It informs on how the product was built and left the factory. If there are further manipulations on the product (for example, firmware upgrade), it is recommended to update the information on the label.

Model number label

Two model number labels containing the first digits of the device model number are available on both the withdrawable internal part ① and the static case ②. They are placed on the device for the purpose of correctly coupling the two parts during maintenance. If the withdrawable internal part of the protection relay is removed from the case, check that their model numbers are identical before assembling.

Figure 6 - Model number labels (PowerLogic P5x30 shown as an example)



① Model number label on the withdrawable internal part

② Model number on the static case

Rear panel identification stickers

Two kinds of identification stickers are available for the analogue input connector, the digital I/O connectors and the communication ports on the rear panel:

- Stickers on analogue input and digital I/O connectors ①:

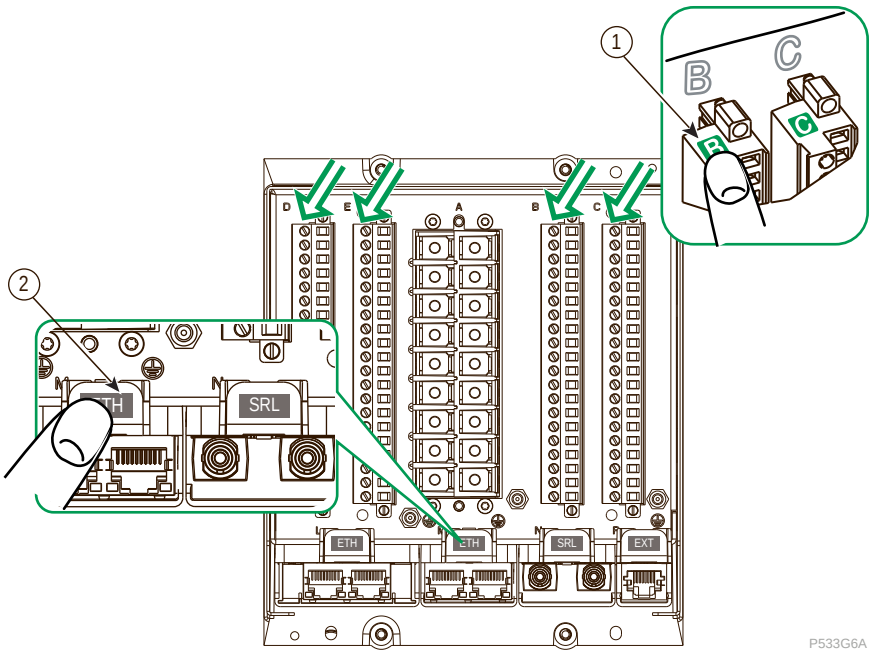
  Each analogue or digital connector on the rear panel is identified using a sticker. Stickers for additional, optional connectors are found in the product package.

- Communication port stickers ②:

  The rear ports of the communication modules are marked as follows:

ETH	Dual port copper (RJ45) or fibreoptic (multi-mode glass fibre) Ethernet ports
SRL	RS485 or fibre optic serial communication ports
EXT	Extension port for connection with external module and demodulated IRIG-B input or back-up memory

Figure 7 - Rear panel identification stickers



Dimensions

Product dimensions

Dimensions of the PowerLogic P5 protection relays are shown below:

Figure 8 - PowerLogic P5x20 dimensions

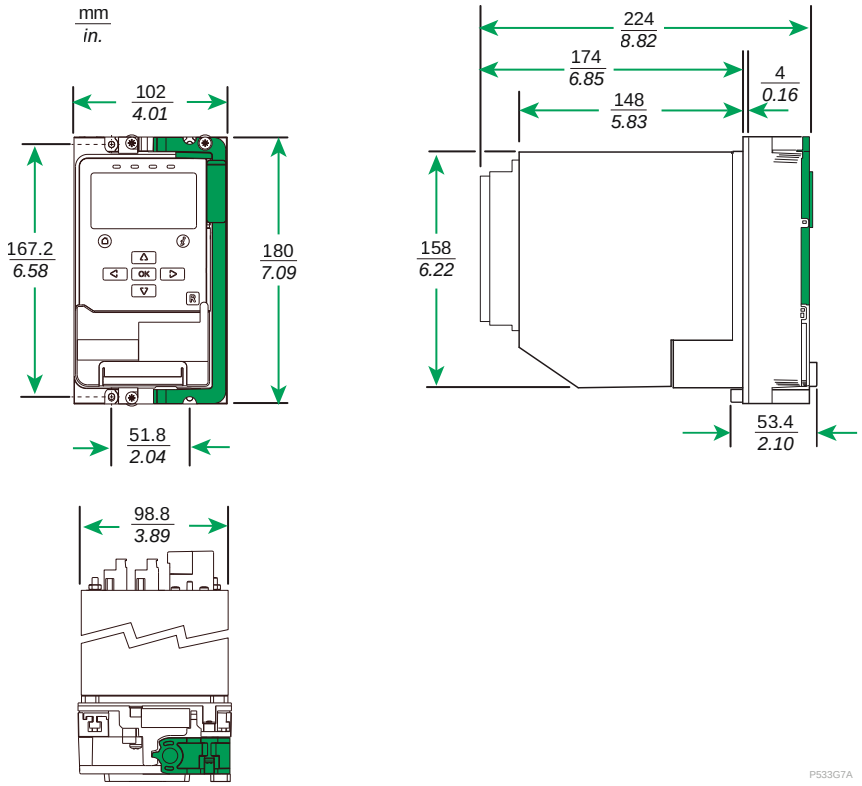


Figure 9 - PowerLogic P5x30 dimensions

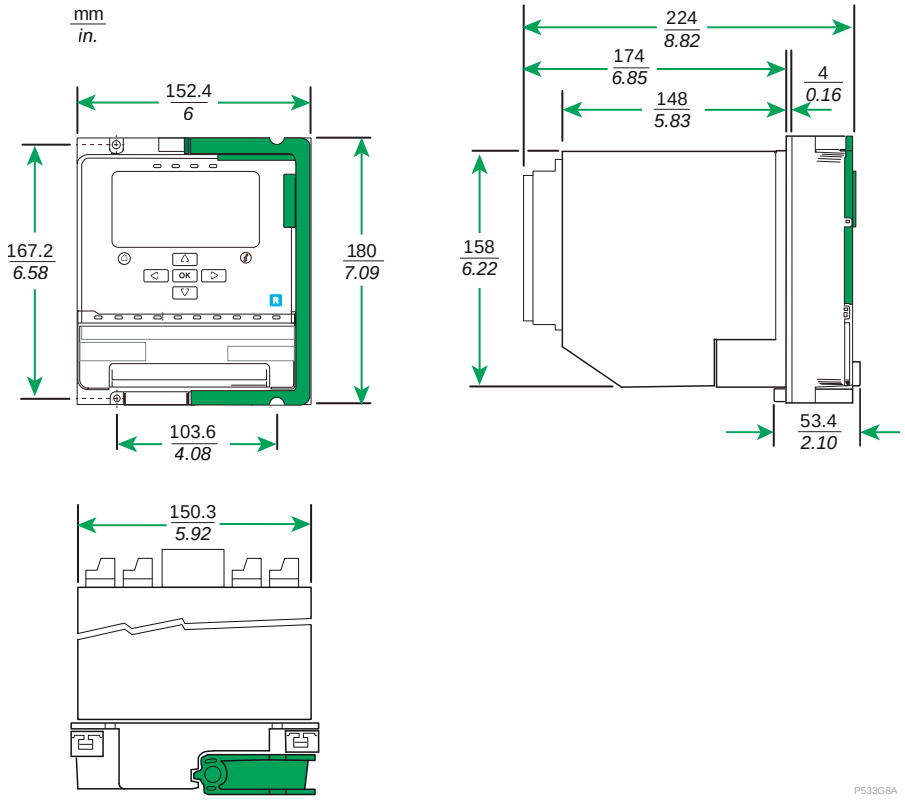
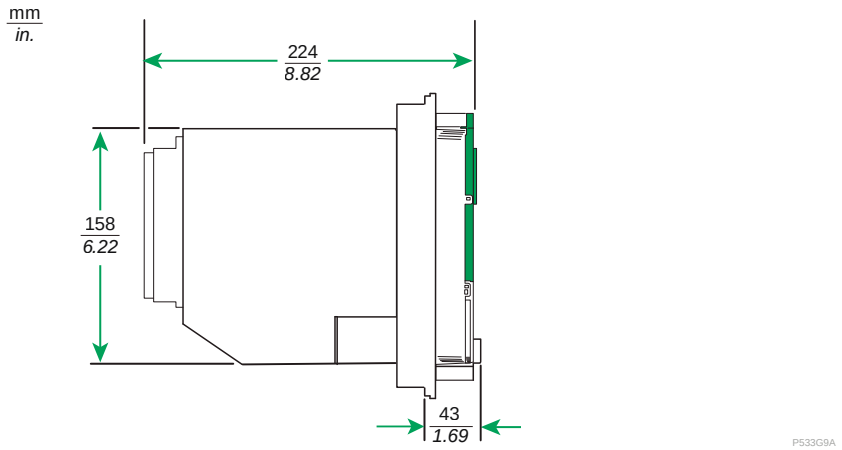


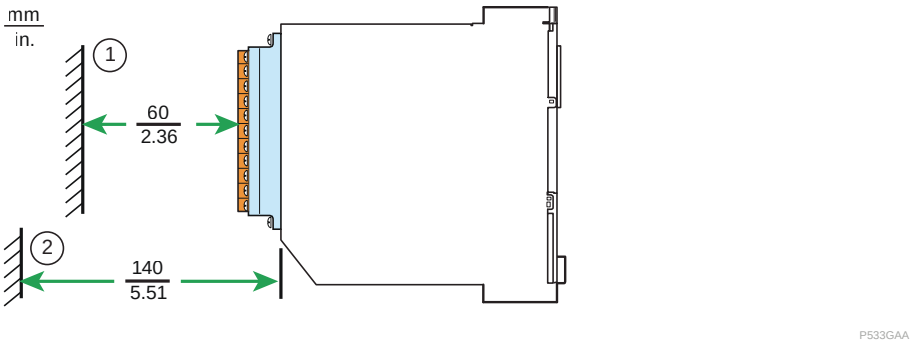
Figure 10 - PowerLogic P5 flush mounting dimension



Rear clearances

For easy access to the rear panel, the rear clearances illustrated below are recommended:

Figure 11 - Rear clearances illustrated



① This clearance must be available permanently for PowerLogic P5 protection relay wiring and assembly.

② This clearance should be transiently available during maintenance operations when communication modules are replaced.

Operating environment

Operating temperature and humidity

NOTICE
POTENTIAL DAMAGE FROM ENVIRONMENTAL CONDITIONS • The PowerLogic P5 protection relay must be installed in an environment within the specified operation temperature and humidity. • The protection relay may not operate correctly if condensation occurs on the electronic boards inside the device. **Failure to follow these instructions can result in equipment damage.**

The PowerLogic P5 protection relay is intended for indoor installation and use only. If it is required for use in an outdoor environment, it must be mounted in a specific cabinet that will enable it to meet the requirements of IEC 60529 with the classification of protection degree IP54 (dust and splashing water protected).

The temperature/relative humidity factors must be compatible with the environmental withstand characteristics of the PowerLogic P5 protection relay:

- Recommended operating range of temperature: -10°C to +55°C (+14°F to +131°F).
- Maximum operating temperature: -40°C to +70°C (-40°F to +158°F).
- Average humidity: <75% RH over the year.
- Temporary permissible humidity: <93% RH (less than 80 hours per year)
- No condensation.

If the operating conditions are outside the normal range, special arrangements should be made before commissioning, such as air conditioning of the premises.

Operation in a polluted atmosphere

A contaminated industrial atmosphere (such as the presence of chlorine, hydrofluoric acid, sulphur, solvents, etc.) can cause corrosion of the electronic components and terminals, in which case environmental control arrangements should be made (such as pressurised premises with filtered air, etc.) before commissioning.

To improve robustness of PowerLogic P5 protection relays against such environment, all the electronic boards of PowerLogic P5 protection relays have a conformal coating, type AVR80 BA.

Mounting

General mounting operations

Mounting the protection relay in panels or on rack frame

The PowerLogic P5 protection relays are available for flush mounting or rack mounting.

The PowerLogic P5 protection relay is fixed by four M4 x 20 mm (0.787 in.) stainless steel self-tapping screws with stainless steel washers (with diameter 4 x 8 mm (0.157 x 0.315 in.) maximum) at lower and upper parts.

Figure 12 - Mounting the PowerLogic P5x20 protection relay

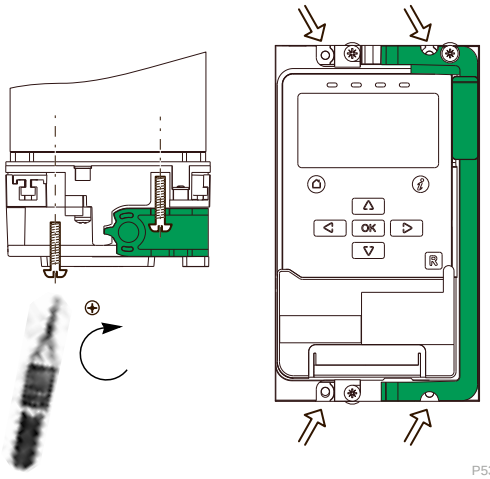
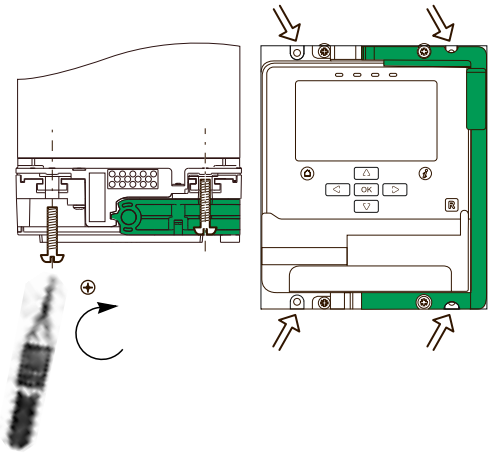


Figure 13 - Mounting the PowerLogic P5x30 protection relay



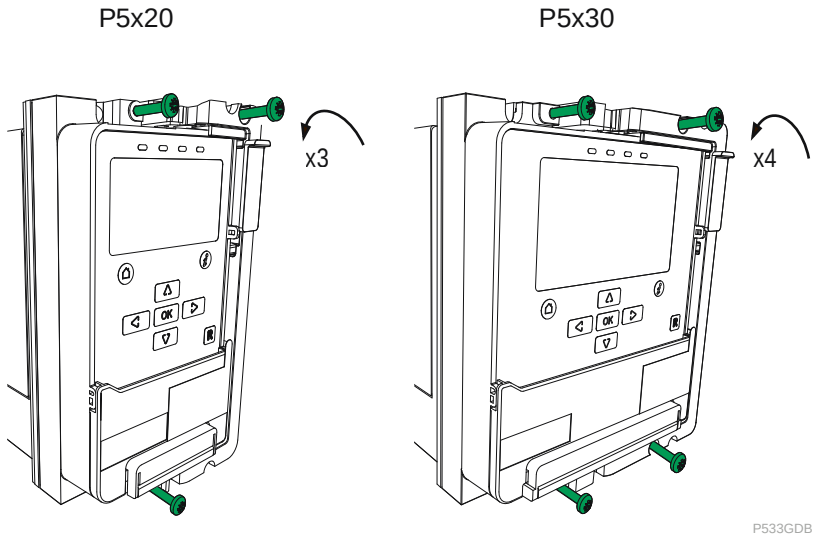
Screw	M4 x 20 mm (0.787 in.) stainless steel self-tapping screws with stainless steel washers (with diameter 4 x 8 mm (0.157 x 0.315 in.) maximum) x 4
Tightening torque	1N·m (8.85 lb-in)
Tool	Digital torque screwdriver

Unlocking the withdrawable part from its outer case

In order to maintain the withdrawable part (internal part) with the fixed part (outer part) of the relay during transportation, locking screws are used on the front face to fix the two relay parts together.

The front face locking screws can be unscrewed as shown in the figure below.

Figure 14 - Unscrewing the front face locking screws

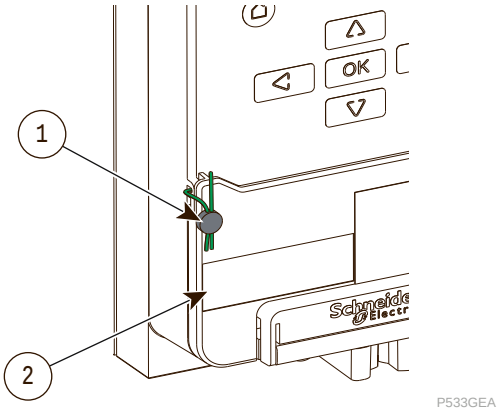


Screw	3 screws mounted on PowerLogic P5x20; 4 screws mounted on PowerLogic P5x30
Tightening torque for installing back the screws	1N·m (8.85 lb-in)
Tool	Digital torque screwdriver

Lock the shutter and handle

In order to help prevent unauthorised access to the command keys and USB ports on the local panel of the PowerLogic P5 protection relay, the shutter for covering the lower section of the protection relay needs to be locked with a wired lead seal.

Figure 15 - Lock the shutter

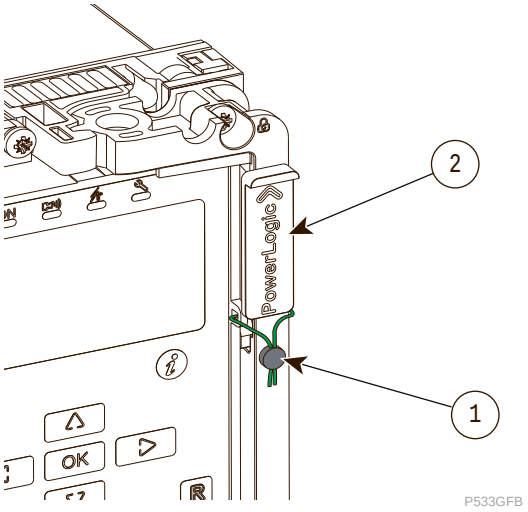


① Wired lead seal

② Protective panel

The handle on the front face of the protection relay is used to separate the withdrawable part from the fixed outer case. In order to help prevent unauthorised dismantling fix the lock tab on the handle with a wired lead seal to restrict the rotation of the handle.

Figure 16 - Lock the handle



① Wired lead seal

② Lock tab on the handle

Flush mounting with accessory

⚠CAUTION

CUTS AND PHYSICAL IMPACT

- Wear gloves and safety shoes.
- Trim the edges of the cut-out plates to remove any jagged edges.
- Carry the assembled relay with withdrawable part locked.
- When cases are mounted on a rack (with withdrawable part not inserted), stay far enough from the protruding part(s) of the case(s).

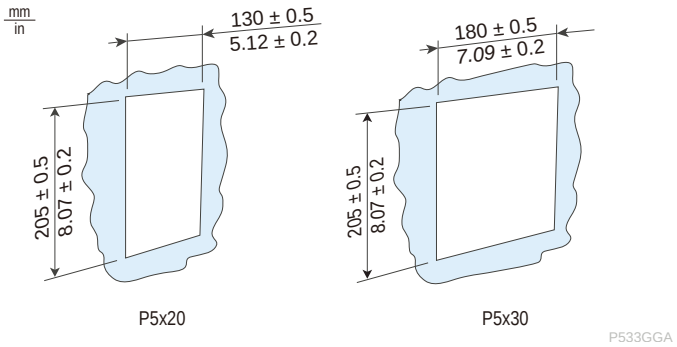
Failure to follow these instructions can result in injury or equipment damage.

The PowerLogic P5 protection relay can be mounted onto panels with the provided accessory. It is recommended to use the flush mounting with accessory for PowerLogic P5 protection relay.

Mounting Procedure

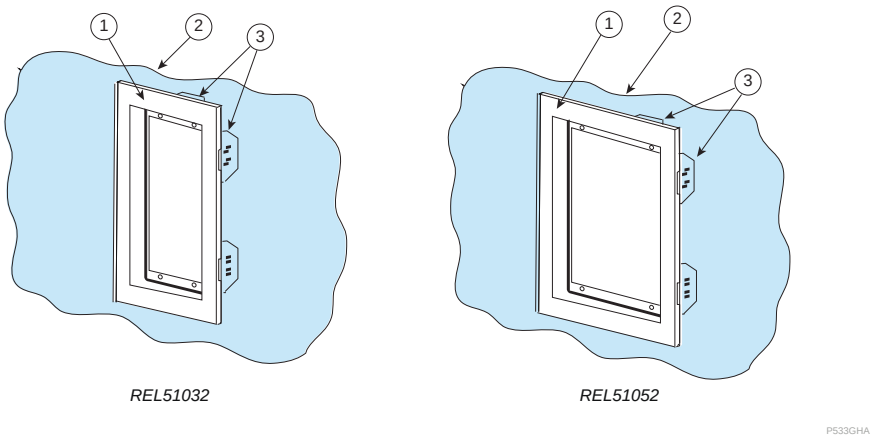
1. Prepare cut-out on the panel according to the following dimensions.

Figure 17 - Panel cut-out for PowerLogic P5x20/PowerLogic P5x30



2. Insert the flush mounting accessory ① in the panel ② and check that the rear mounting supports ③ are accessible for panel mounting kits to be inserted.

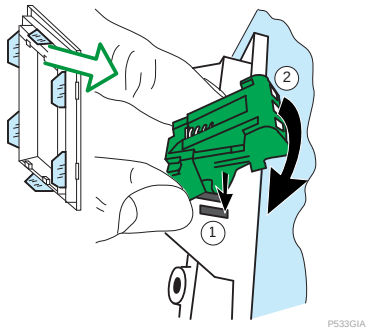
Figure 18 - Flush mounting accessories



Accessory Ref. No.	REL51032 (for use with PowerLogic P5x20)
Accessory Ref. No.	REL51052 (for use with PowerLogic P5x30)

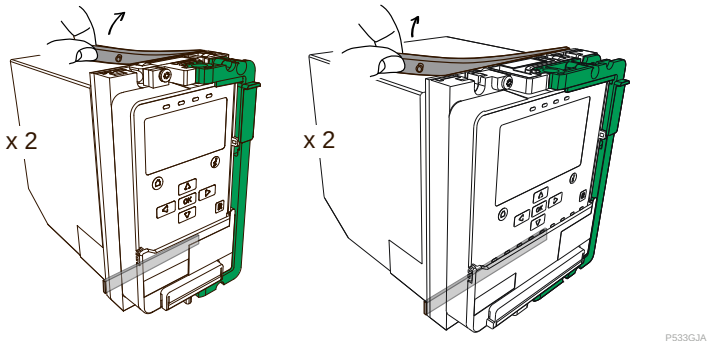
3. Insert the panel mounting kits in the mounting support holes ① and then push down the front parts (flush panel side) ② to lock the flush mounting accessory on the panel.

Figure 19 - Insert the mounting kits



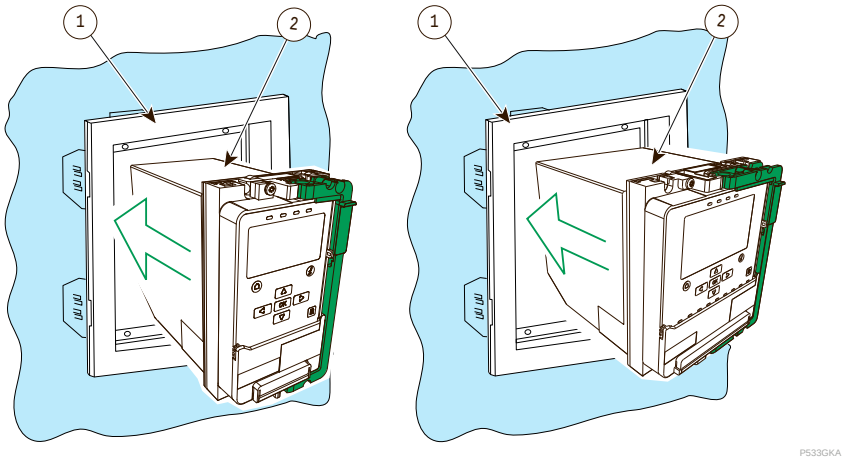
4. Remove the top and bottom seal straps from the rear mounting surface of the protection relay.

Figure 20 - Remove the seal straps from the relay



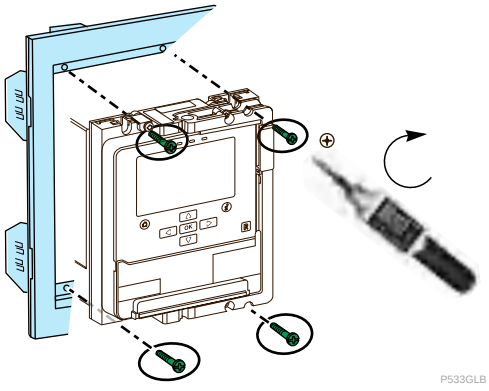
5. Insert the protection relay ② into the mounting accessory ① and hold it in the mounting position.

Figure 21 - Insert the protection relay



6. Fix the protection relay on the accessory with the screws provided in the flush mounting accessory.

Figure 22 - Fix the protection relay (PowerLogic P5x30 shown as an example)



Screw	4 screws provided with the flush mounting accessory
Tightening torque	1 N·m (8.85 lb-in)
Tool	Digital torque screwdriver

Flush mounting without accessory

⚠CAUTION

CUTS AND PHYSICAL IMPACT

- Wear gloves and safety shoes.
- Trim the edges of the cut-out plates to remove any jagged edges.
- Carry the assembled relay with withdrawable part locked.
- When cases are mounted on a rack (with withdrawable part not inserted), stay far enough from the protruding part(s) of the case(s).

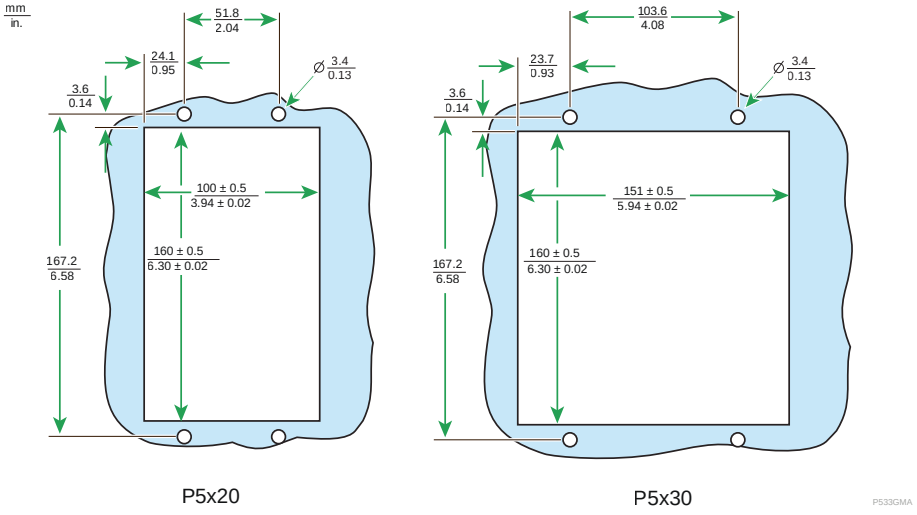
Failure to follow these instructions can result in injury or equipment damage.

The PowerLogic P5 protection relay can be mounted directly onto panels without any accessory.

Mounting Procedure

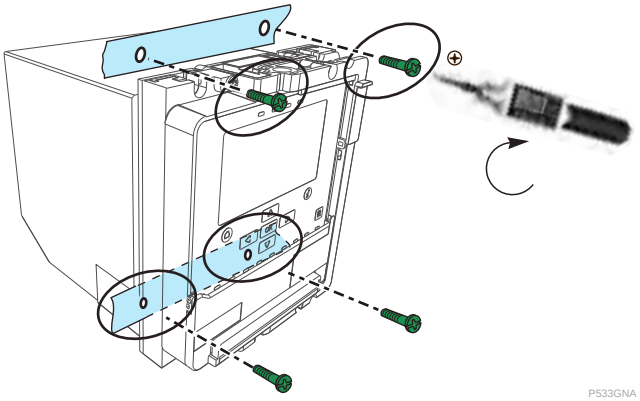
1. Prepare the cut-out in the panel for flush mounting according to the following dimensions.
   The thickness of the panel plate should be a minimum of 3 mm (0.12 in.).

Figure 23 - Panel cut out for PowerLogic P5x20/PowerLogic P5x30



2. Fasten the PowerLogic P5 protection relay in its position with four M4 x 20 mm (0.787 in.) stainless steel self-tapping screws with stainless steel washers (diameter 4 x 8 mm (0.157 x 0.315 in.) maximum) at lower and upper parts.

Figure 24 - Fastening the PowerLogic P5 onto panel (PowerLogic P5x30 shown as an example)



Screw	M4 x 20 mm (0.787 in.) stainless steel self-tapping screws with stainless steel washers (with diameter 4 x 8 mm (0.157 x 0.315 in.) maximum) x 4
Tightening torque	1 N·m (8.85 lb-in)
Tool	Digital torque screwdriver

Rack mounting

⚠CAUTION

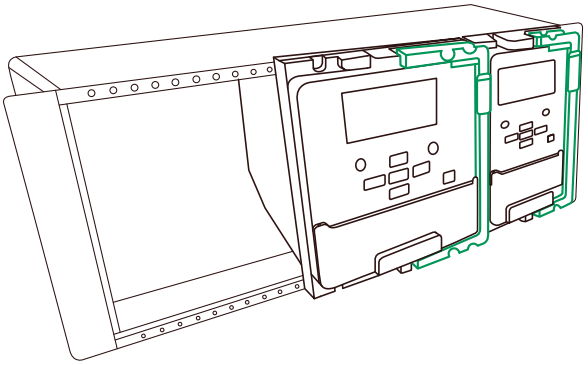
FALLING DEVICES

- Wear gloves and safety shoes.
- Carry the assembled relay with withdrawable part locked.
- When cases are mounted on a rack (with withdrawable part not inserted), stay far enough from the protruding part(s) of the case(s).

Failure to follow these instructions can result in injury or equipment damage.

PowerLogic P5 protection relays may be rack mounted using single rack mounting frames (ref: REL51021), as illustrated in the figure below.

Figure 25 - Rack mounted protection relays



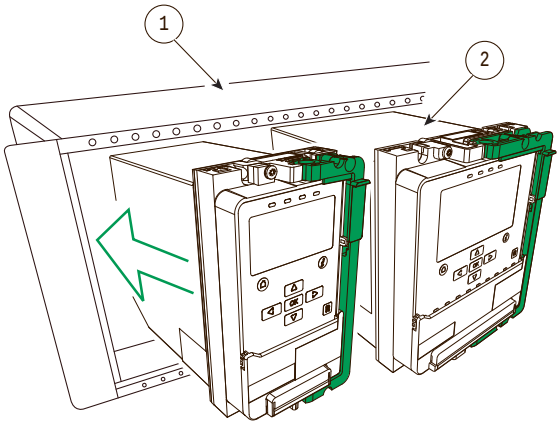
The two horizontal rails of the rack frame are drilled of holes at approximately 26 mm (10 in.) intervals. The PowerLogic P5 protection relays are fixed by their mounting flanges using M4 x 20 mm (0.787 in.) stainless steel self-tapping screws with stainless steel washers (diameter 4 x 8 mm (0.157 x 0.315 in.) maximum).

Relays can be mechanically grouped into single tier or multi-tier arrangements by means of the rack frame. This enables schemes using products from the PowerLogic P5 product ranges to be pre-wired together prior to mounting (rack mounting with M4 self-tapping screws, washers and nut).

Mounting Procedure

1. Insert the PowerLogic P5 protection relay ② into the rack frame ①.

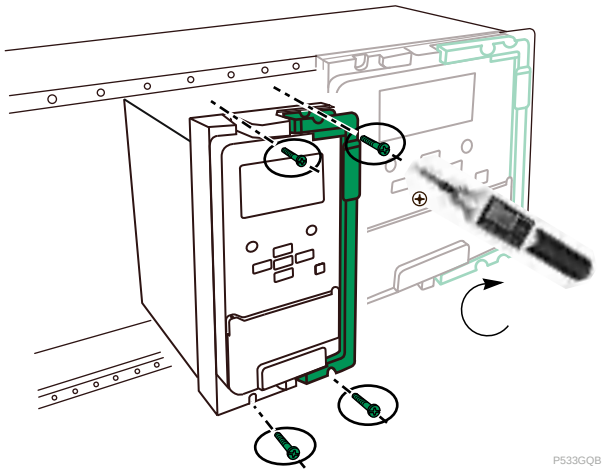
Figure 26 - Insert the protection relay into the rack frame



Rack frame Ref. No.	REL51021

2. Fasten the protection relay onto the rack frame with four M4 x 20 mm (0.787 in.) stainless steel self-tapping screws and stainless steel washers (diameter 4 x 8 mm (0.157 x 0.315 in.) maximum).

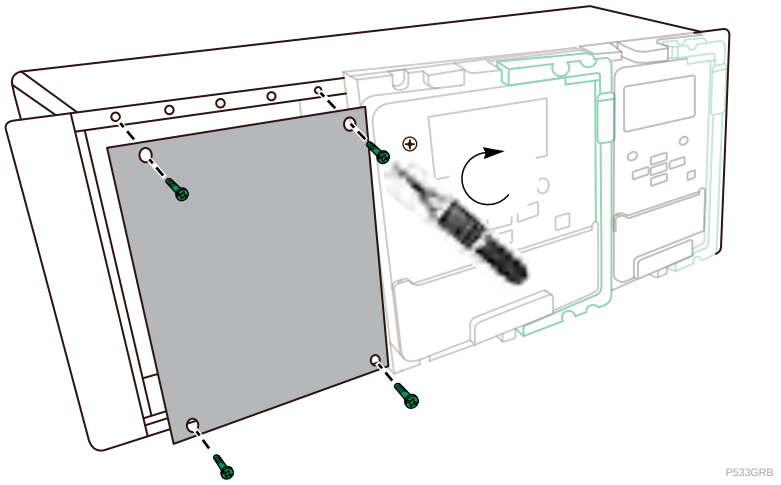
Figure 27 - Fasten the protection relay onto the rack frame (PowerLogic P5x20 shown as an example)



Screw	M4 x 20 mm (0.787 in.) stainless steel self-tapping screws with stainless steel washers (with diameter 4 x 8 mm (0.157 x 0.315 in.) maximum) x 4
Tightening torque	1 N·m (8.85 lb-in)
Tool	Digital torque screwdriver

3. Cover up the open section of the rack frame with blank plates if there is still space left for future installation of protection relays or ancillary components.

Figure 28 - Install the blank plate



Blank plate Ref. No.	REL51018: 30TE 206.8 mm x 177 mm (6 in. x 6.97 in.) REL51019: 20TE 103.2 mm x 177 mm (4 in. x 6.97 in.); REL51020: 10TE 50.2 mm x 177 mm (2 in. x 6.97 in.);
Screws	M4 x 20 mm (0.787 in.) stainless steel self-tapping screws with stainless steel washers (with diameter 4 x 8 mm (0.157 x 0.315 in.) maximum) x 4
Tightening torque	1.0 N·m (8.85 lb-in)
Tool	Digital torque screwdriver
Subsequent operation	Mount the rack frame on the rack using the mounting flanges on both sides of the frame.

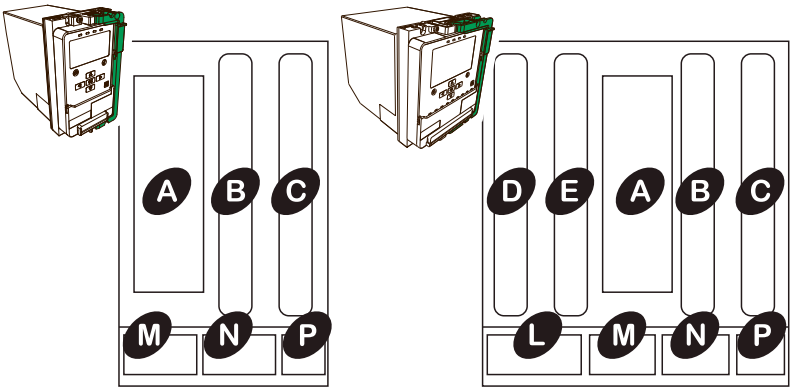
Rear panel connectors and application diagrams

PowerLogic P5 rear panel

Rear panel layout

The PowerLogic P5 protection and control relay rear panels contain the following modules installed in slots and identified by letters:

Figure 29 - PowerLogic P5 protection and control relay rear panels



P533GSA

PowerLogic P5x20	PowerLogic P5x30	Slot: Module
✓	✓	A: Analogue input module
✓	✓	B: Power supply
✓	✓	C: Empty or additional digital input/output module
	✓	D: Empty or additional digital input/output module
	✓	E: Empty or additional digital input/output module
	✓	L: ETH, Ethernet module (TP) or L: P2P, Inter-relay module(FO)
✓	✓	M: ETH, Ethernet module (TP or FO)
✓	✓	N: SRL, Serial communication module (RS485 or FO)
✓	✓	P: EXT, Extension module
✓	✓	M and N: Ethernet HSR/PRP RS485 module 2TP or Ethernet HSR/PRP RS485 module 2FO

NOTE: For the slot occupation rules of PowerLogic P5x30 slot C, D and E, refer to Slot occupation rules, page 590.

PowerLogic P5U20 rear panel (CT version)

Figure 30 - PowerLogic P5U20 rear panel (CT version)

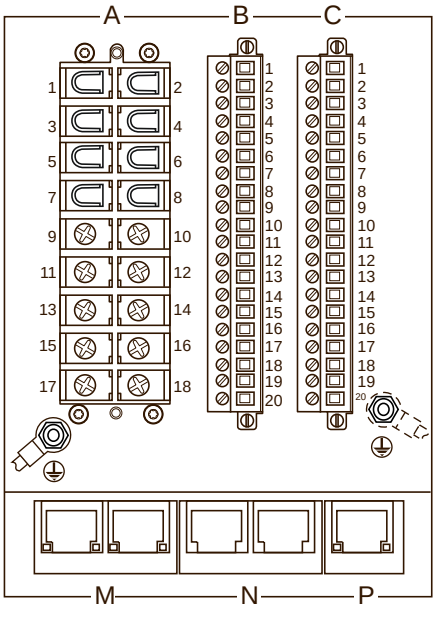
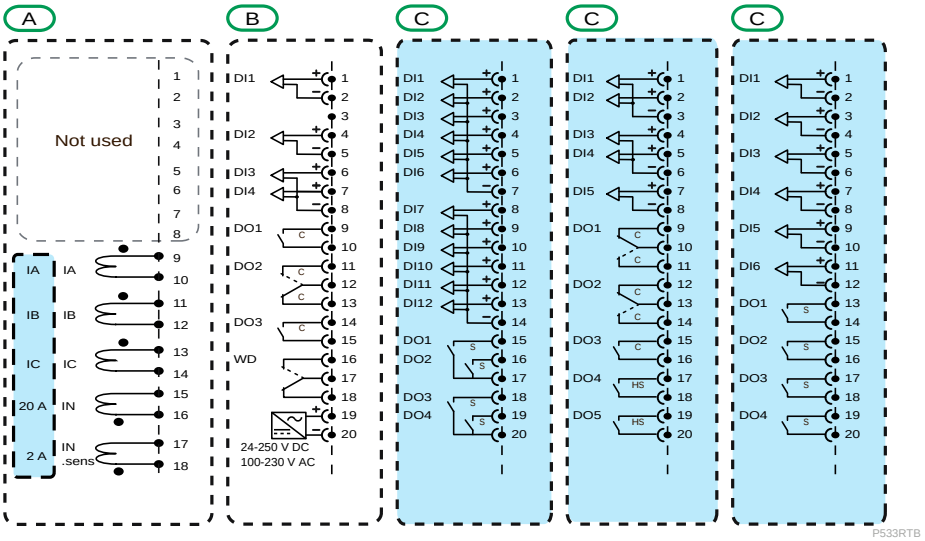


Figure 31 - PowerLogic P5U20 (CT version) rear terminal designations



	Optional
IX	Phase current
DIx	Digital input
DOx	Digital output
- HS	High speed / high break, Trip, 10 A perm.
- C	Control / Trip, 8 A perm.
- S	Signalling, 2 A perm.
IN	Standard earth/ground fault
IN.sens	Sensitive earth/ground fault
WD	Watchdog contact

PowerLogic P5U20 rear panel (LPCT/LPVT version)

Figure 32 - PowerLogic P5U20 rear panel (LPCT/LPVT version)

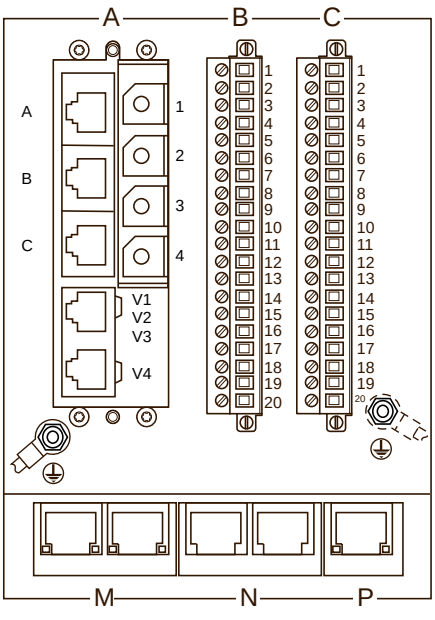
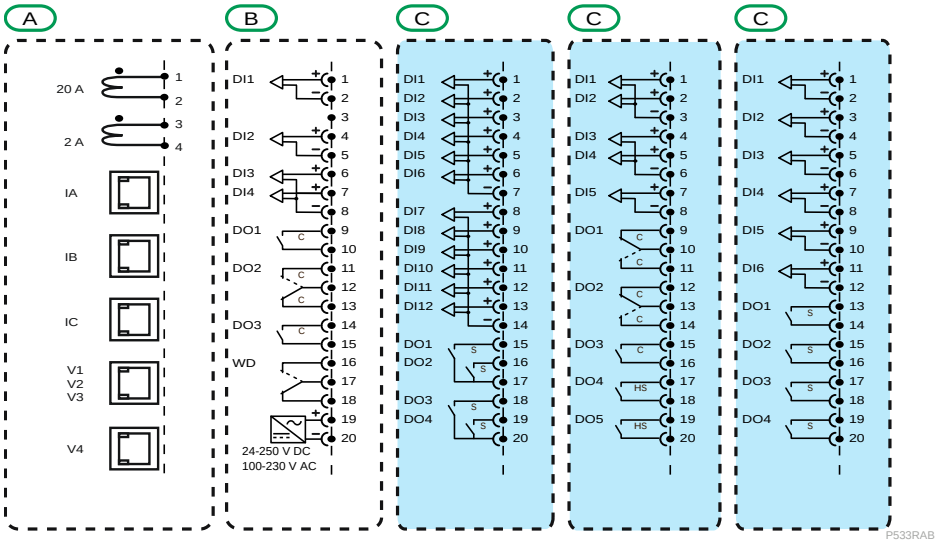


Figure 33 - PowerLogic P5U20 (LPCT/LPVT version) rear terminal designations



	Optional
IX	Phase current
DIx	Digital input
DOx	Digital output
- HS	High Speed / high break, Trip, 10 A perm.
- C	Control / Trip, 8 A perm.
- S	Signalling, 2 A perm.
VX	phase to neutral voltage
WD	Watchdog contact

PowerLogic P5V20 rear panel

Figure 34 - PowerLogic P5V20 rear panel

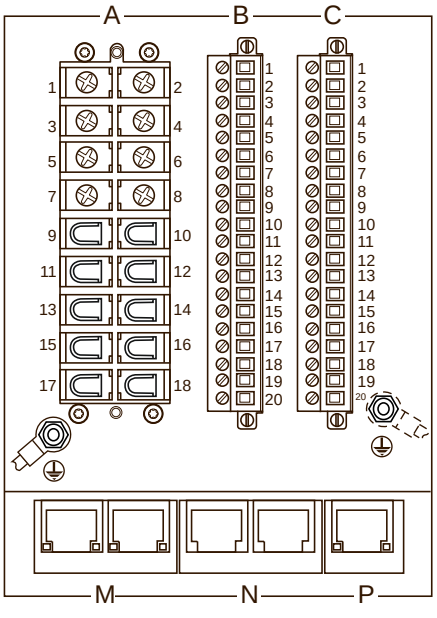
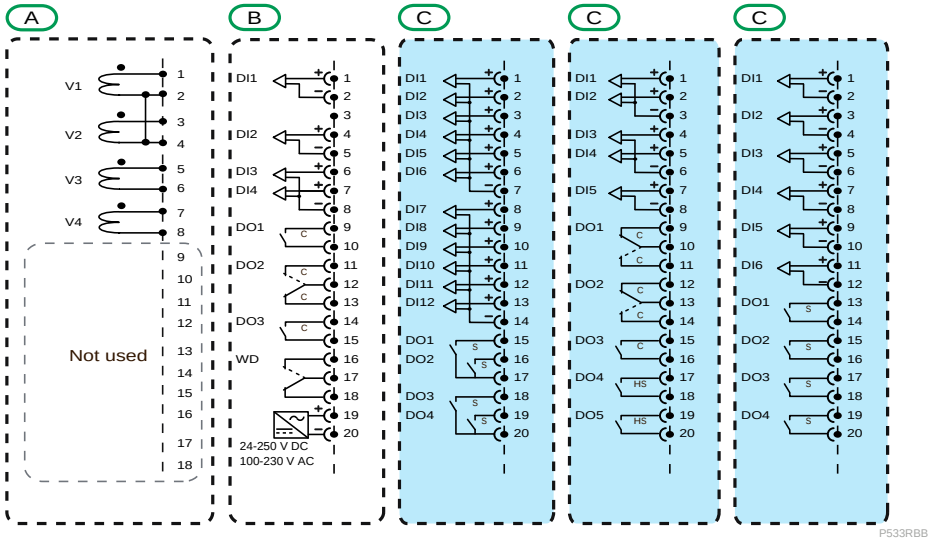


Figure 35 - PowerLogic P5V20 rear terminal designations



	Optional
VX	Phase to neutral voltage
DOx	Digital output
- HS	High Speed / high break,Trip, 10 A perm.
- C	Control / Trip, 8 A perm.
- S	Signalling, 2 A perm.
WD	Watchdog contact
DIx	Digital input

PowerLogic P5F30/P5M30 rear panel (CT/VT version)

Figure 36 - PowerLogic P5F30/P5M30 rear panel (CT/VT version)

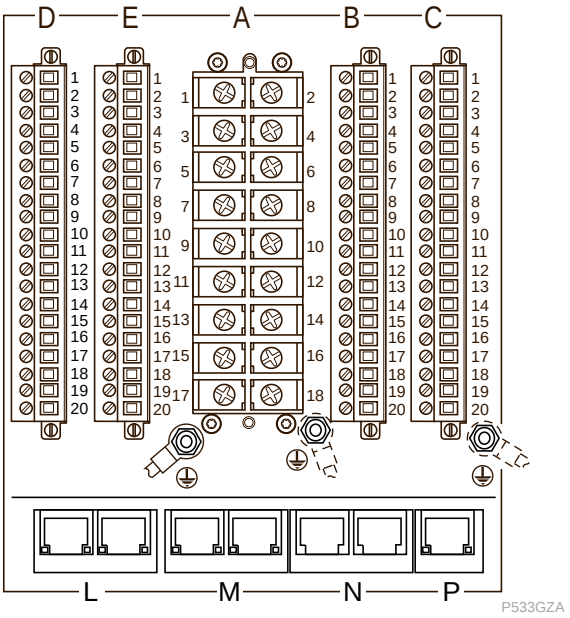
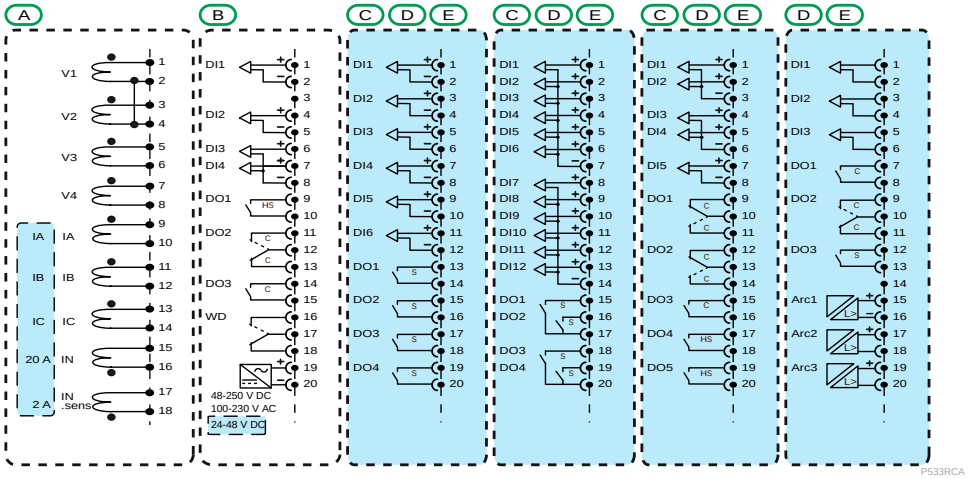


Figure 37 - PowerLogic P5F30/P5M30 (CT/VT version) rear terminal designations



	Optional
IX	Phase current
VX	Phase to neutral voltage
DIx	Digital input
DOx	Digital output
- HS	High Speed / high break, Trip, 10 A perm.
- C	Control / Trip, 8 A perm.
- S	Signalling, 2 A perm.
IN.sens	Sensitive earth/ground fault
IN	Standard earth/ground fault
Arc	Arc sensor
WD	Watchdog contact

PowerLogic P5F30/P5M30 rear panel (LPCT/LPVT version)

Figure 38 - PowerLogic P5F30/P5M30 rear panel (LPCT/LPVT version)

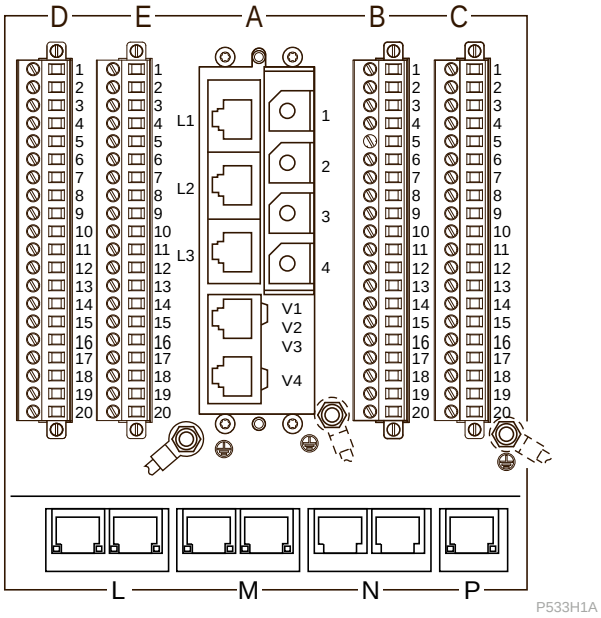
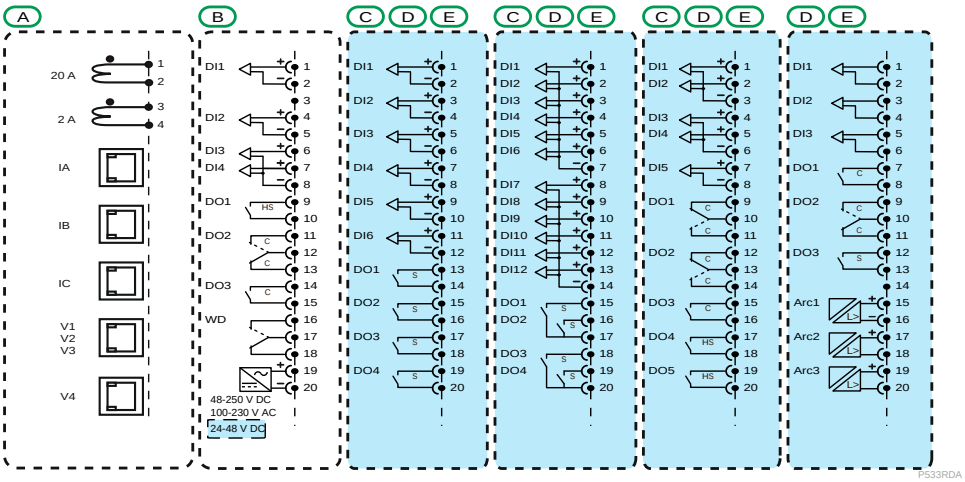


Figure 39 - PowerLogic P5F30/P5M30 (LPCT/LPVT version) rear terminal designations



	Optional
IX	Phase current
DIx	Digital input
DOx	Digital output
- HS	High Speed / high break, Trip, 10 A perm.
- C	Control / Trip, 8 A perm.
- S	Signalling, 2 A perm.
VX	Phase to neutral voltage
Arc	Arc sensor
WD	Watchdog contact

PowerLogic P5T30 rear panel (CT/VT version)

Figure 40 - PowerLogic P5T30 rear panel (CT/VT version)

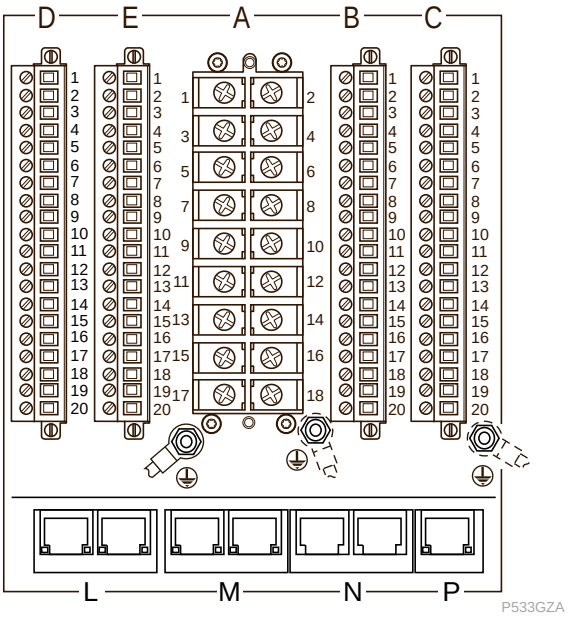
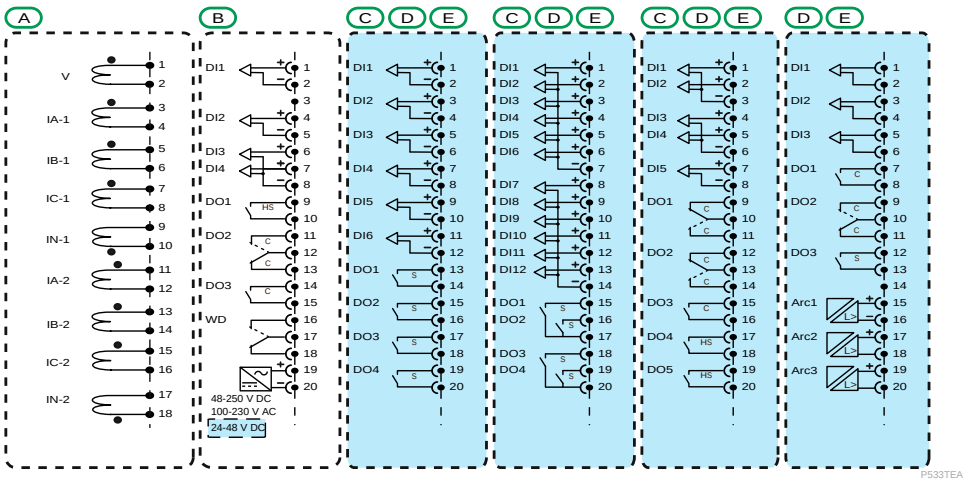


Figure 41 - PowerLogic P5T30 (CT/VT version) rear terminal designations



	Optional
V	Voltage
IX-1/2	Phase current
DIx	Digital input
DOx	Digital output
- HS	High Speed / high break, Trip, 10 A perm.
- C	Control / Trip, 8 A perm.
- S	Signalling, 2 A perm.
IN-1/2	Standard earth/ground fault
Arc	Arc sensor
WD	Watchdog contact

Default DI/DO configuration of the slot B terminals

The following table lists the default configuration of the digital input and digital output terminals in slot B of the PowerLogic P5 protection and control relay.

Table 6 - Default DI/DO configuration of the slot B terminals

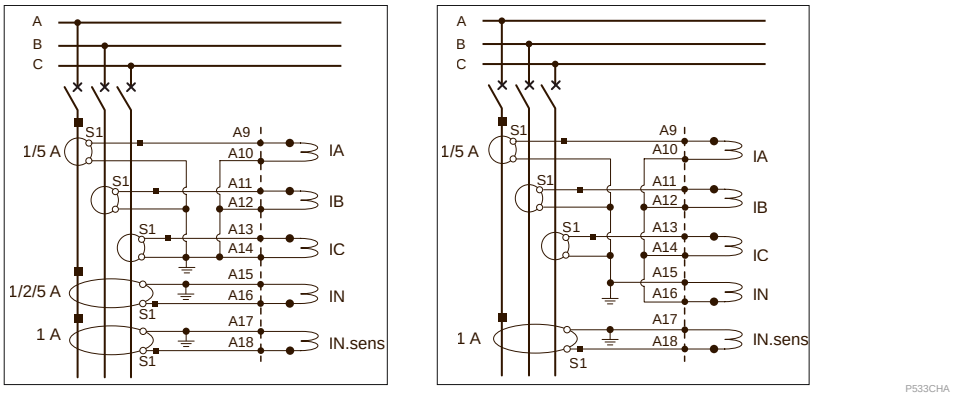
DI1	CB open
DI2	CB close
DI3	Free
DI4	Free
DO1	CB trip
DO2	CB trip lockout
DO3	CB close
WD	Watchdog (not configurable)

Typical application diagrams

The following sections describe typical application diagrams.

CT and LPCT typical application

Figure 42 - 3 x 1/5A CTs and neutral current measured by 1 x 1/2/5A CT and 1 x 1A CT



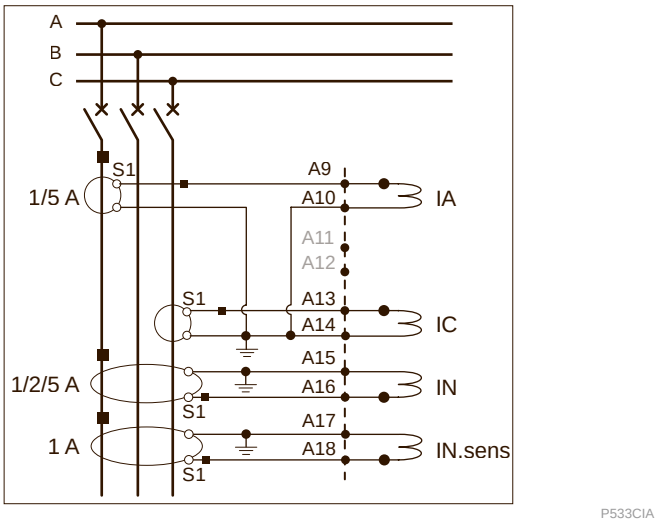
IN: Standard earth/ground fault

IN.sens: Sensitive earth/ground fault

NOTE: For an application with 2 CTs, only IA and IC are used by PowerLogic P5 protection relay (see figure below).

Such so-called 2 CT mode further requires firmware adjustment with setting **Number of connected phase CT** = *A/C* in the **GENERAL** menu/**Scaling** sub-menu. It impacts power measurements as well as protection and monitoring functions using negative sequence currents as detailed in the function descriptions.

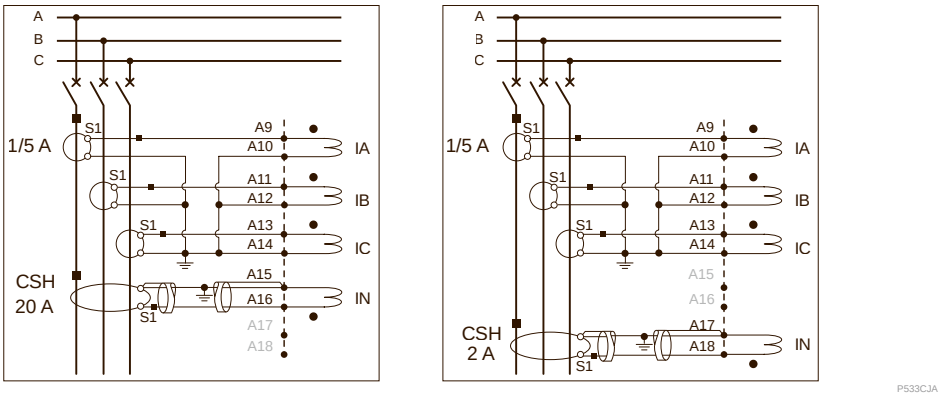
Figure 43 - 3 x 1/5A CTs (with IB not connected) and neutral current measured by 1 x 1/2/5A CT and 1 x 1A CT



IN: Standard earth/ground fault

IN.sens: Sensitive earth/ground fault

Figure 44 - 3 x 1/5A CTs and 1 neutral current measured by CSH



NOTE: For an application with 2 CTs, only IA and IC are used by PowerLogic P5 protection relay(see figure below).

Such so-called 2 CT mode further requires firmware adjustment with setting **Number of connected phase CT** = *A/C* in the **GENERAL** menu/**Scaling** sub-menu. It impacts power measurements as well as protection and monitoring functions using negative sequence currents as detailed in the function descriptions.

Figure 45 - 3 x 1/5A CTs (with IB not connected) and 1 neutral current measured by CSH

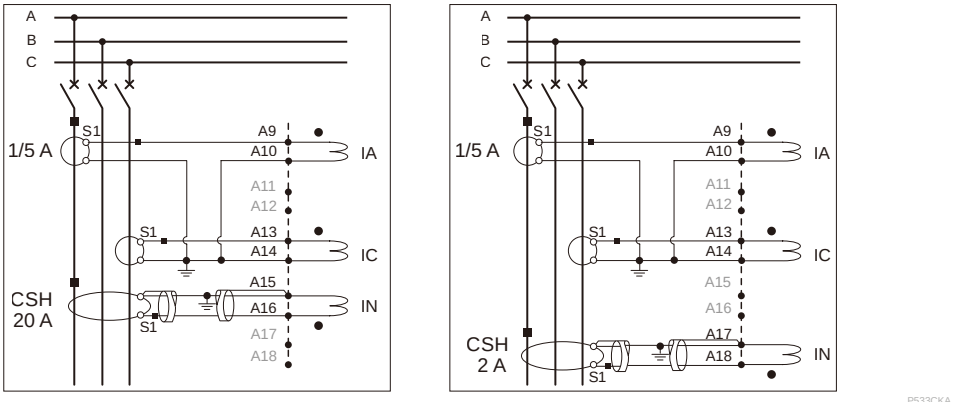
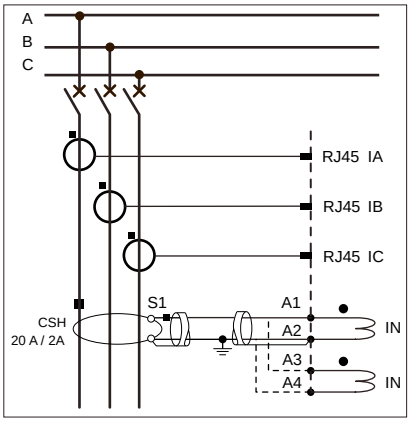
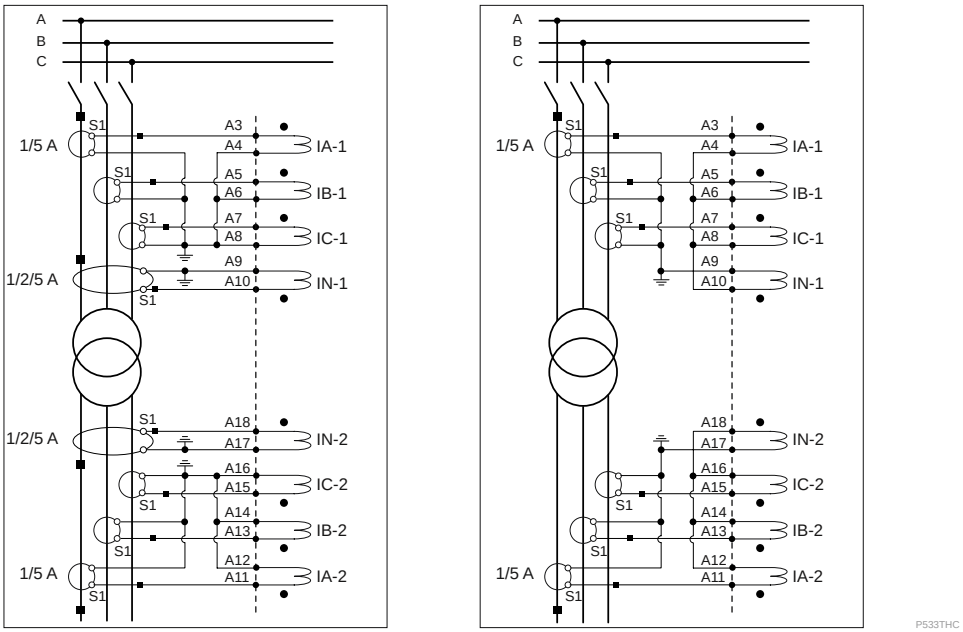


Figure 46 - 3 LPCT and 1 neutral current measured by CSH



NOTE: All 3 LPCTs must always be connected to the PowerLogic P5 protection relay for proper measurement.

Figure 47 - P5T30 with 6 x 1/5A CTs and neutral currents measured by 2 x 1/ 2/5A CTs



NOTE: Figures show standard connection with phase CTs common points on transformer side.

NOTE: Neutral CTs can also be used to measure the current in a star point earthing/grounding of wye or zigzag connected transformer windings; or in the measuring path of a high-impedance earth/ground fault protection scheme.

VT typical application

Voltage input terminals A2 and A4 have been connected internally. For three phase to neutral applications, short terminals A4 and A6 together.

Figure 48 - 3 phase to neutral voltages (3VP)

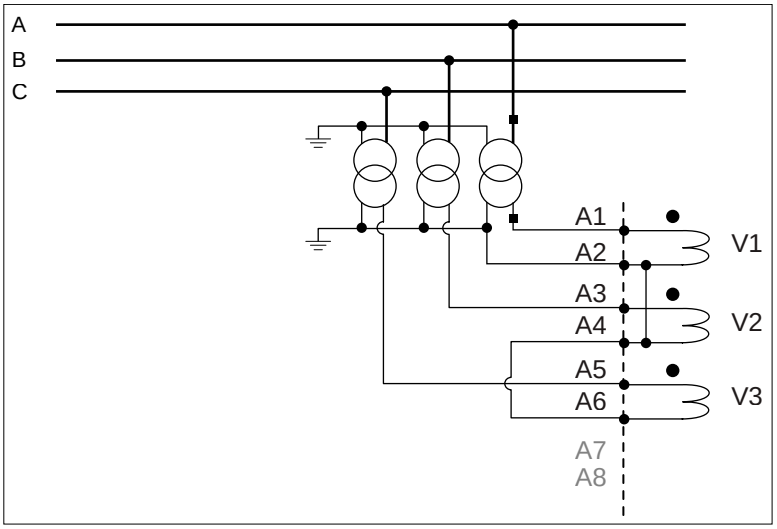


Figure 49 - 3 phase to neutral voltages + 1 neutral voltage (3VP+VN)

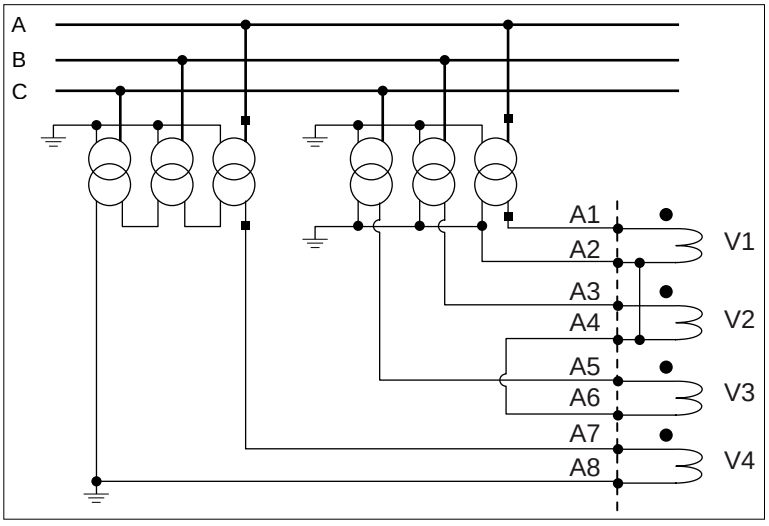


Figure 50 - 3 phase to neutral voltages + 1 phase to neutral voltage (3VP/ VPy)

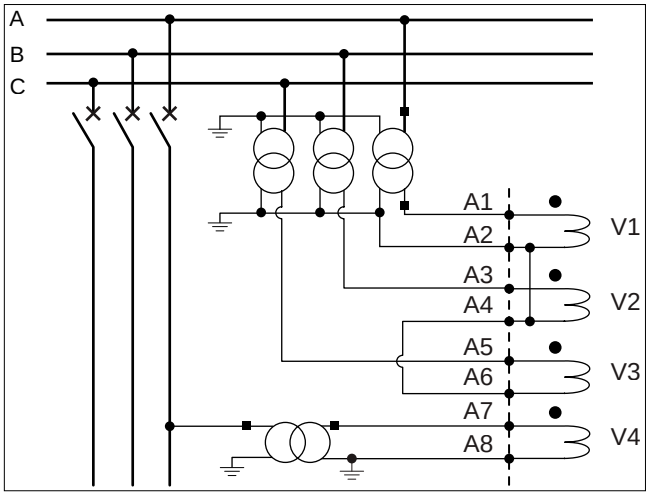


Figure 51 - 3 phase to neutral voltages + 1 phase to phase voltage (3VP/ VPPy)

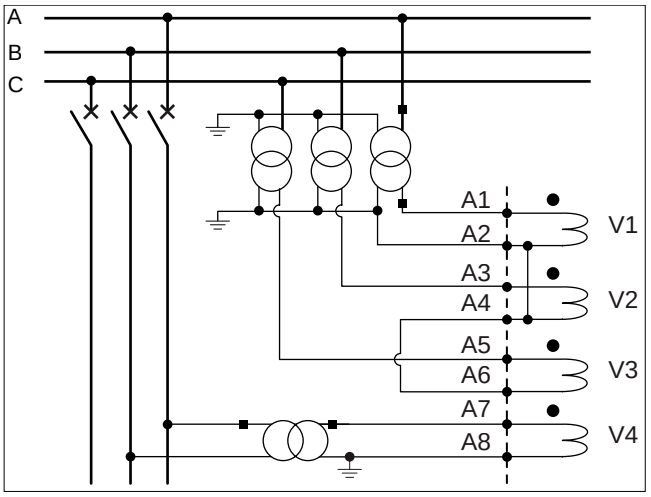


Figure 52 - 2 phase to phase voltages + 1 neutral voltage + phase to phase voltage (2VPP+VN+VPPy)

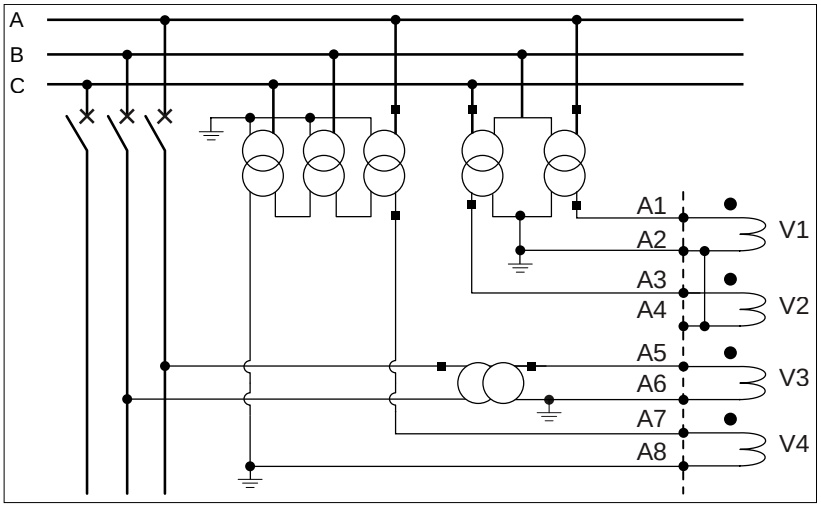


Figure 53 - 2 phase to phase voltages + 1 neutral voltage (2VPP + VN)

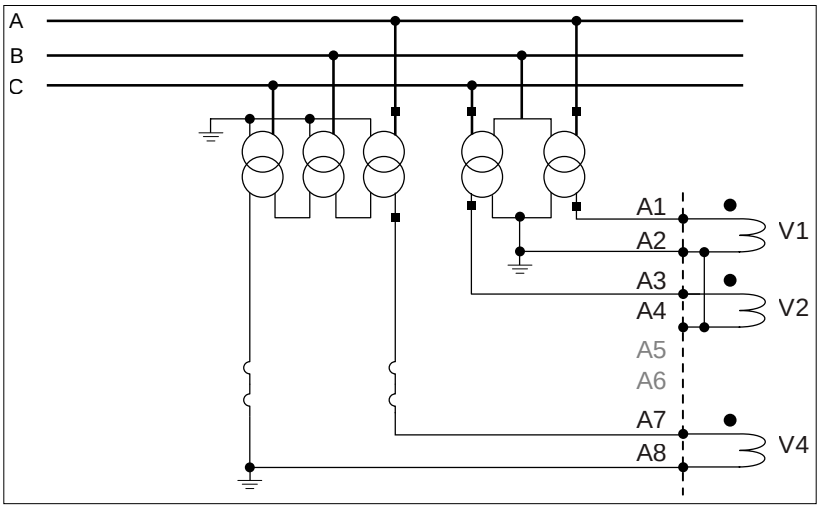


Figure 54 - 1 phase to phase voltage + 1 phase to phase voltage (VPP/VPPy)

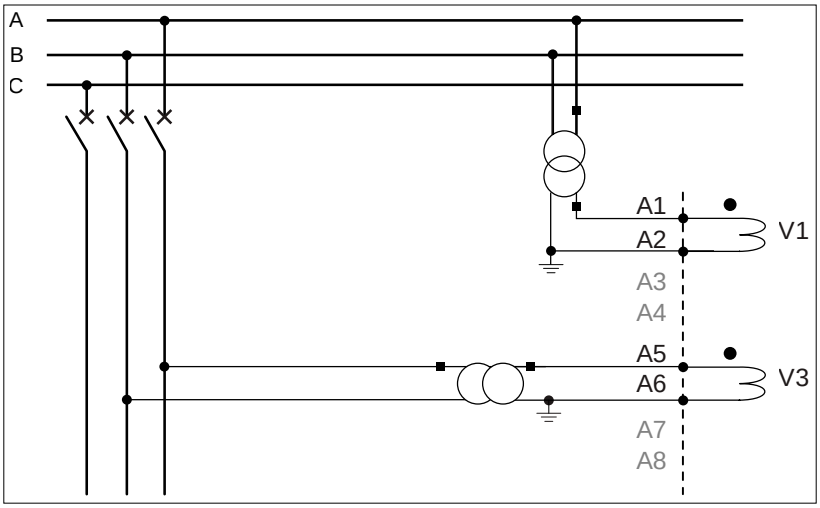
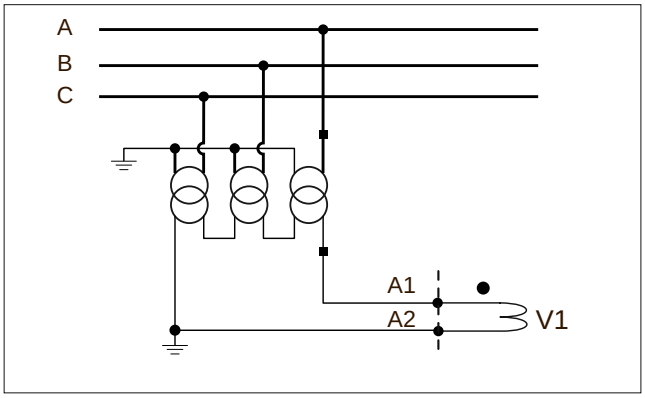


Figure 55 - P5T30 with neutral voltage (VN)



LPVT typical application

Figure 56 - 3 phase to neutral LPVT (3VP)

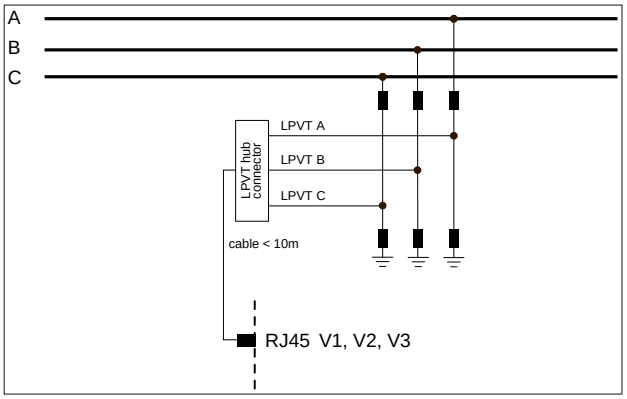
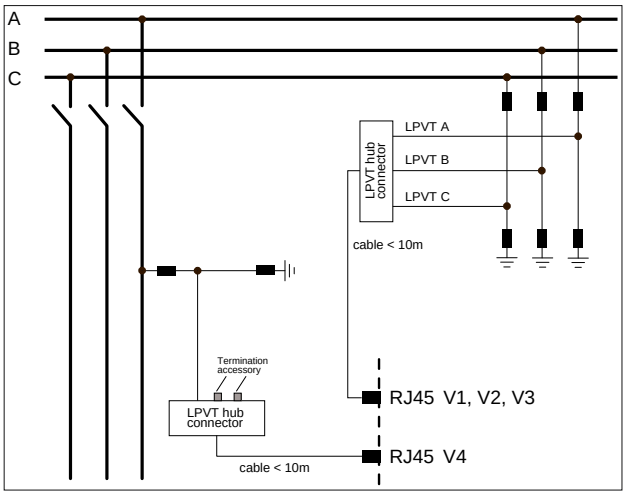


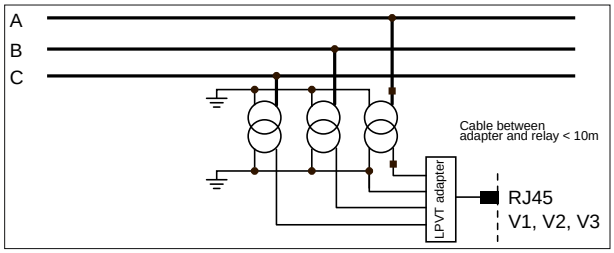
Figure 57 - 3 phase to neutral LPVT + 1 phase to neutral LPVT (3VP/VPy)



NOTE: If one or two LPVTs are connected to the LPVT hub connector, the termination accessories should be plugged to the 2nd and third input. These termination accessories are delivered with each LPCT/LPVT hardware variant in accessories bag. In case the accessories are lost, it is recommended to order spare part accessories for LPCT/LPVT variant (REL51079).

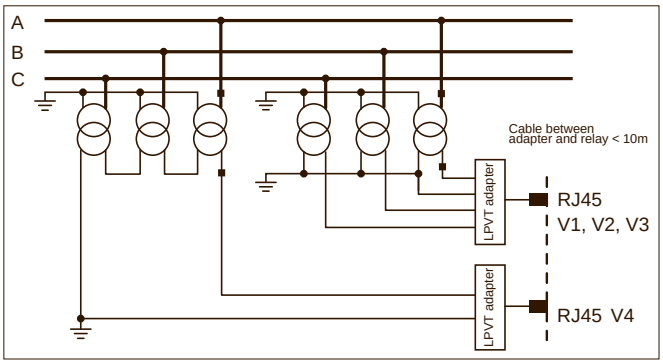
LPVT adapter typical application

Figure 58 - 3 phase to neutral voltages (3VP)



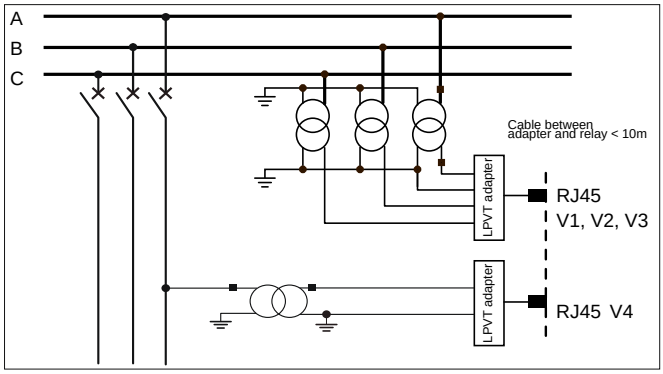
P533CWB

Figure 59 - 3 phase to neutral voltages + 1 neutral voltage (3VP+VN)



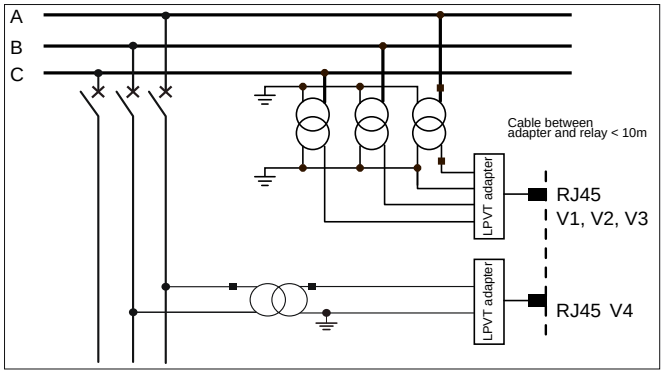
P533CYB

Figure 60 - 3 phase to neutral voltages + 1 phase to neutral voltage (3VP/VPy)



P533D0B

Figure 61 - 3 phase to neutral voltages + 1 phase to phase voltage (3VP/VPPy)



P533D2C

Wiring on the real panel

⚠DANGER

FIRE HAZARD

Apply proper tightening torque to all wire connections.

Failure to follow these instructions will result in death or serious injury.

Slot A: analogue module

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Use the appropriate (3 or 4-terminal) copper jumper for common connections.
- After cabling, protect the rear connector A with the two protective caps.

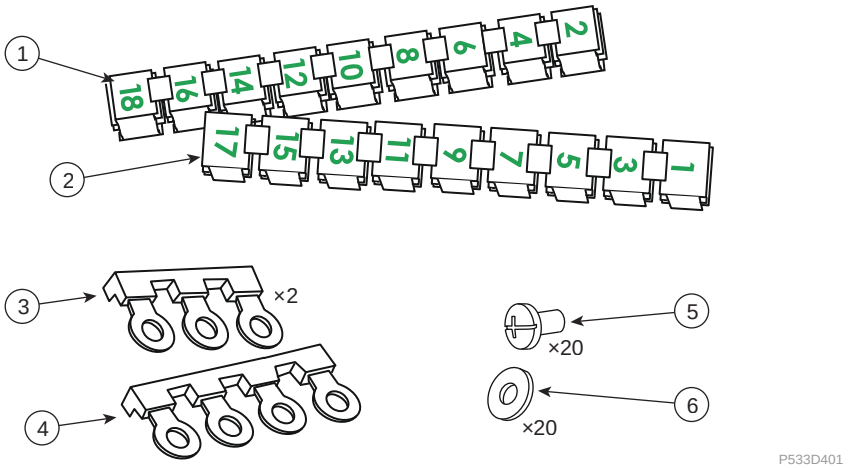
Failure to follow these instructions will result in death or serious injury.

Cabling kit for connector A

The PowerLogic P5 protection relays are delivered with a cabling kit for connector A. Depending on the type of analogue inputs of the protection relay, one of the following packages will be provided for your device:

- Cabling kit for CT/VT analogue inputs, including:

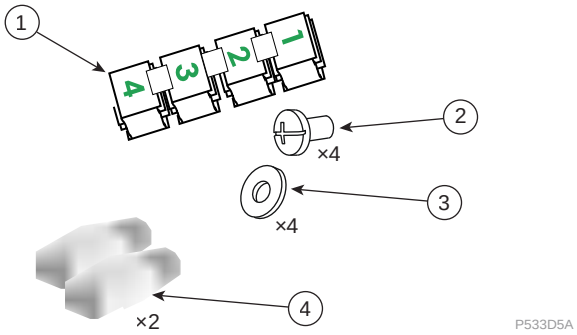
Figure 62 - Connector A cabling kit for CT/VT analogue inputs (REL51078)



- One protective cap with even numbers marked ①
- One protective cap with odd numbers marked ②
- Two three-terminal jumpers ③
- One four-terminal jumper ④
- Twenty mounting screws ⑤ and washers ⑥

- Cabling kit for LPCT/LPVT analogue inputs, including:

Figure 63 - Connector A cabling kit for LPCT/LPVT analogue inputs (REL51079)



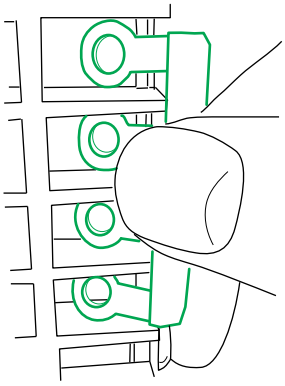
  - One four-terminal protective cap ①
  - Four mounting screws ② and washers ③
  - Two termination accessories ④

General cabling operation on connector A

The following procedure presents the general mounting and cabling operation on the connector A (for PowerLogic P5 model with 2 neutral CTs only):

1. Insert and connect the terminal jumper for common connections.

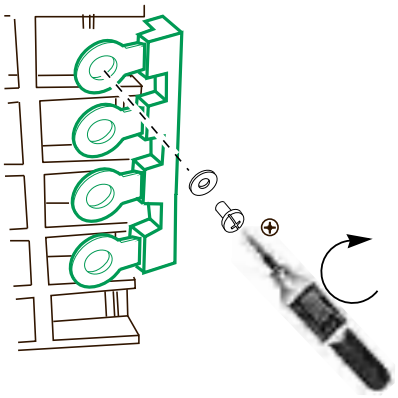
Figure 64 - Insert the terminal jumper (example with 4-pin comb-busbar)



Tools	Application connection diagram

2. Fasten the terminal jumper with the provided mounting screws and washers.

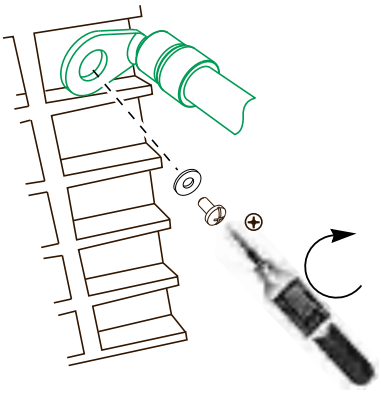
Figure 65 - Fasten the terminal jumper (example with 4-pin comb-busbar)



Fasteners	Mounting screws and washers included in the package
Tightening torque	1.2 N·m (10.6 lb-in)
Tool	Digital torque screwdriver with + PZ2 tip

3. Connect the bent ring lug end of the cables to the terminal using the provided mounting screws and washers.

Figure 66 - Connect the cable with bent ring lug



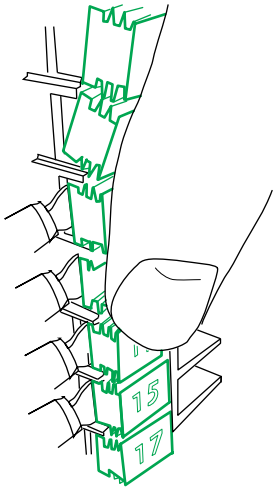
Fasteners	Mounting screws and washers included in the package
Tightening torque	1.2 N·m (10.6 lb-in)
Tool	Digital torque screwdriver with + PZ2 tip

NOTE: Bent ring lugs are commercially available from Schneider-Electric in three sizes (see table below). Order the accessories before cabling the protection relays.

Commercial Reference	Wire Section	Description
REL51059	0.5 ... 1.5 mm^2 (AWG 20 ... 16)	Ring lug terminal 3.68 mm (0.14 in)
REL51060	1.5 ... 2.5 mm^2 (AWG 16 ... 14)	Ring lug terminal 4.45 mm (0.18 in)
REL51061	2.5 ... 6 mm^2 (AWG 14 ... 10)	Ring lug terminal 6.35 mm (0.25 in)

4. After cabling, place and insert the protective caps on the terminal.

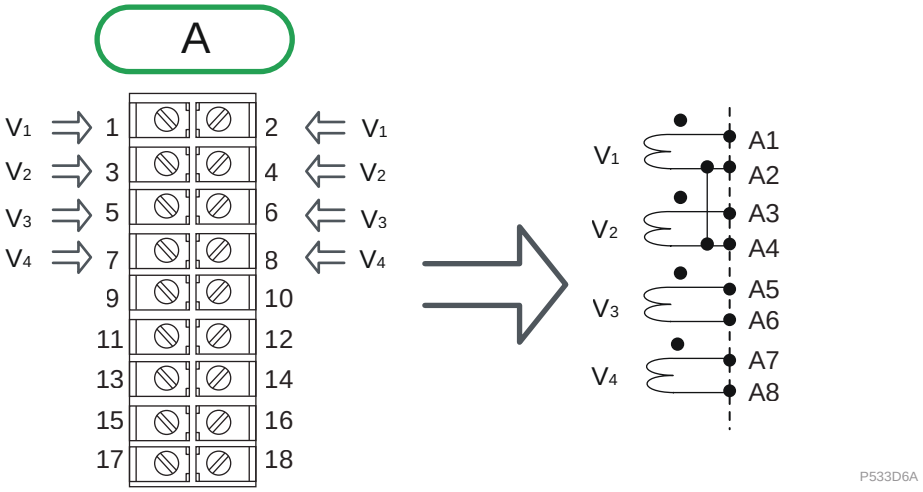
Figure 67 - Insert the protective cap



Phase voltage with VT inputs

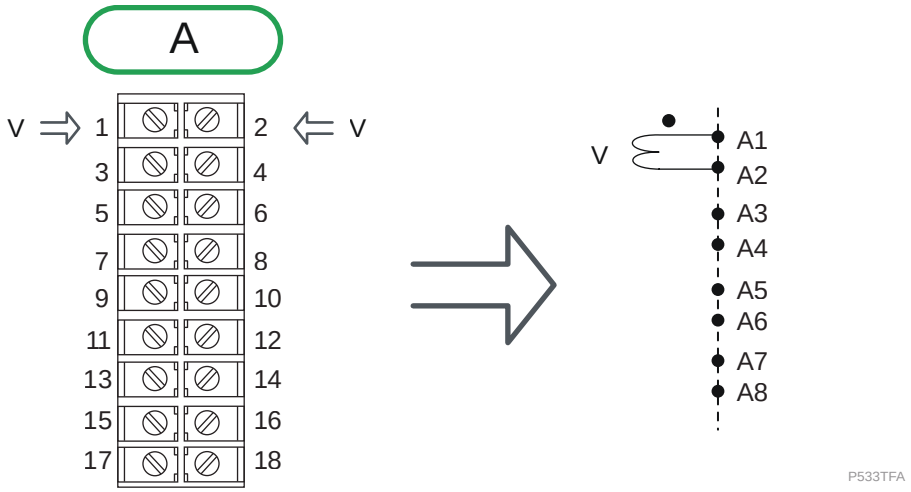
The phase voltage inputs of PowerLogic P5F30/P5M30 are situated in the upper part of the rear connector "A", terminals A1 to A8. The voltage measuring inputs are the following:

Figure 68 - Phase voltage inputs on connector A of PowerLogic P5F30/ P5M30



The phase voltage input of PowerLogic P5T30 is situated in the upper part of the rear connector "A", terminals A1 and A2. The voltage measuring inputs are the following:

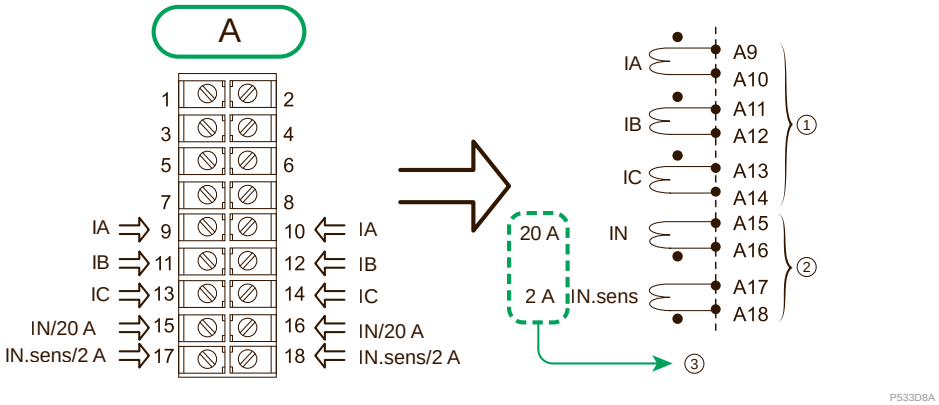
Figure 69 - Phase voltage inputs on connector A of PowerLogic P5T30



Phase currents with CT inputs and earth/ground fault current inputs

The current inputs of PowerLogic P5F30/P5M30 are situated in the lower part of the rear connector A, terminals A9 to A18. The current measuring inputs are the following:

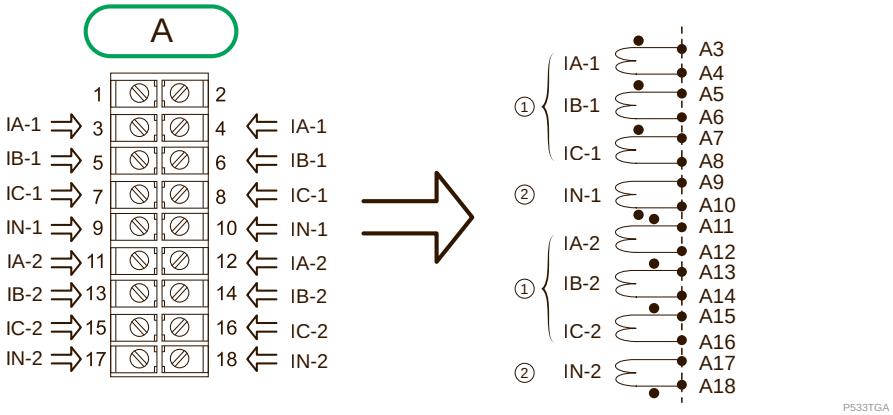
Figure 70 - Current inputs on connector A of PowerLogic P5F30/P5M30



①	Current inputs
②	Neutral current inputs
③	Option with CSH core balance CT 2A or 20A
IN:	Standard earth/ground fault
IN.sens:	Sensitive earth/ground fault

The current inputs of PowerLogic P5T30 are situated in the lower part of the rear connector A, terminals A3 to A18. The current measuring inputs are the following:

Figure 71 - Current inputs on connector A of PowerLogic P5T30



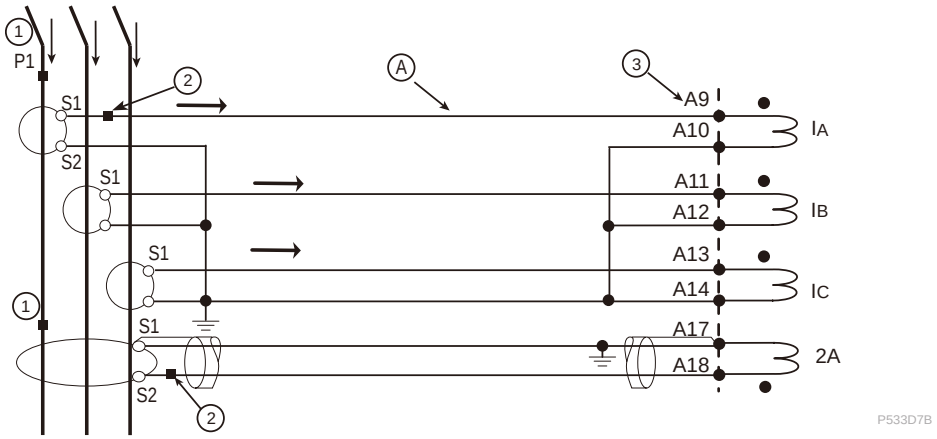
①	Current inputs
②	Neutral current inputs

NOTE: Communication modules may be replaced (for example, when communication network is modified). Take into account the access to these modules when you install and clamp rear connector wires.

Current Transformer Connections

The PowerLogic P5 protection relays use current transformers to measure phase or neutral currents. The current transformer connections are as follows:

Figure 72 - Connecting the current transformers with example of CSH earth/ ground fault connection (shielded)



where:

① Terminal P1[23] (primary current).

② Terminal S1[23] (secondary current).

③ Connector A + terminal number.

Ⓐ Implementation of the cabling between the CTs and the connector:

- Conductors contained in the same strand, in a sheath
- Conductors run along the metal structures of the MV cubicle

Recommended cable for Schneider Electric's CSH120, CSH200, CSH300 and GO110 core balance CTs:

- Sheathed cable (to be compliant with electromagnetic compatibility requirements), shielded by tinned copper braid.
- Resistance per unit length < 100 mΩ/m (30.5 mΩ/ft).
- Minimum dielectric strength: 1000 V (700 Vrms).
- Connect the cable shielding in the shortest manner possible to PowerLogic P5.
- Flatten the connection cable against the metal frames of the cubicle.

The maximum resistance of the connection wiring must not exceed 4 Ω (20 m maximum for 100 mΩ/m or 66 ft maximum for 30.5 mΩ/ft).

Wiring details

Refer to the table below for the detailed information on wiring the screw-type input connectors of the analogue module in slot A:

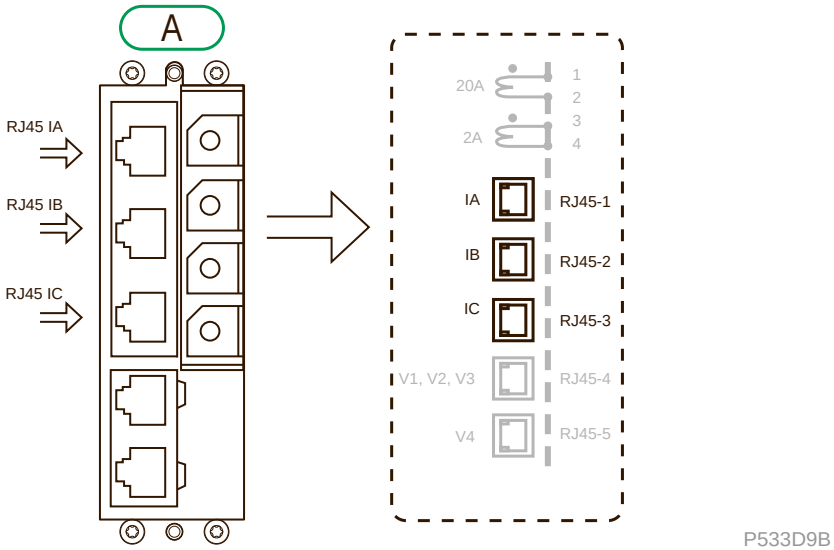
Applicable cable end	Wire gauge	Tightening torque	Tool	
 Ø 1 = 4 mm (0.16 in.) Ø2 < 8.5 mm (0.33 in.)	0.5 ... 1.5 mm² (AWG 20 ... 16) 1.5 ... 2.5 mm² (AWG 16 ... 14) 2.5 ... 6 mm² (AWG 14 ... 10)	1.2 N·m (10.6 lb-in)	(-) 6.5 mm (1/4 in.) screwdriver	(+) PZ2 screwdriver

23. Markings of current transformer terminals S1, S2, P1 and P2 according to IEC 61869-1 Standard

LPCT inputs

NOTICE
IMPROPER EQUIPMENT OPERATION Use original cable from OEM with a cable no longer than 10 m (32.8 ft) for EMC immunity. **Failure to follow these instructions can result in improper operation.**

Figure 73 - LPCT inputs on slot A



An LPCT sensor is characterised among other parameters by:

- The rated primary current I_{pr} (value of the primary current for U_{ser} secondary voltage output)
- The rated extended primary current I_{epr}
- The rated secondary voltage is 22.5 mV

The LPCT input of the PowerLogic P5 protection relay is characterised by the rated input voltage that depends on the rated extended primary current of the sensor. As an LPCT sensor covers a wide range of primary current and therefore has a high dynamic input here it is necessary to adapt the input interface of the relay to the primary current selected. More generally the LPCT inputs must be compliant with the IEC61869-10 standard.

Parameter	Value	Comment
Rated secondary voltage	22.5 mV	
Rated primary current factor	0.25 - 0.50 - 1.00 - 1.25 - 1.33 - 2.00 - 2.50 - 3.20 - 4.00 - 5.00 - 6.30 - 6.66 - 10 - 16 - 20 - 31.5	This configuration parameter corresponds to the rated extended primary current factor of the LPCT.

LPVT inputs

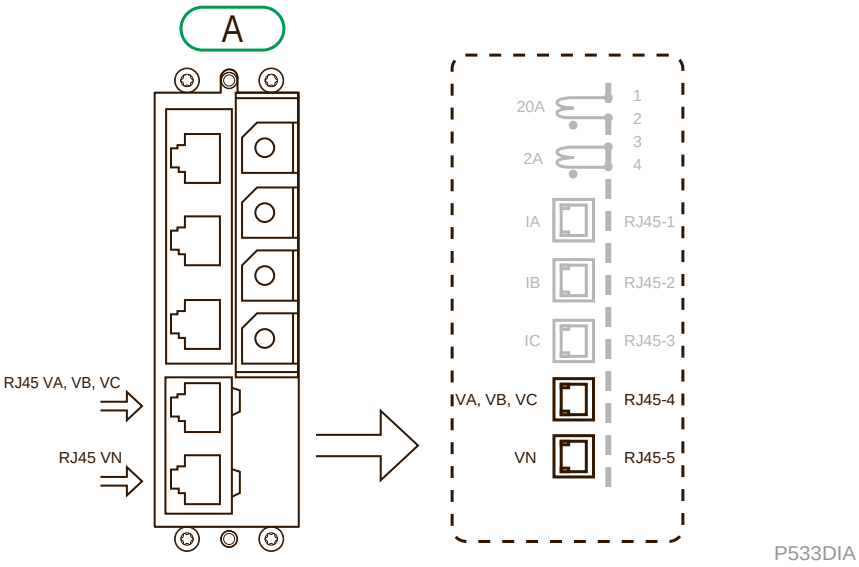
NOTICE

IMPROPER EQUIPMENT OPERATION

Use original cable from OEM to connect to the hub or merger. The total cable length between LPVT and P5 has to be no longer than 10 m (32.8 ft) for EMC immunity.

Failure to follow these instructions can result in improper operation.

Figure 74 - LPVT inputs on slot A



More generally the LPVTs inputs must be compliant with the IEC61869-11 standard.

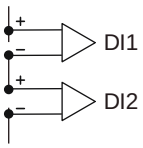
The table below lists the technical data concerning the ratings and limits of the LPVT channels:

Parameter	Value
Rated secondary voltage	3.25 V / √3
Extended rated voltage	0.25 to 1.5 rated voltage

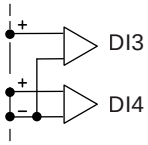
Digital input connections

The PowerLogic P5 protection relays provide two types of digital inputs:

- Digital inputs isolated from earth/ground and independent.
- Digital inputs isolated from earth/ground, with a common connection point.



P533REB



P533RFB

The operating nominal voltage for digital inputs is:

- 24 V DC to 250 V DC
- 90 V AC to 230 V AC

The activation voltage threshold is software settable. More information can be found on Digital inputs, page 486 section.

The isolated independent digital inputs are isolated from earth/ground, and each other. They should be used to acquire data from the following digital sensors:

- Non-isolated sensors (earthed/grounded).
- Remote sensors.
- Sensors from several zones in the installation that do not have equipotential bonding.
- Sensors from different devices.

To help ensure that each digital input is isolated, each digital input must be connected with an independent cable.

The isolated digital inputs with a common connection point are isolated from earth/ground, but are not isolated in relation to one another (common point). They should be used to acquire data from the following digital sensors:

- Isolated sensors.
- Sensors that are not isolated but come from the same zone of an installation with equipotential bonding.
- Sensors that preferably come from the same equipment. The different digital inputs are contained in the same cable.

The electrical conductors connected to the digital inputs of the PowerLogic P5 protection relays should run along the metal structures of the cubicle to reduce earth/ground loops. The conductors are contained in the same strand and, if possible twisted, to avoid the creation of cabling loops.

NOTICE

IMPROPER EQUIPMENT OPERATION

When connecting the digital inputs:

- Avoid large cabling loops in the various power supplies.
- Do not short-circuit any of the galvanic insulation.

Failure to follow these instructions can result in improper operation or equipment damage.

When the environmental and installation conditions are highly unfavorable for the PowerLogic P5 protection relay, a shielded twisted pair should be used. In such cases, the cable shielding is connected to the local earth/ground at both ends (provided that the installation has an equipotential bonding network).

Slot B: power supply + digital 4-input/4-output

Power supply

⚠DANGER

FIRE HAZARD

- Protect the power supplying circuit of the PowerLogic P5 protection relay against overcurrents.
- For breaking capacity higher than 40W with L/R = 40 ms, protect the digital output contacts with an additional customer protection (RC or zener diode).

Failure to follow these instructions will result in death or serious injury.

The power supply range and inrush currents are provided for easier selection of Miniature Circuit Breaker (MCB).

Protection relay	Power supply range	Inrush current
PowerLogic P5x20	100...230 V AC	< 5 A 230 V AC
	24...250 V DC	< 8 A 250 V DC
PowerLogic P5x30	100...230 V AC	< 5 A 230 V AC
	48...250 V DC	< 8 A 250 V DC
	24...48 V DC	< 4 A 48 V DC

The nominal voltage range of PowerLogic P5 protection relays is specified on the reference label (local panel).

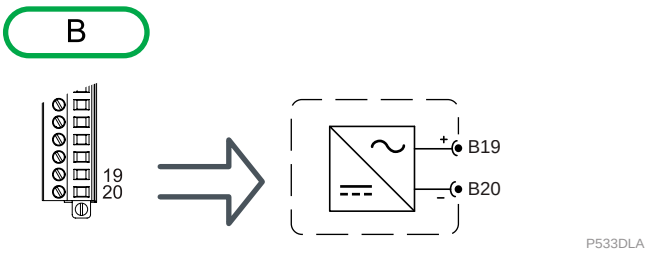
NOTICE

POWER SUPPLY DAMAGE

Before connecting the auxiliary voltage to the PowerLogic P5 protection relay, make sure the nominal value of the auxiliary device voltage corresponds with the nominal value of the auxiliary system voltage.

Failure to follow these instructions can result in equipment damage.

Figure 75 - Power supply terminals on connector B



Digital inputs/outputs

The digital 4-input/4-output module (4I4O) is always mounted in slot B of an PowerLogic P5 protection relay. Digital outputs DO1, DO2 and DO3 are specifically enhanced for circuit breaker (CB) control. Digital output WD is defined as a Watchdog.

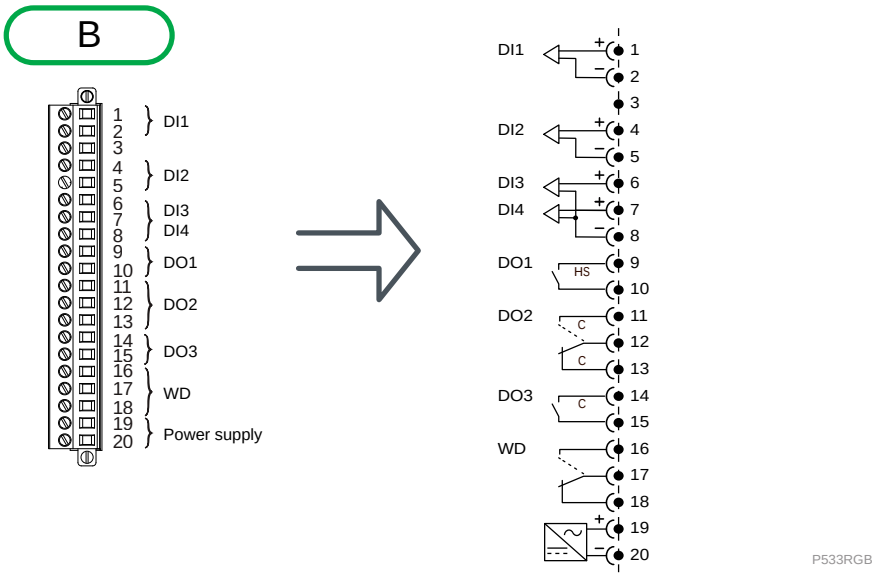
The operating nominal voltage for digital inputs is:

- 24 V DC to 250 V DC

- 90 V AC to 230 V AC

The configuration of the 20-terminal connector of the module is shown in the following figure:

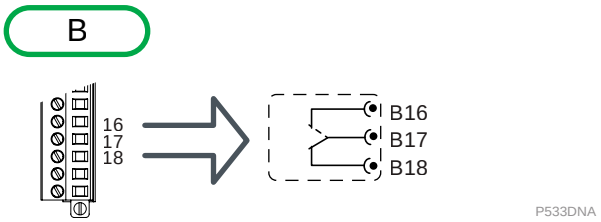
Figure 76 - Configuration of connector B



Watchdog

The watchdog (self-monitoring) is a changeover contact provided on slot B, digital output WD, to indicate the health of the device (refer to Watchdog relay, page 561). Schneider Electric strongly recommends that these contacts are hardwired into the substation's automation system for alarm purposes.

Figure 77 - Watchdog terminals on connector B

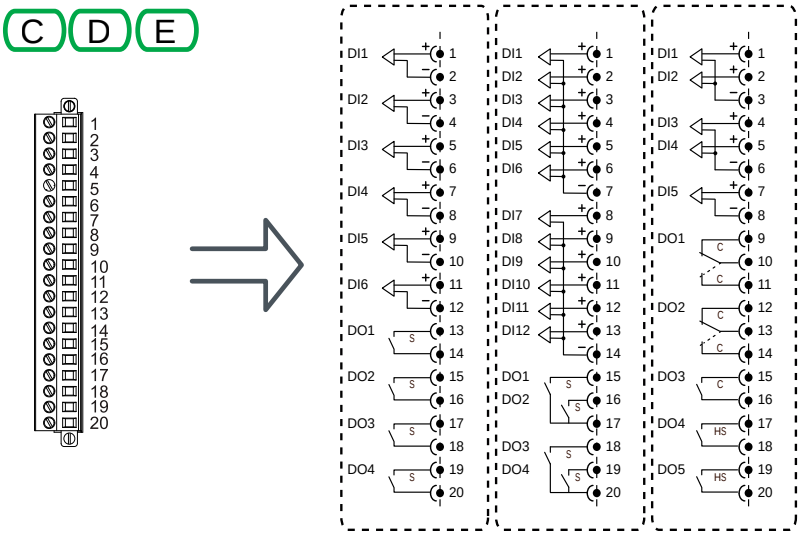


NOTE: Refer to Wiring accessories for Slot B, C, D, E, page 88 for the detailed information on wiring the terminals of this module.

Slot C, D, E: additional digital input/output modules (6I4O/12I4O/5I5O)

The PowerLogic P5 protection relay can be provided with additional digital input/output modules (6I4O, 12I4O and 5I5O) in slot C, D and E (only slot C in P5x20). The configuration of the 20-terminal connector of the module is shown in following image:

Figure 78 - Configuration of connector



NOTE: Refer to Wiring accessories for Slot B, C, D, E, page 88 for the detailed information on wiring the terminals of this module. And refer to Slot occupation rules, page 590 for the information on the slot occupation rules.

The DI1 input on 12I4O can be used as a standard digital input (by default) or as a counting input.

NOTICE

IMPROPER EQUIPMENT OPERATION

Specific wiring requirements for counting input 12I4O DI1:

- Unshielded twisted pair cable between pin 1 and pin 7
- 0.4 to 1.5 mm² cross section
- Example of recommended cable : Belden 9409 or equivalent
- No earth/ground connection on the PowerLogic P5 side or on the other side to keep the line symmetrical
- Maximum cable length: 10 m

Failure to follow these instructions can result in equipment damage.

NOTICE

IMPROPER EQUIPMENT OPERATION

If the counting input DI1 on 12I4O is selected, this input cannot be used by any other protection functions.

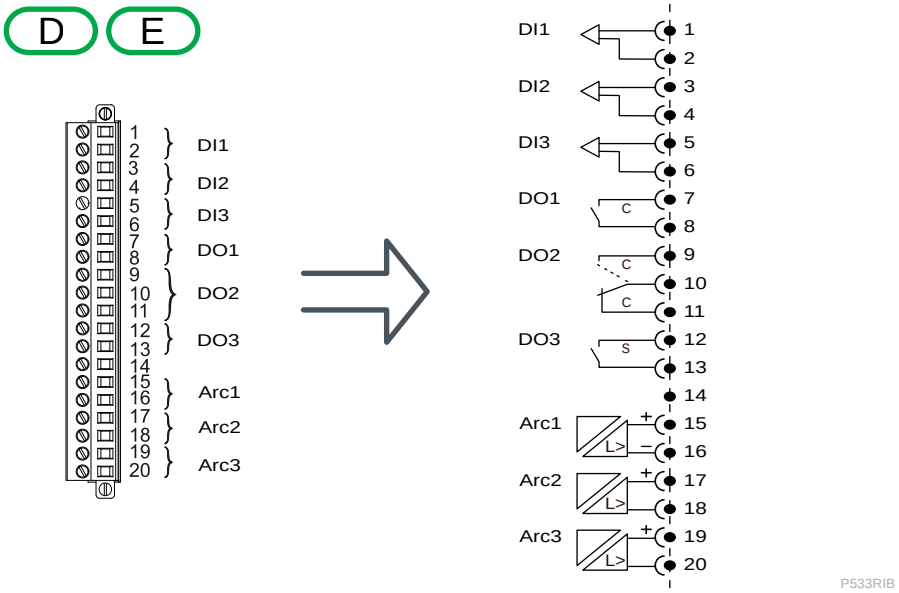
Failure to follow these instructions can result in equipment damage.

Slots D and E: Arc-flash module (for PowerLogic P5x30 only)

The PowerLogic P5x30 can be equipped with up to 2 Arc-flash modules (with 3 light sensor inputs, 3 digital inputs and 3 digital outputs each) in its slot D and E.

The configuration of the 20-terminal connector of the Arc-flash module is shown in following image:

Figure 79 - Configuration of terminals in Slot D and E

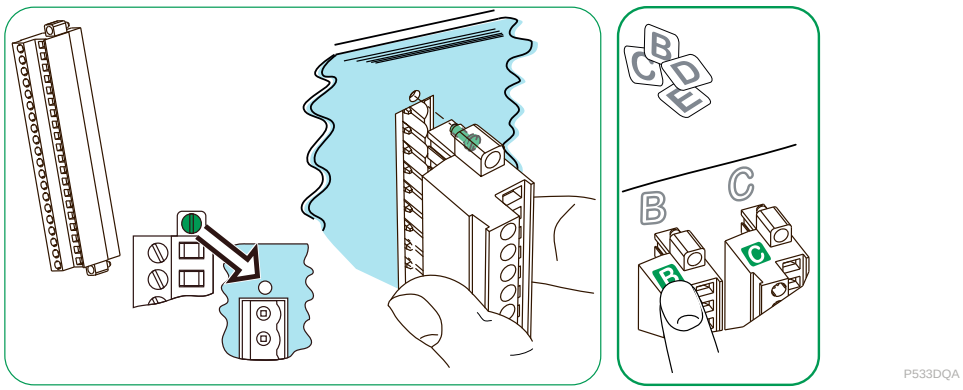


NOTE: Refer to Wiring accessories for Slot B, C, D, E, page 88 for the detailed information on wiring the terminals of this module.

Installing the digital I/O connectors

The digital I/O connectors provided with the protection relay are mounted on the rear panel fixed with screws came with the connectors.

Figure 80 - Installing digital I/O connectors on the rear panel

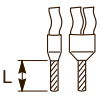


Tool	2.5 mm (3/32 in.) flat screwdriver
Tightening torque	0.4 N·m (3.5 lb-in)
Subsequent operation	Identification labels of connector are included in the package. After connectors installed, stick the labels on rear top of the connectors.

Wiring accessories for Slot B, C, D, E

Wiring the screw-type terminals

The detailed information for wiring the screw-type DI/DO terminals in slot B, C, D, and E is listed in the table below:

Cable end	Wire gauge	Tightening torque	Tool
 Contact tip length L = 12 mm (0.5 in.)	Single wire: 0.2 ... 2.5 mm² (AWG 24 ... 14) Double wires: 0.2 ... 1.5 mm² (AWG 24 ... 16)	0.4 ... 0.5 N·m (3.5 ... 4.4 lb-in)	(—) 2.5 mm (3/32 in.) flat blade screwdriver

Comb-busbars for wiring at slot C, D, E

The comb-busbar can be used to optimise the installation, for example, by creating rapidly a common point for digital inputs.

To facilitate wiring the terminals in Slot C, D, E of PowerLogic P5 protection relay, the user can order the following comb-busbars that comes in the form of 50-piece or 100-piece packs.

Commercial Reference	Description	Quantity/Pack	Illustration
REL51054	2-pin comb-busbar	100 pieces	
REL51055	3-pin comb-busbar	100 pieces	
REL51056	4-pin comb-busbar	50 pieces	
REL51057	5-pin comb-busbar	50 pieces	
REL51058	6-pin comb-busbar	50 pieces	

Connecting earth/ground

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Connect the PowerLogic P5 protection relay to earth/ground with a nut and washer using any of the indicated stud terminals (see Fixing the earthing/grounding cable to the PowerLogic P5 protection relay, page 89 below).
- Check equipotential earthing/grounding network and test earth/ground during installation.

Failure to follow these instructions will result in death or serious injury.

The earth/ground connections are accessible on the rear panel of the protection relays. For PowerLogic P5x20, there are two connectors located in the bottom left and right corner of the protection relays; for PowerLogic P5x30, there are three, one in the bottom right corner and the other two near Connector A.

Figure 81 - Earth/ground studs on PowerLogic P5x20

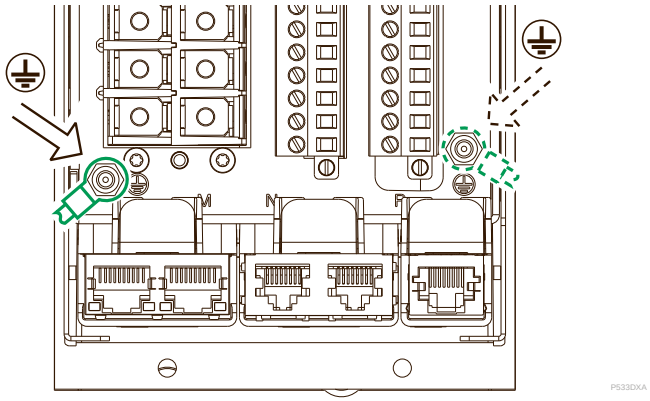


Figure 82 - Earth/ground studs on PowerLogic P5x30

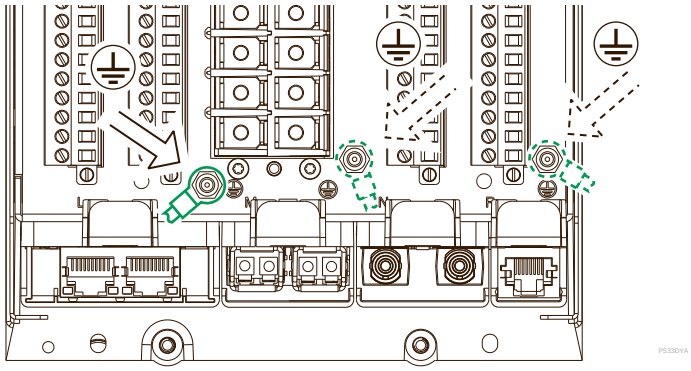
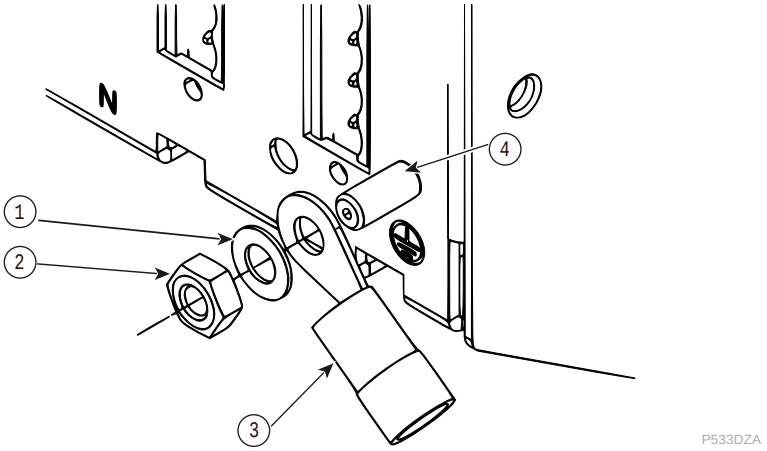


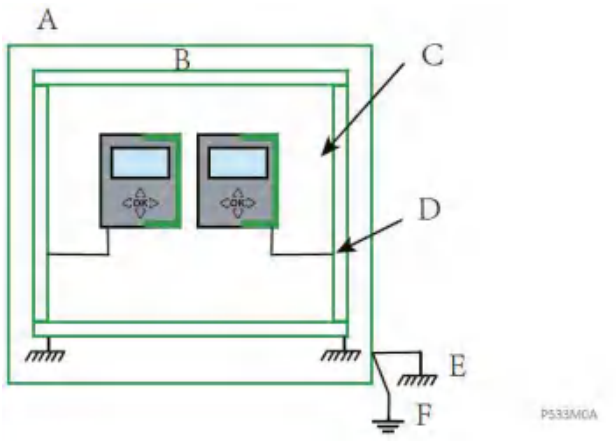
Figure 83 - Fixing the earthing/grounding cable to the PowerLogic P5 protection relay



①	Washer	③	Earthing/grounding cable
②	M4 hexagon nut	④	Earth/ground stud on the protection relay

Every PowerLogic P5 must be connected to the local earth/ground bar using one M4 earth/ground stud on the relay case to help prevent dangerous voltages being present in case of a wiring fault or damage to the product. Also, it helps ensure that the PowerLogic P5 protection relay meets EMC claims.

Figure 84 - Compartment earthing/grounding terminal



A	Metal upright of the LV compartment	D	Earth/ground connection made to a surface with no paint, varnish or any insulating material. Spring washers must be used.
B	LV compartment	E	Local earth/ground
C	The PowerLogic P5 protection relay is installed in the LV compartment near the earthing/grounding terminal or near one of the metal uprights.	F	Electrical protection

The minimum recommended wire size is 2.5 mm² (AWG 14) and should have a ring terminal at the relay end. Due to the limitations of the ring terminal, the maximum wire size that can be used is 6.0 mm² (AWG 10) per wire.

Terminal type	Applicable cable end	Wire gauge	Max. wire length	Tightening torque	Tool
earth/ ground stud	 P533M1A Ø = 4 mm (0.16 in.)	2.5 ... 6 mm2 (AWG 14 ... 10)	50 cm (21 in.)	1.2 N·m (10.6 lb-in)	socket wrench for M4 screw

NOTE: To avoid any possibility of electrolytic action between brass or copper earth/ground conductors and the rear panel of the protection relay, precautions should be taken to isolate them from one another. It is recommended to place a nickel-plated or insulating washer between the conductor and PowerLogic P5 case or to use tinned ring terminals.

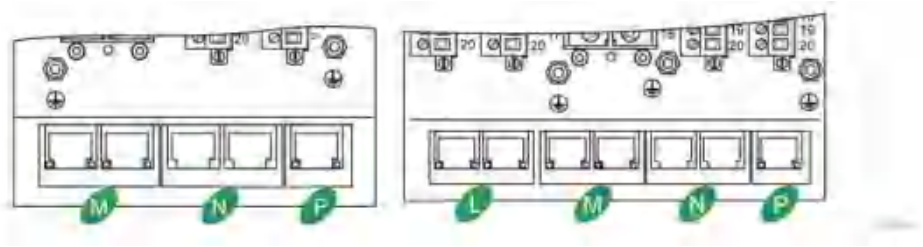
Optional rear communication ports and modules

Location of the communication ports

NOTICE
IMPROPER EQUIPMENT OPERATION Use RJ45 cable no longer than 10 m (32.8 ft). **Failure to follow these instructions can result in improper operation.**

The PowerLogic P5 protection relay range includes optional rear communication ports and modules with RJ45 or fibre optic connections. The ports and modules are accessible in the lower part of the rear panel. The following figure shows the location of these single or dual communication ports and modules:

PowerLogic P5x20 PowerLogic P5x30



	PowerLogic P5x20	PowerLogic P5x30
Slot L	-	Dual port Ethernet TP module with RSTP redundancy
	-	Inter-relay module(FO)
Slot M	Dual port Ethernet TP or fibre optic module, configurable to RSTP redundancy mode or Dual IP mode without redundancy	
Slot N	Dual port RS485 or fibre optic serial communication module	
Slot P	Single extension port for connection with external module and demodulated IRIG-B input and Back-up memory	
Slot M + N	Ethernet HSR/PRP RS485 module 2TP or Ethernet HSR/PRP RS485 module 2FO	

Installing the modules

NOTICE

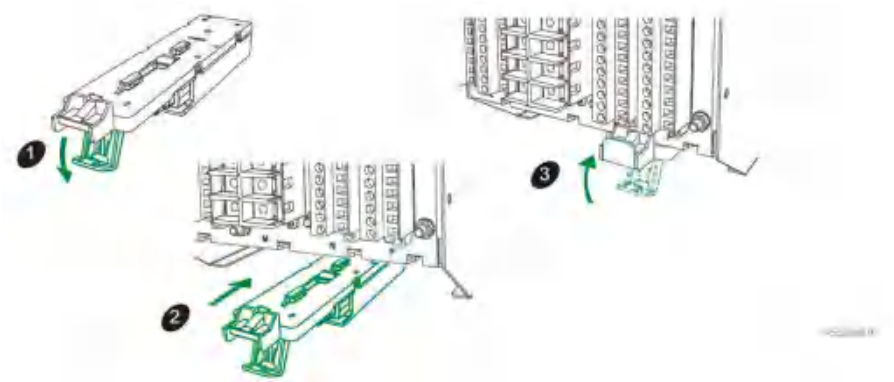
IMPROPER EQUIPMENT OPERATION

- Check and make sure the communication modules are locked on the protection relay.
- Never plug in or draw out the communication modules while the PowerLogic P5 protection relay is in service, otherwise the PowerLogic P5 protection relay will reboot and consequently lose the setting changes made within the last 30 minutes.

Failure to follow these instructions can result in setting change erasure and consequently mis-operation of the protection relay.

The communication modules are designed with a self-locking structure. After sliding along the bottom slots and fixing into position, the module locks itself in final place. The green flippable locker at one end locks the communication module in place.

Figure 85 - Installing the communication module



Slot L: Ethernet communication module with RSTP redundancy (reference REL51042)

Used for PowerLogic P5x30 only

The Ethernet communication module is installed in slot L of PowerLogic P5x30. It is an optional selection when ordering the device or can be purchased after on-site installation.

It works with RSTP protocol, which allows fast reconfiguration of the communication system.

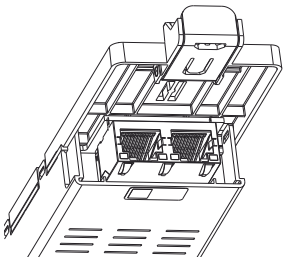


Figure 86 - Example of Ethernet module connection

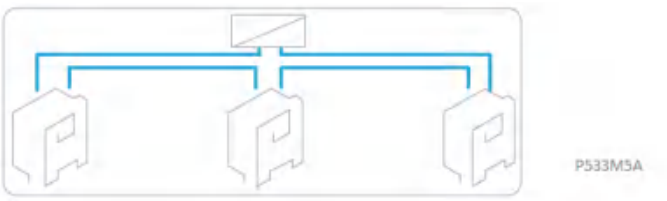
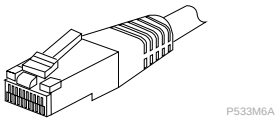


Table 7 - Characteristics of the Ethernet communication module (reference REL51042)

Characteristics	
Location	Slot L
Connection	2 x RJ45 connectors with communication indicators 
Ethernet connection	10/100 Mbps
Protocol	TP or RSTP
Maximum cable length	10 m (32.8 ft)

Slot L: Inter-relay module(FO) with SDLC (reference REL51041)

Used for PowerLogic P5x30 only

The serial communication module is mounted in slot L of PowerLogic P5x30. It can be selected as an option when ordering the device or purchased later and installed on site.

It provides data transfer by GOOSE communications with IEC 61850 station bus.

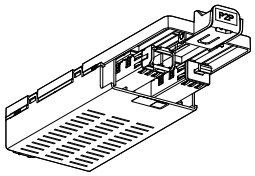


Figure 87 - Example of P2P module connection

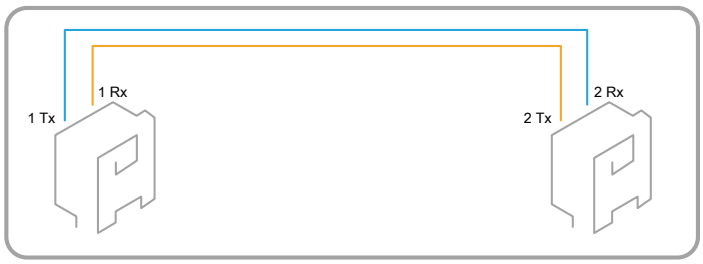
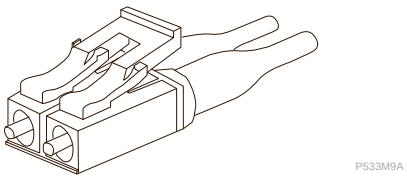


Table 8 - Characteristics of the serial communication module (reference REL51041)

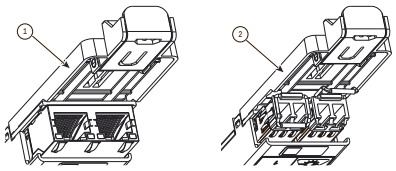
Characteristics	
Location	Slot L
Connection	2 LC connectors  P533M9A
Ethernet connection	selectable: 56/64/115.2 kBit/s
Protocol	SDLC
Maximum cable length	40 km (24.8 mi)

Slot M: Ethernet communication module with RSTP redundancy

The Ethernet communication module is installed in slot M of the device. It is an optional selection when ordering the device or can be purchased after on-site installation.

It is available in two versions for cable connection ① or fibre optic ② connection.

It works with RSTP redundancy protocol, which allows fast reconfiguration of the communication system.



Ethernet module with RJ45 connectors (reference REL51038)

Figure 88 - Example of Ethernet module connection

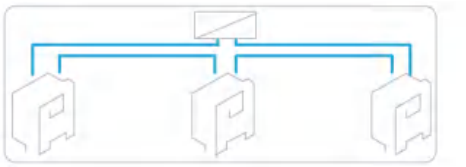
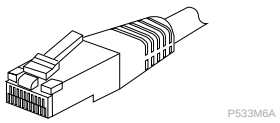


Table 9 - Characteristics of the Ethernet communication module (reference REL51038)

Characteristics	
Location	Slot M
Connection	2 x RJ45 connectors with communication indicators 
Ethernet connection	10/100 Mbps
Protocol	TP or RSTP
Maximum cable length	10 m (32.8 ft)

Ethernet module with fibre optic connectors (reference REL51039)

⚠CAUTION

EYE DAMAGE AND BLINDNESS

Never look into the end of the fibre optic.

Failure to follow these instructions can result in serious injury.

NOTICE

IMPROPER EQUIPMENT OPERATON

- Use only Schneider approved optical transceiver components.
- Never replace the optical transceiver components with unauthorised manufactured parts.

Failure to follow these instructions can result in equipment damage.

Use optical power meters to determine the operation or signal level of the device.

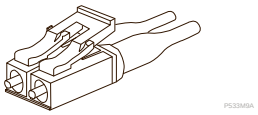
In case of electrical-to-optical converters used, the converters must be equipped with character idle state management (when the fibre optic cable interface is "Light off").

The bending radius of fibres should be especially taken care of, and it is not recommended to use optical shunts, they can decrease the communication performance of the transmission path over time.

Figure 89 - Example of Ethernet module connection

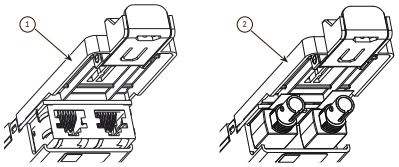


Table 10 - Characteristics of the Ethernet communication module (reference REL51039)

Characteristics	
Location	Slot M
Connection	2 LC connectors 
Ethernet connection	100 Mbps
Protocol	TP or RSTP
Optical wavelength	1300 nm
Fibre type	Multi-mode glass fibre
Maximum attenuation (fibre optic + connectors)	14 dB (at fibre optic diameter: 62,5/125 µm or 50/125 µm)
Minimum range	2000 m (6561,7 ft)

Slot N: serial line communication modules

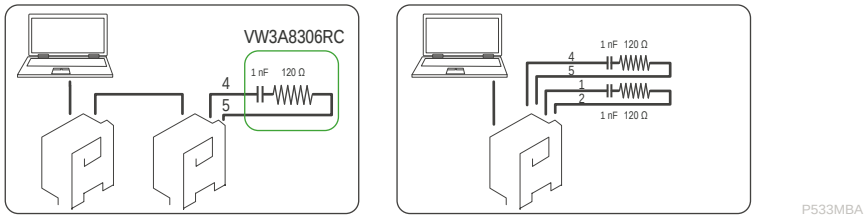
The Serial line communication module is installed in slot N of the device. It is an optional selection when ordering the device or can be purchased after on-site installation. It is available in 2 versions for RS485 ① or fibre optic ② connection.



RS485 serial line module (reference REL51036)

The PowerLogic P5 protection relay can be connected to any RS485 full duplex or half duplex communication network and can exchange data with SCADA. The serial RS485 ports are designed for RJ45 connections with the following characteristics for each terminal.

Figure 90 - Examples of RS485 serial link module connection



The integrated polarisation resistor 620 Ω can be enabled or disabled with eSetup Easergy Pro (see parameter "pull line" in the communication manual).

In order to avoid signal reflections on the line, data transmission lines should always be terminated with a RC terminating impedance (120 Ω/1 nF, reference VW3A8306RC), or with a 4 line option that includes 2 pairs of 120 Ω/1 nF RC terminating impedance, fitted at both ends across the signal wires.

Figure 91 - Terminating the transmission line with a RC terminating accessory

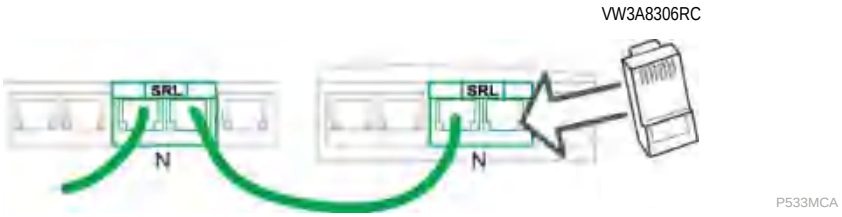


Table 11 - Characteristics of the RS485 serial line module (reference REL51036)

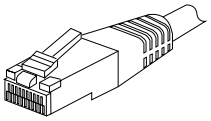
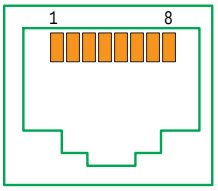
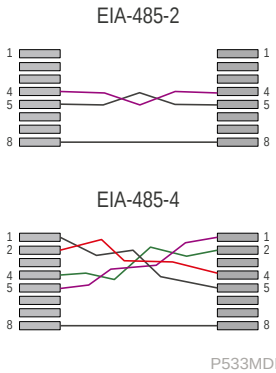
Characteristics	
Location	Slot N
Standard	EIA 2-wires RS485 differential or EIA 4-wires RS485 differential
Connection	2 x RJ45 connectors  P533M6A
Protocol	TP or RSTP
Line polarisation	620 Ω
Communication network	Half or full duplex
Maximum cable length	10 m (32.8 ft)

Figure 92 - RJ45 female connector viewed from front



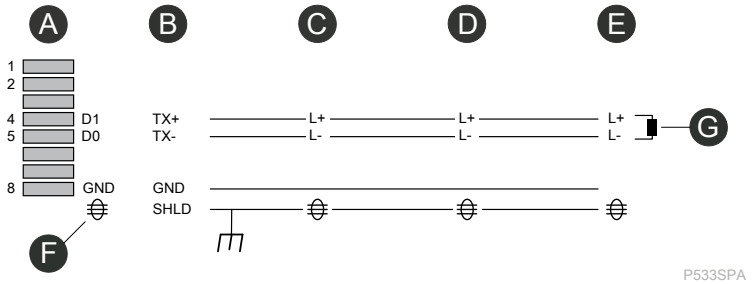
P533RWA

Figure 93 - RJ45 female connector wiring



P533MDB

Figure 94 - RJ45 for RS485 interface



P533SPA

A	Gateway RJ45	B	Adapter
C	Slave 1	D	Slave 2
E	Slave 3	F	Shield
G	Termination		

Fibre optic serial line module (reference REL51040)

⚠CAUTION

EYE DAMAGE AND BLINDNESS

Never look into the end of the fibre optic.

Failure to follow these instructions can result in serious injury.

Use optical power meters to determine the operation or signal level of the device.

In case of electrical-to-optical converters used, the converters must be equipped with character idle state management (for when the fibre optic cable interface is "Light off").

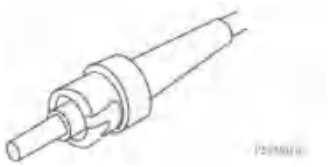
The bending radius of fibres should be especially taken care of, and it is not recommended to use optical shunts, they can decrease the communication performance of the transmission path over time.

The relay uses 1300 nm multi-mode 100BaseFx ST(BFOC) 2.5 connectors (one Tx/optical emitter, one Rx/optical receiver).

Figure 95 - Example of fibre optic serial line module connection

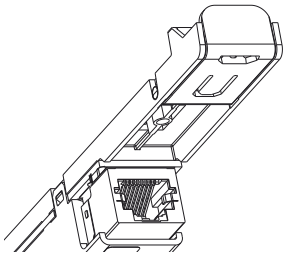


Table 12 - Characteristics of the fibre optic serial line module (reference REL51040)

Characteristics	
Location	Slot N
Connection	2 x ST (BFOC) connectors
Optical wavelength	820 nm 
Maximum attenuation (fibre optic + connectors)	• 5.6 dB at fibre diameter 50/125 µm • 9.4 dB at fibre diameter 62.5/125 µm • 14.9 dB at fibre diameter 100/140 µm • 19.2 dB at fibre diameter 200 (HCS) µm
Minimum range	2000 m (6561,7 ft)

Slot P: extension module (reference REL51034)

The extension module is installed in slot P of the device. It is an optional selection when ordering the device or can be purchased after on-site installation.



P533MGA

NOTICE
ETHERNET PORT DAMAGE Connect only PowerLogic P5 accessories to the extension module. **Failure to follow these instructions can result in equipment damage.**

Connection of other equipment such as computer, switch, low power current transducer (LPCT) type sensor or other protection relay can result in the damage of its Ethernet port.

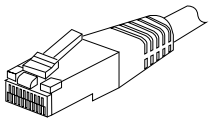
The extension module provides:

- Automatic back-up of data (refer to Backup memory, page 563):
  - Active configuration file
  - Disturbance records
  - Sequence of events records
  - Power system maintenance data log
- Connection to the external modules

The following PowerLogic P5 accessories can be connected to the extension module:

- IRIG-B module (see IRIG-B module (reference REL51045), page 126 for more information)
- MET148-2 temperature sensor module (see MET148-2 - temperature sensor module (reference 59641), page 123 for more information)
- TH110: connection thermal sensors, connected through Zigbee
- CL110: environmental sensors, connected through Zigbee

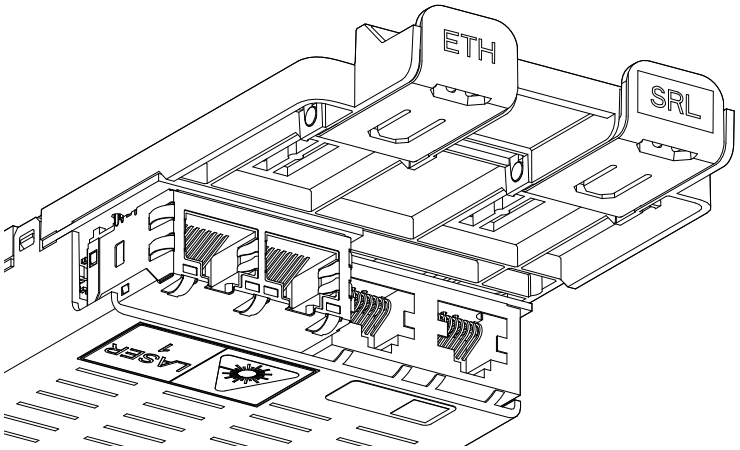
Table 13 - Characteristics of the extension module (reference REL51034)

Characteristics	
Location	Slot P
Connection	RJ45 connector  P533M6A
Type of cable	The following cables (Reference numbers) can be selected for connection: • Reference 59660, length: 0.6 m (1.97 ft); • Reference 59661, length: 2 m (6.56 ft); • Reference 59662, length: 4 m (13.1 ft);

Slot M & N: Ethernet HSR/PRP RS485 module 2TP communication module with HSR and PRP redundancy (reference REL51048)

The Ethernet communication module is inserted in both slot M and N of the device. It can be selected as an option when ordering the device or purchased later and installed on site. It provides PRP (Parallel Redundancy Protocol) and HSR (High-availability Seamless Redundancy) and is selectable by configuration.

The module allows instantaneous reconfiguration of the communication system without communication packet loss.



NOTICE
ETHERNET PORT DAMAGE Connect only PowerLogic P5 accessories to the extension module. **Failure to follow these instructions can result in equipment damage.**

For the RS485 serial line module, please refer to Slot N: serial line communication modules, page 97.

Figure 96 - Example of Ethernet module connection

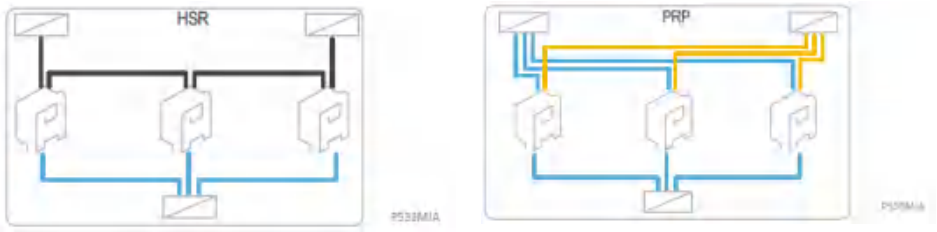


Table 14 - Characteristics of the Ethernet HSR/PRP RS485 module 2TP (reference REL51048)

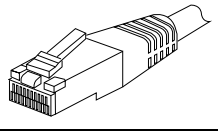
Characteristics	
Location	Both slot M and N
Connection	2 x RJ45 connectors 
Type of cable	The following cables (Reference numbers) can be selected for connection: • Reference 59660, length: 0.6 m (1.97 ft); • Reference 59661, length: 2 m (6.56 ft);

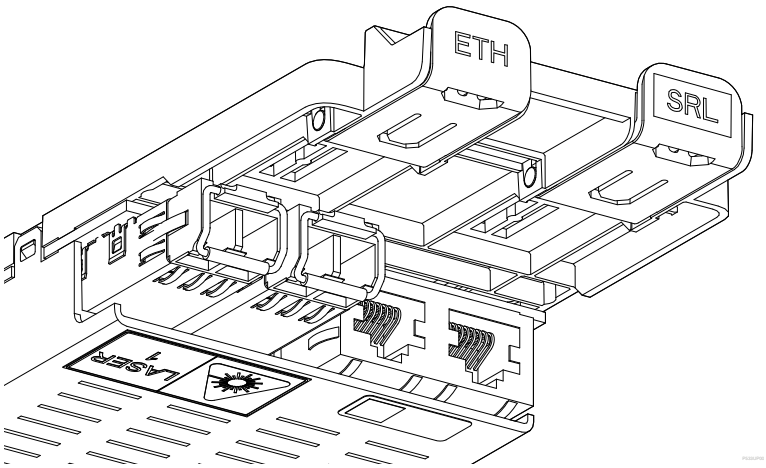
Table 14 - Characteristics of the Ethernet HSR/PRP RS485 module 2TP (reference REL51048) (Continued)

Characteristics	
	• Reference 59662, length: 4 m (13.1 ft);
Protocol	TP or RSTP
Ethernet connection	100 Mbps
Line polarisation	620 Ω
Communication network	Half or full duplex
Maximum cable length	10 m (32.8 ft)

Slot M & N: Ethernet HSR/PRP RS485 module 2FO communication module with HSR and PRP redundancy (reference REL51049)

The Ethernet communication module is inserted in both slot M and N of the device. It can be selected as an option when ordering the device or purchased later and installed on site. It provides PRP (Parallel Redundancy Protocol) and HSR (High-availability Seamless Redundancy) and is selectable by configuration.

The module allows instantaneous reconfiguration of the communication system without communication packet loss.



⚠CAUTION

EYE DAMAGE AND BLINDNESS

Never look into the end of the fibre optic.

Failure to follow these instructions can result in serious injury.

Use optical power meters to determine the operation or signal level of the device.

If electrical-to-optical converters are used, they must have management of character idle state capability (when the fibre optic cable interface is "Light off").

Specific care should be taken with the bending radius of the fibres, and the use of optical shunts is not recommended as these can decrease the communication performance of the transmission path over time.

For the RS485 serial line module, please refer to Slot N: serial line communication modules, page 97.

Figure 97 - Example of Ethernet module connection

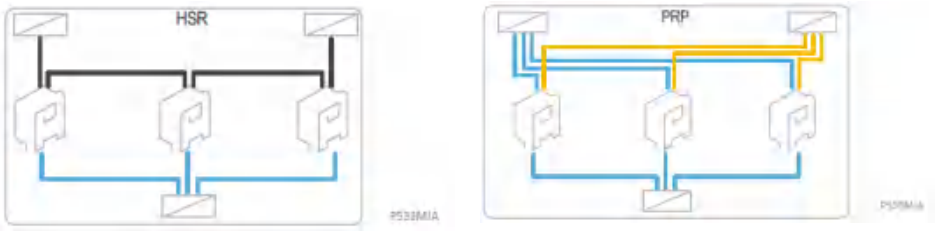
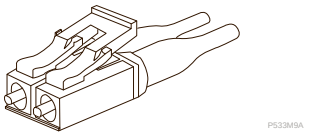


Table 15 - Characteristics of the Ethernet HSR/PRP RS485 module FO (reference REL51049)

Characteristics	
Location	Both slot M and N
Connection	2 x LC connectors 
Ethernet connection	100 Mbps
Optical wavelength	1300 nm
Fibre type	Multi-mode glass fibre
Maximum attenuation (fibre optic + connectors)	14 dB (at fibre diameter 50/125 µm or 62.5/125 µm)

Other accessories

CSH120 (reference 59635), CSH200 (reference 59636), CSH300 (reference 59637) and GO110 (reference 50134)

Description

The CSH120, CSH200, CSH300 and GO110 core balance current transformers (CT) are designed for direct neutral current measurement. Due to their low voltage insulation, they can only be used around insulated cables.

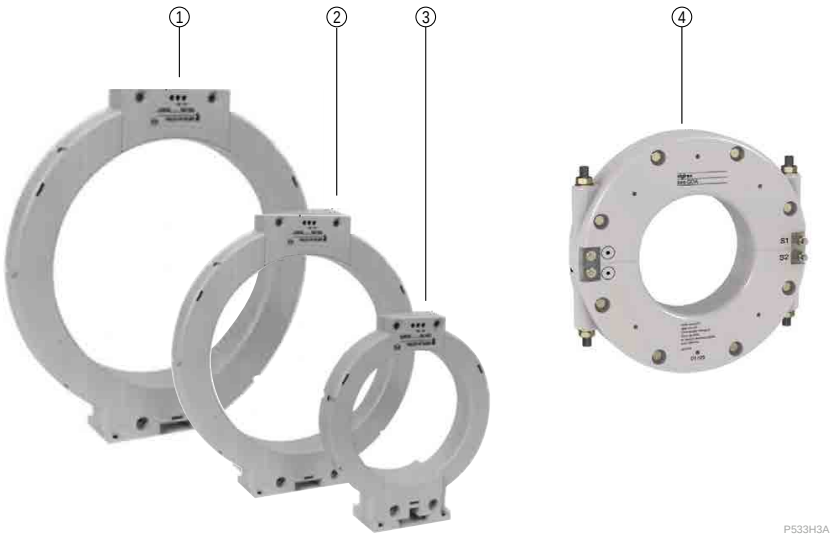
CSH300 ①, CSH200 ② and CSH120 ③ are closed CTs, with different inner diameters:

- Inner diameter of CSH300 ①: 291mm (11.46 in.)
- Inner diameter of CSH200 ②: 196 mm (7.72 in.)
- Inner diameter of CSH120 ③: 120 mm (4.72 in.)

GO110 ④ is a split CT, with an inner diameter of 110 mm (4.33 in.).

NOTE: GO110 core balance transformer is not sold anymore. However, for any refurbishing projects, the PowerLogic P5 protection relay is compliant with this core balance transformer and therefore can be connected together as shown in Typical application diagrams, page 66.

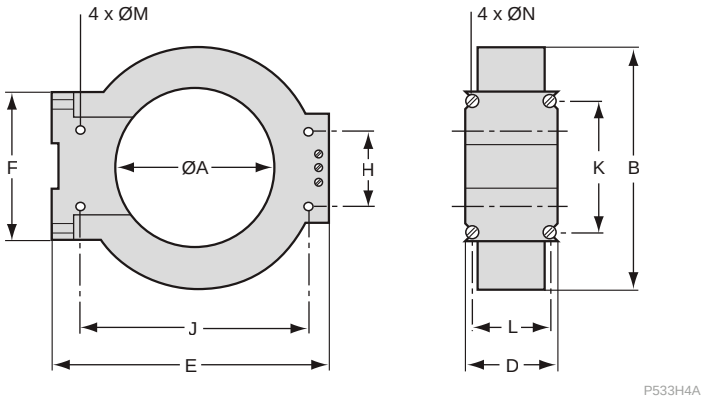
Figure 98 - Core balance current transformers (CT)



① CSH300 core balance CT
② CSH200 core balance CT
③ CSH120 core balance CT
④ GO110 core balance CT

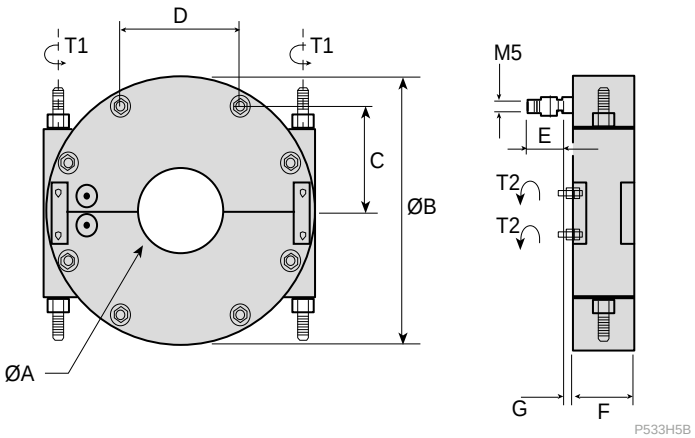
Dimensions

Figure 99 - CSH120, CSH 200 and CSH300 dimensions



	A	B	D	E	F	H	J	K	L	M	N
CSH120	120 mm (4.72 in.)	164 mm (6.46 in.)	44 mm (1.73 in.)	190 mm (7.48 in.)	80 mm (3.15 in.)	40 mm (1.57 in)	166 mm (6.54 in.)	65 mm (2.56 in.)	35 mm (1.38 in.)	6 mm (0.24 in.)	5 mm (0.2 in.)
CSH200	196 mm (7.72 in.)	256 mm (10.1 in.)	46 mm (1.81 in.)	274 mm (10.8 in.)	120 mm (4.72 in.)	60 mm (2.36 in.)	254 mm (10 in.)	104 mm (4.09 in.)	37 mm (1.46 in.)		
CSH300	291 mm (11.46 in.)	360 mm (14.17 in.)	46 mm (1.81 in.)	390 mm (15.35 in.)	120 mm (4.72 in.)	60 mm (2.36 in.)	369 mm (14.53 in.)	104 mm (4.09 in.)	37 mm (1.46 in.)		

Figure 100 - GO110 dimensions



A	B	D	E	F	G
110 mm (4.33 in.)	224 mm (8.82 in.)	92 mm (3.62 in.)	16 mm (0.63 in.)	44 mm (1.73 in.)	8 mm (0.31 in.)

Opening and closing the GO110 CT

To open the GO110 CT:

- Undo both T1 nuts and remove the two pins.
- Undo both T2 nuts and remove the two bars.

To close the GO110 CT:

- Replace the two bars and tighten both T2 nuts (T2 tightening torque: 30 N·m or 0.34 lb-in).
- Replace the two pins and tighten both T1 nuts (T1 tightening torque: 70 N·m or 0.79 lb-in).

Assembly

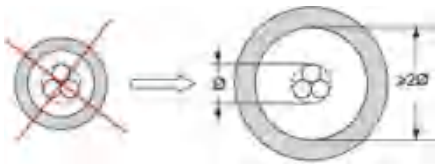
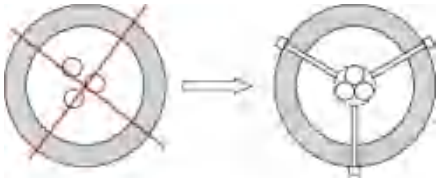
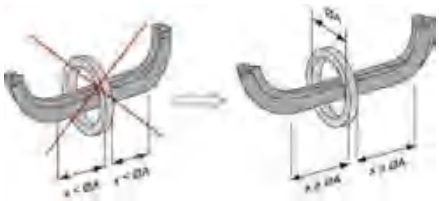
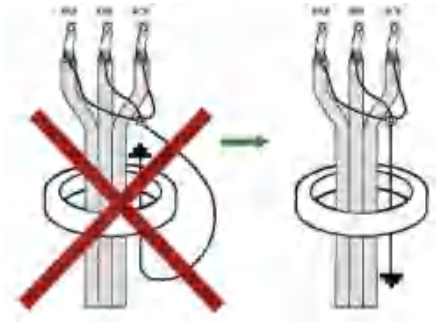
DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Only qualified personnel should install this equipment. Such work should be performed only after reading this entire set of instructions.
- NEVER work alone.
- Turn off all power supplying this equipment before working on or inside it. Consider all sources of power, including the possibility of back feeding.
- Always use a properly rated voltage sensing device to confirm that all power is off.
- Only CSH120, CSH200, CSH300 and GO110 core balance CTs can be used for direct neutral current measurement.
- Install the core balance CTs on insulated cables.
- Cables with a rated voltage of more than 1000 V must also have an earthed/grounded shielding.

Failure to follow these instructions will result in death or serious injury.

Table 16 - Instructions for assembling the core balance CTs

	Select a CT with a diameter at least twice the size of the cable harness going through it.
	Group the cable(s) in the middle of the CT and use non-conducting binding to hold the CT in place around the cable harness.
	Do not bend the cable(s) close to the CT; install the CT on a straight section of the cable(s) that is at least twice as long as the CT diameter.
	Remember to pass the shielded earthing/grounding braid on the cables back through the CT. Check that the braid goes the right way through the CT.

When assembling the core balance CTs, group the medium voltage cable (or cables) in the middle of the core balance CT, use non-conductive binding to hold the cables, and remember to insert the shielded earthing/grounding braid of the medium voltage cable through the core balance.

Connection

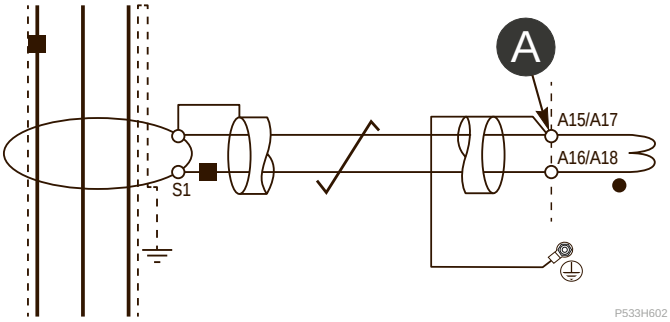
Recommended cable:

- Sheathed cable (to be compliant with electromagnetic compatibility requirements), shielded by tinned copper braid.
- Resistance per unit length < 100 mΩ/m (30.5 mΩ/ft).
- Minimum dielectric strength: 1000 V (700 Vrms).
- Connect the cable shielding in the shortest manner possible to the protection relay.
- Flatten the connection cable against the metal frames of the cubicle.

Core balance CT	Wiring	Type of terminal	Tools	Tightening torque
CSH120 CSH200 CSH300	1 to 2.5 mm² (AWG 18 to 14) wire[24] Stripped length: 8 mm (0.31 in.)	M3.5 screw	Flat blade screwdriver 3.5 mm (0.14 in.)	0.8 to 1 N·m (7.1 to 8.8 lb-in.)
GO110	1.5 to 6 mm² (AWG 16 to 10) wire[24] Lug with inner diameter: 5 mm (0.2 in.)	M5 screw	Flat spanner for M5 nut	30 N·m (0.34 lb-in.)

The maximum resistance of the connection wiring must not exceed 4 Ω (20 m maximum for 100 mΩ/m or 66 ft maximum for 30.5 mΩ/ft).

Figure 101 - Connecting the core balance CT



A — CSH 20 A input on P5: terminals A15–A16 on standard CV/VT board or A1–A2 on LPCT/ LPVT board

CSH 2 A input on P5: terminals A17–A18 on standard CV/VT board or A3–A4 on LPCT/ LPVT board

Note that for specific application, it is possible to connect 2 CSH200 core balance CTs in parallel, for example, when the medium-voltage cables have a large diameter, and the installation uses 2 or 3 conductors per phase.

NOTICE

UNINTENDED AND NUISANCE TRIPPING

The shield of the CSH cable must be connected to the nearest PowerLogic P5 protection relay stud with a cable of less than 12 cm (4.72 in.).

Failure to follow these instructions can result in equipment misoperation.

24. Depending on the earth/ground fault current input selected (2 A or 20 A).

Characteristics

Table 17 - Characteristics of the core balance CTs

Characteristics	CSH120	CSH200	CSH300	GO110
Inner diameter	120 mm (4.72 in)	196 mm (7.72 in)	291 mm (11.46 in.)	110 mm (4.33 in.)
Weight	0.6 kg (1.32 lb)	1.4 kg (3.09 lb)	2.5 kg (5.51 lb)	3.2 kg (7.04 lb)
Accuracy (1CT)	±5% at +20°C (68°F) ±6% max. at -25°C to 70°C (-13°F to +158°F)			< 0.5% (10 A to 50 A)
Accuracy (2 CTs in parallel)	-	±10%	±10%	-
Transformation ratio	470/1			
Maximum permissible current (1CT)	20 kA - 1s			
Operating temperature	-25°C to +70°C (-13°F to +158°F)			
Storage temperature	-40°C to +85°C (-40°F to +185°F)			

Interposing CSH30 (reference 59634)

Description

The interposing CSH30 is a ring-core CT which is used as an interface where the neutral current is measured using standard 1 A or 5 A current transformers and the P5 device is equipped with CSH 2/20A inputs. Such application may be present when using LPCTs for phase current measurement, but keeping conventional CT for neutral/earth/ground current measurement.

It is adapted for the type of current transformer, 1 A or 5 A, by the number of turns of the CT secondary wiring through the interposing CSH30 ring CT:

- 5 A rating - 4 turns
- 1 A rating - 2 turns

Figure 102 - Connection to 5 A secondary circuit: 4 turns

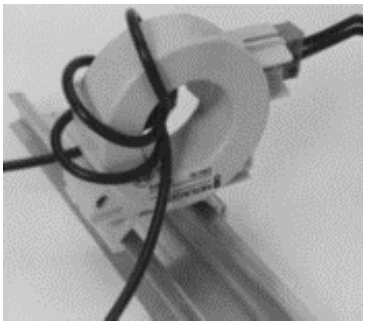
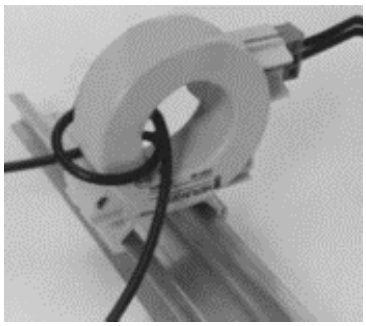


Figure 103 - Connection to 1 A secondary circuit: 2 turns

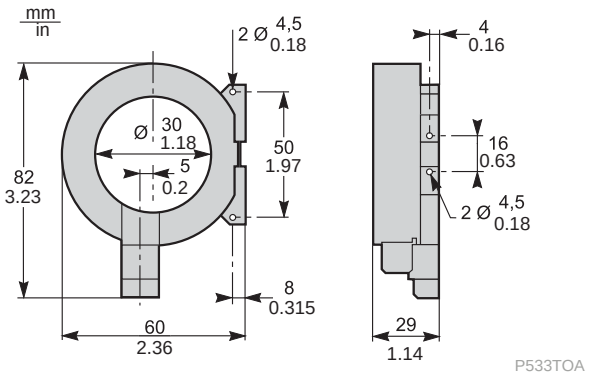


Dimensions

The CSH30 is mounted on symmetrical DIN rail, either in vertical or horizontal position.

Mechanical dimensions are given in the figure below:

Figure 104 - Dimensions for CSH30



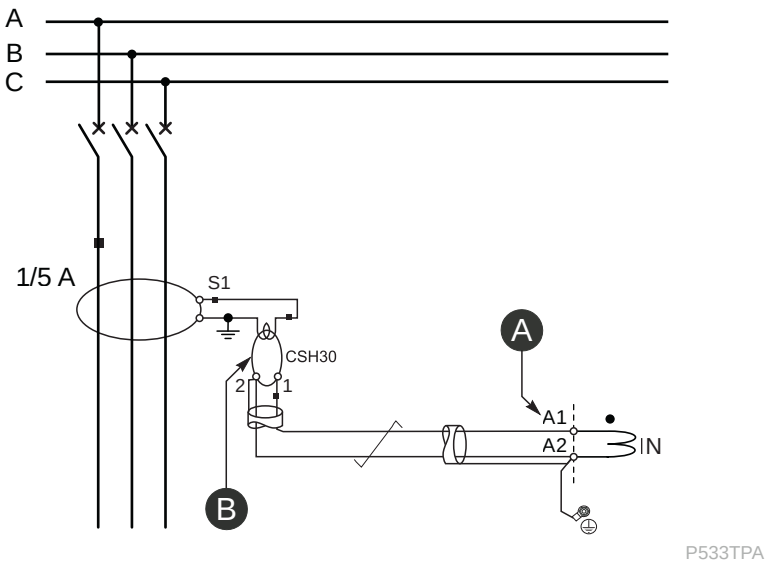
Connection

Recommended cable:

- Sheathed cable, shielded by tinned copper braid
- Minimum cable cross-section 0.93 mm² (AWG 18) (max. 2.5 mm², AWG 12)
- Resistance per unit length < 100 mΩ/m (30.5 mΩ/ft)
- Minimum dielectric strength: 1000 V (700 Vrms)
- Maximum length: 2 m (6.6 ft)

The connection cable shielding has to be earthed/grounded on PowerLogic P5 end at one of the earth/ground connections on the back plate. Do not earth/ground the cable by any other means.

Figure 105 - Connection diagram of CSH30 interposing ring CT and P5 (CSH 20 A/CSH 2 A)



A	CT 1 A - interposing CSH30 - CSH 2 A input on P5 (terminals A17–A18 on standard CT/VT board or A3–A4 on LPCT/LPVT board) CT 5 A - interposing CSH30 - CSH 20 A input on P5 terminals A15–A16 on standard CT/VT board or A1–A2 on LPCT/LPVT board)	B	CT 1 A: 2 turns CT 5 A: 4 turns

Characteristic

Table 18 - Characteristics of the interposing CSH30

Characteristics	CSH30
Weight	0.12 kg (0.265 lb)
Accuracy	±5% at +20°C (68°F) ±6% max. at -25°C to +70°C (-13°F to +158°F)
Operating temperature	-25°C to 70°C (-13°F to +158°F)
Storage temperature	-40°C to 85°C (-40°F to +185°F)

LPVT hub connector (reference EMS59573)

Description

The LPVT hub connector is a simple passive device that combines three LPVT signals coming from 3 different connectors on one single RJ45 connection.

The output of the LPVT hub connector is directly connected to the LPVT input of PowerLogic P5 protection relay.

The LPVT hub connector also manages the presence of each LPVT connection thanks to a daisy chain across the three sensors. If at least one LPVT is missing or one cable is damaged, an alarm event is logged and displayed on the local panel.

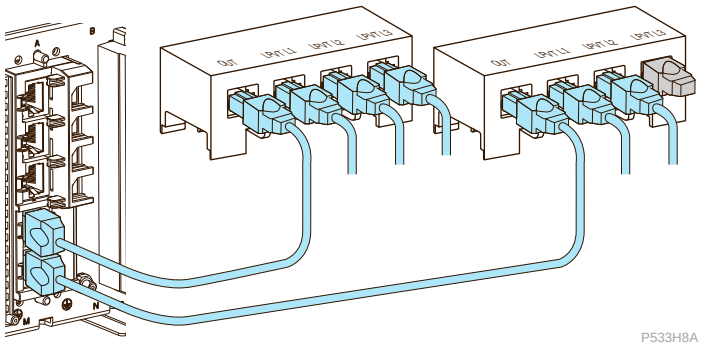
Figure 106 - LPVT hub connector



Connection

The LPVT hub connector is connected to protection relay through its RJ45 output connector and to the LPVT sensors through the RJ45 input connectors.

Figure 107 - LPVT hub connector connected to PowerLogic P5x30 protection relay



Characteristics

Table 19 - Characteristics of the LPVT hub connector

Characteristics	Values	
Electric		
Input voltage	< 10 V	
Input voltage limits	< 30 V	
Network frequency	50/60 Hz	
Electrical connection	Output: RJ45 connector Input: 3 RJ45 connector	
Form factor		
Dimension (L x W x H)	95 mm x 40 mm x 40 mm (3.74 x 1.57 x 1.57 in)	
Weight	0.25 kg (0.55 lb)	
Mounting support	DIN rail	
Environment		
IP degree of protection	IEC 60529	IP30
IK degree of protection	IEC 62262	IK07
Ambient air temperature for operation	-	-40°C to 85°C (-40°F to 185°F)
Ambient air temperature for storage	-	-40°C to 85°C (-40°F to 185°F)
Fire resistance	IEC 60695-2-11	850°C (1562°F)
Environmental characteristic	IEC 60068-2-11	Salt mist: 200 hours
Relative humidity	IEC 60068-2-30	95%
Operating altitude	-	≤ 3000 m (1.86 miles)

Voltage adapter (reference EMS59572)

Description

The voltage transformer adapter is made with 4 resistor bridges used to interface conventional voltage transformers (VTs) with the PowerLogic P5 protection relay equipped for LPCT/LPVT sensors (please order this accessory separately from Schneider Electric).

Connection

NOTICE
INCORRECT VOLTAGE MEASUREMENT • The earth/ground of the connection diagrams below must be the same of the whole PowerLogic P5 protection relay. The 0 V of the PowerLogic P5 power supply input must be connected to this earth/ground. • Earth/ground connection point of AC voltage adapter must be connected to the isolated ground of VT sensor (LV transformer). For other wiring cases, please consult Schneider Electric. **Failure to follow these instructions can result in measurement error.**

Figure 108 - 3 phase to neutral voltages connection

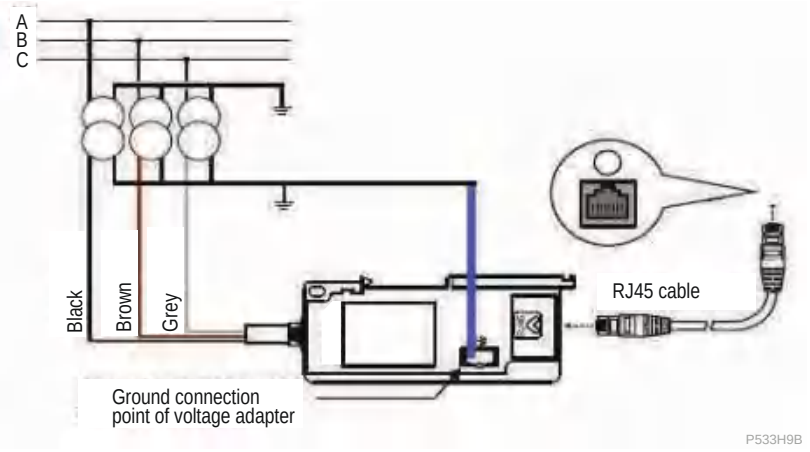


Figure 109 - 2 phase to phase voltages connection

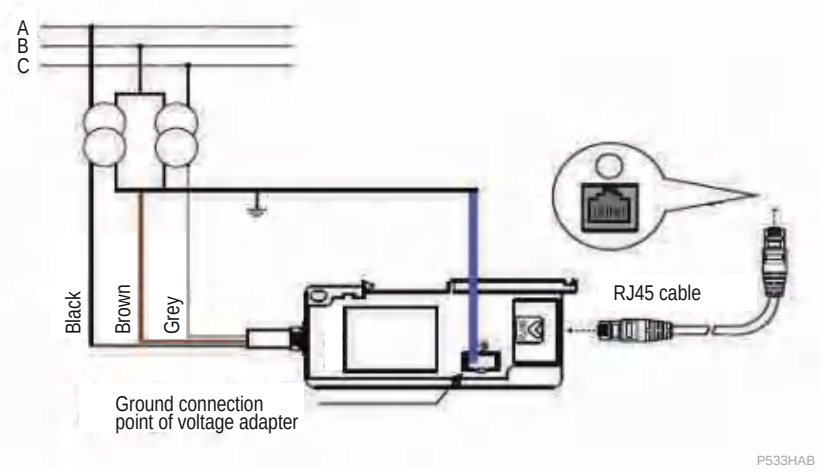


Figure 110 - 1 additional phase to phase voltage connection

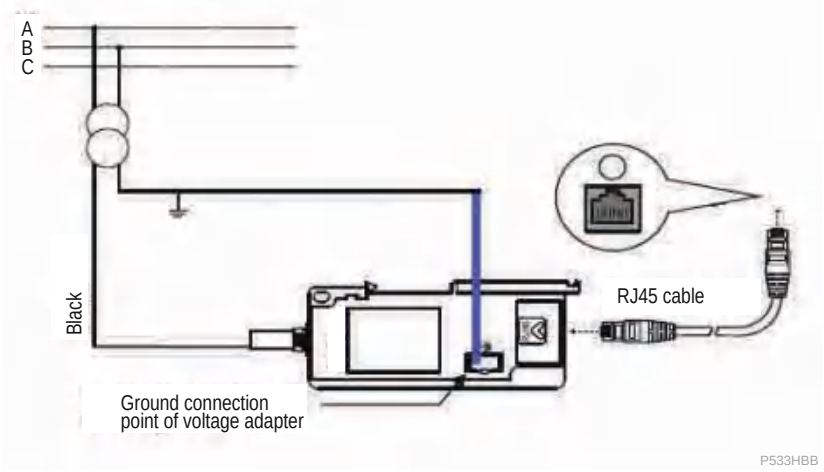
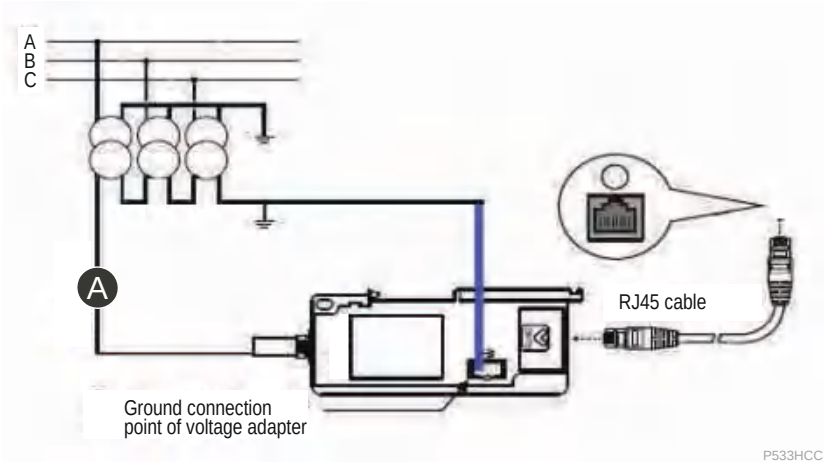


Figure 111 - Open-delta voltage connection



A Cable:
- Black for P5x30
- Brown for P5U20

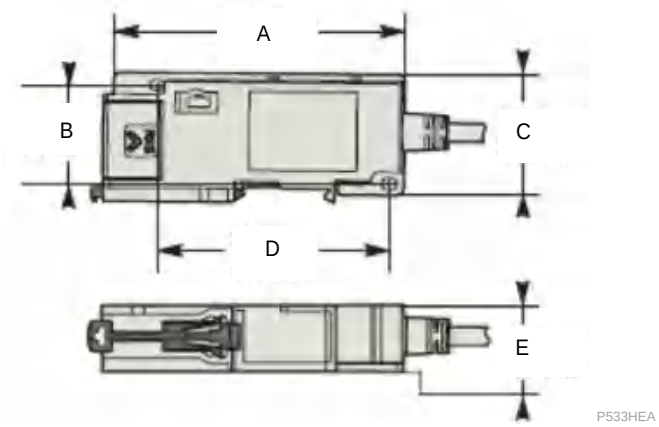
The Ethernet RJ45 cable is connected to the PowerLogic P5 protection relay.
Length maximum: 4 m (13.12 ft)

- CCA770 - 0.6 m (1.97 ft) (reference: 59660)
- CCA772 - 2 m (6.56 ft) (reference: 59661)
- CCA774 - 4 m (13.12 ft) (reference 59662)

NOTE: The voltage adapter is delivered with black, brown, grey and light blue cable. The light blue cable in the voltage transformer adapter input is not used.

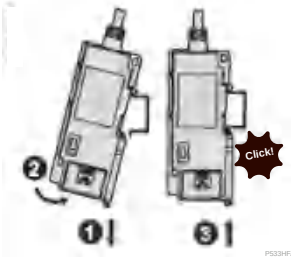
Dimensions

Figure 112 - External dimensions of the AC voltage adapter



A	B	C	D	E
120 mm (4.72 in.)	38 mm (1.49 in.)	52 mm (2.04 in.)	90 mm (3.54 in.)	25 mm (0.98 in.)

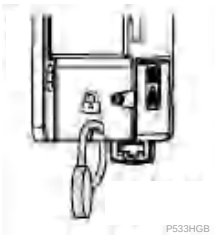
Mounting

DIN rail mounting	Fastening with collar	Mounting on telequick grid
		
Mounting the adapter by its fixture structure on rail	Mounting the adapter using two fastening collars (width: 4 mm/0.16 in)	Mounting the adapter on Telequick grid using two screws (4 mm/0.16 in)

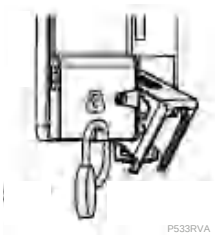
RJ45 terminal locking

The RJ45 input of the voltage transformer adapter can be locked in the open or closed position by placing a seal in the hole marked with a lock symbol (see figure below). This allows to lock the RJ45 connector of the Ethernet cable in its slot or helps prevent its connection.

Figure 113 - RJ45 terminal lock



Locked in close position



Locked in open position

Characteristics

Table 20 - Characteristics of the voltage adapter

Characteristics	Standard	Value
Input voltage		50 V AC to 200 V AC (phase to phase)
Voltage max		600 V max permanent
Network frequency		50/60 Hz
Ambient air temperature for operation	IEC 60068-2-1 IEC 60068-2-2	-40°C to 70°C (-40°F to 158°F)
Ambient air temperature for storage	IEC 60068-2-1 IEC 60068-2-2	-40°C to 85°C (-40°F to 185°F)
Humidity	IEC 60068-2-30	95% HR; 144 hours (6 cycles of 12 hours at 55°C (131°F) and another 12 hours at 25°C (77°F))
Salt spray	IEC 60068-2-11	168 hours
Vibration	IEC 60068-2-6	10 Hz to 2000 Hz; 10 cycles at 2 Gn (peak value)
Bump	IEC 60068-2-29	20 Gn/16 ms/1000 bumps, module de-energised
Shock	IEC 60068-2-27	10 Gn; 11ms; 3 pulses, module in operation
Seismic	IEC 60255-21-3	Class 2 - module in operation: 3 to 35 Hz/15 mm/2 Gn/1 cycle Horizontal axe 3 to 35 Hz/7 mm/1 Gn/1 cycle Vertical axe
High voltage withstand (dielectric)	IEC 60255-27	2 kV for 1 minute
Impulse voltage	IEC 60255-27	5 kV, 1.2/50 µs, 0.5 J
Robustness	IEC 62262	IK7, 2J
Degree of protection	IEC 60529	IP20, module body (without wires)
Weight		150 g (0.33 lb)
Mounting support		Symmetrical DIN rail

RJ45 LPCT/LPVT plug

This RJ45 LPCT/LPVT plug is used when a sensor is not present to close the loop of the sensors presence detection (see Connector A cabling kit for LPCT/LPVT analogue inputs (REL51079), page 75). It could be used on LPVT hub inputs or on LPVT or LPCT P5x inputs.

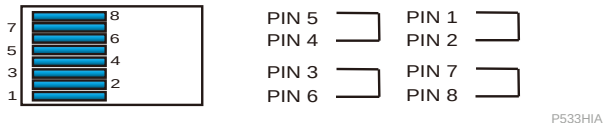
Figure 114 - RJ45 LPCT/LPVT plug



P533ONA

Its purpose is to close the loop of the sensor presence detection on pins 3-6 of the RJ45 and to zero the low voltage inputs shorting the 3 others pairs of the RJ45 connector. (1-2, 4-5, 7-8)

Figure 115 - Pairs of the RJ45 connector



Arc-flash sensor (reference REL52801 to REL52810)

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

Clean the arc sensor periodically as instructed in this user manual and after an arc-flash fault.

Failure to follow these instructions will result in death or serious injury.

Description

The arc-flash sensors are used by PowerLogic P5x30 to detect light coming from an arc-flash incident. They are installed in the protection zone and connected to the connector terminal on the protection relay.

The arc-flash sensor is activated by strong light caused by an arcing fault. The sensor transforms light to electrical signal, which is used by the protection relay to detect an arc-flash and provides the corresponding protection function.

Dimensions

Figure 116 - Dimensions of the standard arc-flash sensors

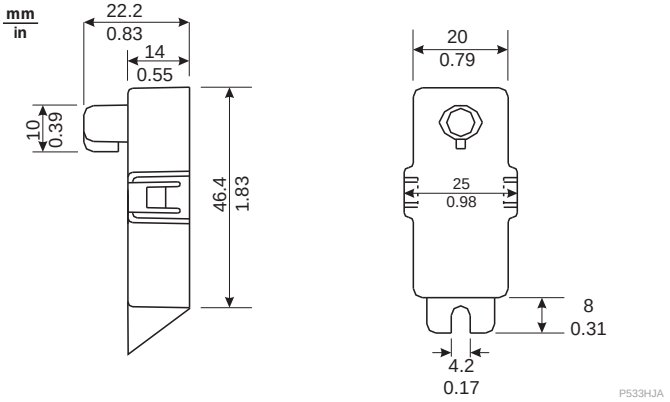
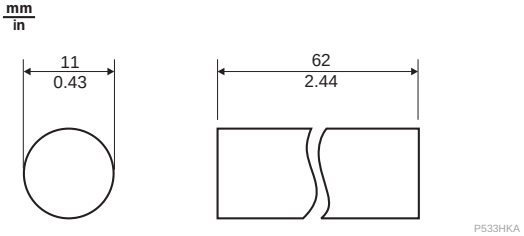


Figure 117 - Dimensions of the pipe type arc-flash sensors



Characteristics

Table 21 - Characteristics of the standard arc-flash sensors

Characteristics	REL52801	REL52802	REL52803	REL52804	REL52805	REL52806
Cable length (m)[25]	6	20	20	6	6	6
Shielded cable	-	-	■	-	-	■
Halogen free	-	■	-	■	-	-
Material	Plastic					
Weight (g/lb)	1,000/2.2	1,300/2.87	1,300/2.87	300/0.66	400/0.88	400/0.88
Environment	Pollution Degree 2					
Operation temperature	-25°C to +70°C (-13°F to +158°F)					
Light spectrum sensitive area	400 – 1100 nm					
Detection time	100 to 300 µs depending on the flashlight received					
Light sensitivity	8,000 – 10,000 lux					
Loop supervision	Yes					

Table 22 - Characteristics of the pipe type arc-flash sensors

Characteristics	REL52807	REL52808	REL52809	REL52810
Cable length (m)[25]	20	20	6	6
Shielded cable	-	■	-	■
Halogen free	-	-	-	-
Material	Plastic			
Weight (g/lb)	1,000/2.2	1,300/2.87	300/0.66	400/0.88
Environment	Pollution Degree 2			
Operation temperature	-25°C to +70°C (-13°F to +158°F)			
Light spectrum sensitive area	400 – 1100 nm			
Detection time	100 to 300 µs depending on the flashlight received			
Light sensitivity	8,000 – 10,000 lux			
Loop supervision	Yes			

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

Never attempt to extend the length of arc-flash sensor cables.

Failure to follow these instructions will result in death or serious injury.

25. To connect the interface in the PowerLogic P5 protection relay, use REL52883 cable.

Mounting the sensors to the switchgear

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. See NFPA 70E, NOM-029-STPS-2011, or CSAZ462.
- The arc fault detection system is not a substitute for proper PPE when working on or near equipment being monitored by the system.
- Information on this product is offered as a tool for conducting arc-flash hazard analysis. It is intended for use only by qualified persons who are knowledgeable about power system studies, power distribution equipment, and equipment installation practices. It is not intended as a substitute for the engineering judgement and adequate review necessary for such activities.
- Only qualified personnel is allowed to install and service this equipment. Read this entire set of instructions and check the technical characteristics of the device before performing such work.
- Perform wiring according to national standards (NEC) and any requirements specified by the customer.
- Observe any separately marked notes and warnings.
- NEVER work alone.
- Before performing visual inspections, tests, or maintenance on this equipment, disconnect all sources of electric power. Assume all circuits are live until they are completely de-energised, tested, and tagged. Pay particular attention to the design of the power system. Consider all sources of power, including the possibility of back feeding.
- Always use a properly rated voltage sensing relay to ensure that all power is off.
- The equipment must be properly grounded.
- Connect the device's protective ground to functional earth according to the connection diagrams presented in this document.
- Do not open the device. It contains no user-serviceable parts.
- Install all devices, doors and covers before turning on the power to this device.

Failure to follow these instructions will result in death or serious injury.

Install arc-flash sensors inside the switchgear. There are two options for the mounting:

- in customer-drilled holes on the switchgear
- on VYX001 Z-shape or VYX002 L-shape mounting plates available from Schneider Electric or locally fabricated from supplied drawings

Figure 118 - VYX 001 mounting plate for sensor

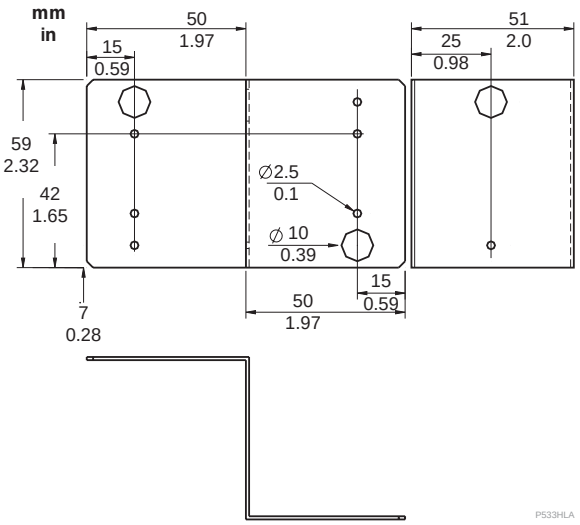


Figure 119 - VYX 002 mounting plate for sensor

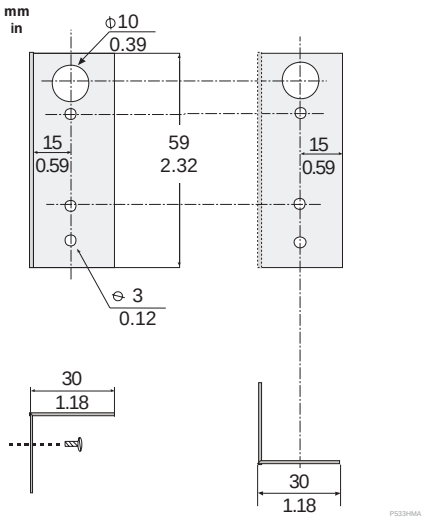
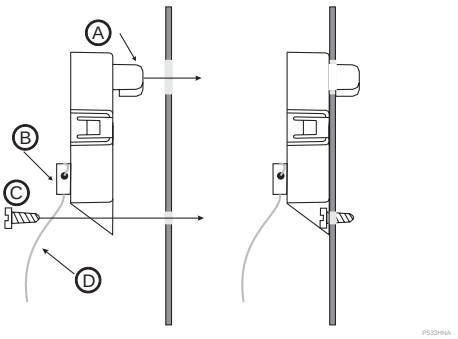


Figure 120 - Mounting the sensor



Ⓐ Active part of the sensor

Ⓑ Cable clamp

Ⓒ Fastening with M4 x 15 mm (0.59 in) screw

Ⓓ Sensor cable

- Press the active part of the sensor through the 10 mm hole on the panel.
- Fix it with an M4 screw.

Connecting the sensors to the device

The sensors are delivered with 6 m (19.7 ft) or 20 m (65.6 ft) cables.

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

Never attempt to extend the length of arc-flash sensor cables.

Failure to follow these instructions will result in death or serious injury.

After mounting the sensors, connect them to the device.

1. Route the wire to the nearest device with the shortest route possible.

   Cut the wire to a suitable length.

   Take into account the wiring methods inside the equipment. This should be compliant with local regulations.
2. Connect the arc sensors to the screw terminals.

   The polarity of the arc sensor cables is not critical.

Figure 121 - Point sensor connections

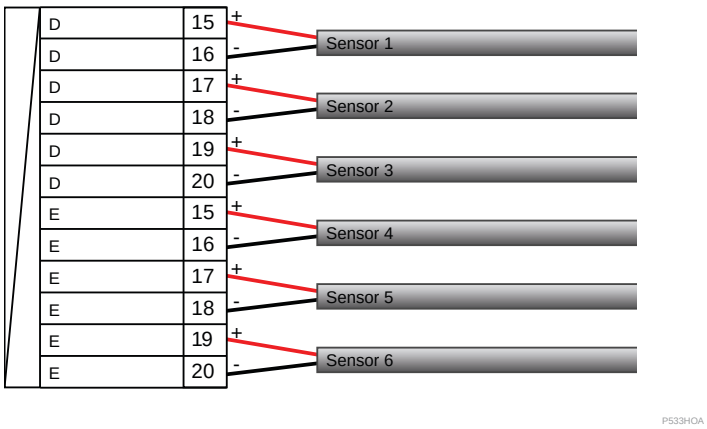


Table 23 - Point sensor connections

Slot	Pin no.	Description
D	15	Arc sensor 1 positive terminal
	16	Arc sensor 1 negative terminal
	17	Arc sensor 2 positive terminal
	18	Arc sensor 2 negative terminal
	19	Arc sensor 3 positive terminal
	20	Arc sensor 3 negative terminal
E	15	Arc sensor 4 positive terminal
	16	Arc sensor 4 negative terminal
	17	Arc sensor 5 positive terminal
	18	Arc sensor 5 negative terminal
	19	Arc sensor 6 positive terminal
	20	Arc sensor 6 negative terminal

3. Connect the cable shield to the corresponding grounding stud connector on slot D or E when using shielded cable on the sensors.

MET148-2 - temperature sensor module (reference 59641)

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

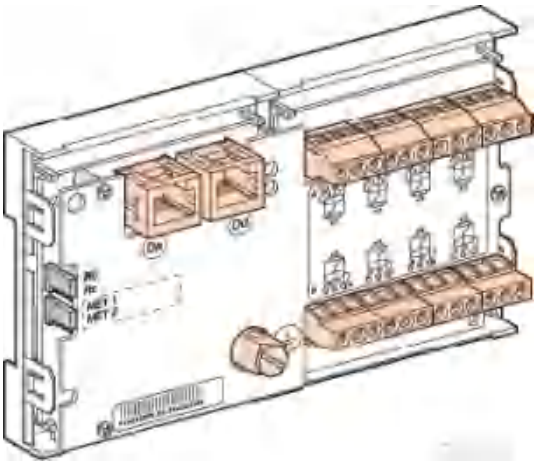
Check that the temperature sensors are isolated from dangerous voltages.

Failure to follow these instructions will result in death or serious injury.

Description

The temperature sensor module is an external module used for temperature measurement with Resistance Temperature Detectors (RTDs). It is connected to the extension module. It is an optional selection when ordering the device or can be purchased after on-site installation. It provides 8 RTD inputs.

Figure 122 - MET148-2 temperature sensor module



The MET148-2 module can be used to connect 8 temperature sensors (RTDs) of the same type:

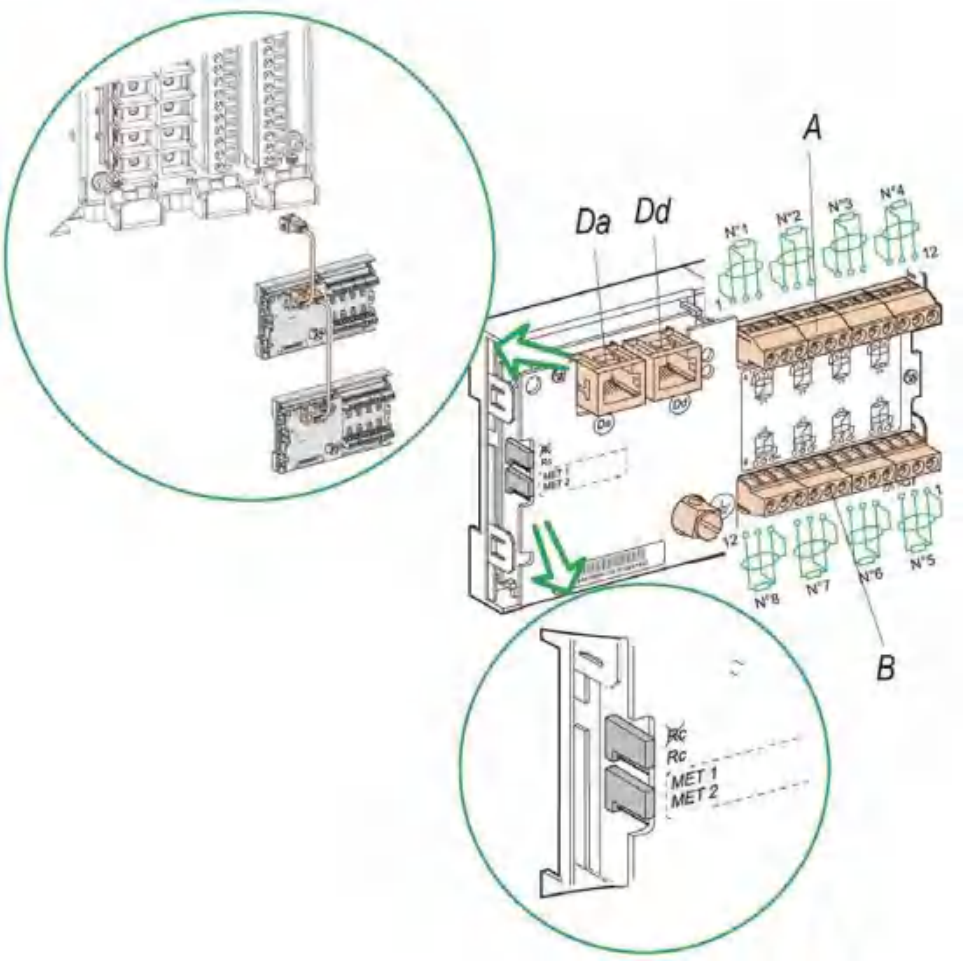
- Pt100, Ni100 or Ni120 type RTDs, according to parameter setting
- 3-wire temperature sensors
- A single module for each PowerLogic P5 protection relay to be connected by one of the CCA770 (0.6 m or 2 ft), CCA772 (2 m or 6.6 ft) or CCA774 (4 m or 13.1 ft) cords

The temperature measurement (for example, in a transformer or motor winding) is used by the following protection functions:

- Thermal overload (to take ambient temperature using RTD number 8)
- Temperature monitoring.

Connection

Figure 123 - Connection of the MET148-2 temperature sensor module



Connectors and terminals on the module:

- A: Terminal block for RTDs 1 to 4
- B: Terminal block for RTDs 5 to 8
- Da: RJ45 connector to connect the module to the PowerLogic P5 protection relay with a CCA77x cord
- Dd: RJ45 connector to link up the next remote module with a CCA77x cord

Jumper for impedance matching terminal with load resistor (Rc) to be set to:

- Rc - if the module is not the last interlinked module (default position).
- RC - if the module is the last interlinked module.

Jumper used to select module number, to be set to:

- MET1: first MET148-2 module, to measure temperatures T1 to T8 (default position)
- MET2: second MET148-2 module, to measure temperatures T9 to T16.

Characteristics

Table 24 - Characteristics of the MET148-2 temperature sensor module

Characteristics	Values	
Dimensions (L × W × D)	144 mm × 88 mm × 30 mm (5.67 in × 3.46 in × 1.81 in)[26]	
Weight	0.2 kg (0.441 lb)	
Mounting support	On symmetrical DIN rail	
Operating temperature	-40°C - +70°C (-40°F - +158°F)	
Temperature sensors		
Type of sensors	Pt100	Ni100/Ni120
Isolation from earth/ground	None	None
Current to RTD	4 mA	4 mA
Maximum distance between sensor and MET148-2	1 km (0.62 mi)	

Recommended cross-sections according to distance:

- Up to 100 m (330 ft) ≥ 1 mm^2 (AWG 18)
- Up to 300 m (990 ft) ≥ 1.5 mm^2 (AWG 16)
- Up to 1 km (0.62 mi) ≥ 2.5 mm^2 (AWG 12)

Maximum distance between sensor and module: 1 km (0.62 mi).

26. Depth is 70 mm (2.8 in) with cable connected

IRIG-B module (reference REL51045)

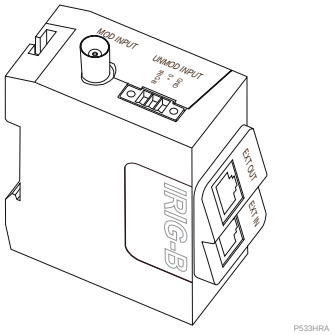
Description

The IRIG-B module is an external module used for accurate time synchronisation. It is connected to the extension module. It is an optional selection when ordering the device or can be purchased after on-site installation.

The module provides both a modulated (MOD INPUT) and an unmodulated input (UNMOD INPUT) and can automatically detect the type of input. No configuration of input type is needed in the PowerLogic P5 protection relay.

It does not require any auxiliary supply connection.

Figure 124 - IRIG-B module



Characteristics

Table 25 - Characteristics of the IRIG-B module

Characteristics	Values
Standard	
Standard	IRIG 200-04
Form factor	
Height	95 mm (3.7 in)
Width	36 mm (1.4 in)
Depth	87 mm (3.4 in)
Weight	100 g (3.53 oz)
Mounting support	Symmetrical DIN rail
Modulated IRIG-B input	
Connection	BNC socket
Type of cable	50 Ohm coaxial
Length of cable	< 150 m (492.13 ft)
Time code format	B120 to B127
Input signal level	200 mV to 10 V
Unmodulated IRIG-B input	
Connection	Screw-type terminals
Type of cable	Twisted pair
Length of cable	< 50 m (164.04 ft)
Time code format	B000 to B007
Input impedance	10 kΩ
Input signal level	2 V to 6 V peak

Connection

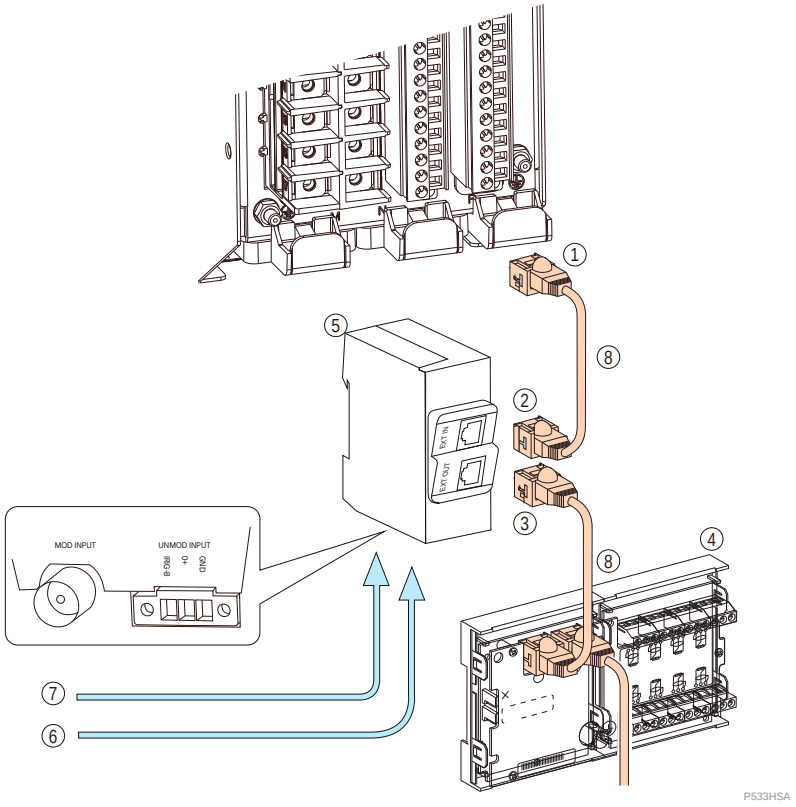
The IRIG-B module is connected to the PowerLogic P5 protection relay from its EXT IN port. The cable used for connection must be shielded and of a length not exceeding 10 m (32.8 ft).

The IRIG-B module provides an additional extension port (EXT OUT) to connect other accessories such as the MET148-2 module with CCA77x cords.

The time source is connected to the module through the modulated input, or through the unmodulated input by connecting signal + to the IRIG-B terminal, and signal - to the 0+ terminal.

NOTE: If one source is connected on the modulated input and another one on the unmodulated input, the modulated signal is prioritised.

Figure 125 - Connection of IRIG-B



① to extension port P of relay

② to EXT IN port of IRIG-B

③ to EXT OUT port of IRIG-B

④ MET148-2 module

⑤ IRIG-B module

⑥ Time source to unmodulated IRIG-B input

⑦ Time source to modulated IRIG-B input

⑧ CCA77x cord

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Install IRIG-B module between PowerLogic P5 protection relay and any other accessories like MET148-2 temperature module.
- Do not interface any accessories between PowerLogic P5 protection relay and IRIG-B module.

Failure to follow these instructions will result in death or serious injury.

CT requirements

⚠WARNING

IMPROPER EQUIPMENT OPERATION

Select the CT size according to the requirement from the electric network.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

The PowerLogic P5 phase current inputs can be connected to standard 1 A or 5 A CTs.

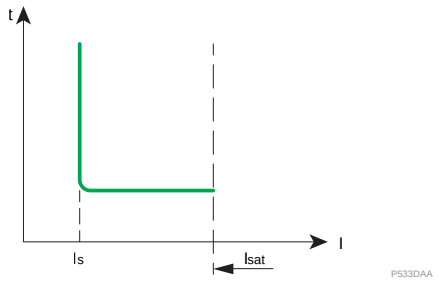
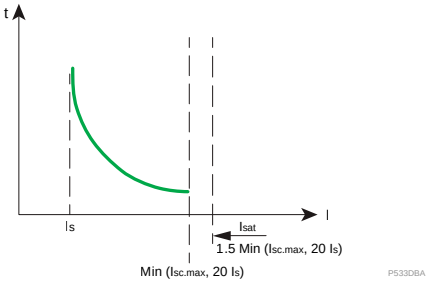
Sizing rules of phase and neutral CTs can be specific for each function and depend on which of the following have to be considered:

- Phase overcurrent protection
- Neutral overcurrent protection
- Restricted earth fault protection
- Transformer differential protection

Phase and neutral overcurrent protection

The CTs must be sized to avoid saturation during steady state short circuit currents where accuracy is required, according to the rules described below for Definite Time (DT) or Inverse Definite Minimum Time (IDMT) operation.

The condition to be fulfilled by the CT saturation current (I_{sat}) depends on the type of overcurrent protection operation time:

Time Delay	Condition to be Fulfilled	Illustration
DT	I_{sat} > 1.5 x set point (Is)	
IDMT	I_{sat} > 1.5 x the smallest of the following 2 values: • $I_{sc.max}$, maximum installation short-circuit current • 20 x Is (IDMT curve dynamic range)	

The method for calculating the saturation current depends on the CT accuracy class as indicated further below.

Practical information

In the absence of any information about the settings, the characteristics below are suitable for most situations:

Rated Secondary Current ($I_{sec.nom}$)	Rated Burden (VA_{CT})	Accuracy Class and Accuracy Limit Factor	CT Secondary Resistance (R_{CT})	Wiring Resistance (R_w)
1 A	2.5 VA	5P20	< 3 Ω	< 0.075 Ω
5 A	7.5 VA	5P20	< 0.2 Ω	< 0.075 Ω

Restricted earth fault protection

For accuracy, Class PX, Class 5P or 5PR CTs should be used for low impedance Restricted earth fault (REF) applications.

A series of tests with internal and external faults were performed to determine the CT requirements for the REF function. These tests were performed according to IEC 60255-187 standard for different primary system constants (X/R ratios up to 64), CT burdens, fault currents, fault types and points on wave.

Both bias characteristics of REF protection were checked at their default settings:

- Low set Id1 = 0.20 pu

Further in Max (IP) bias mode:

- Slope k1 = 20%
- Low set Ib1 = 1.00 pu
- Slope k2 = 150%
- Min measured IG = 0.1 pu

According to the test results, to achieve fast trip during internal faults and to keep stability for through faults, the CT dimensioning must comply with the following requirements:

- CT class 5P with an operational accuracy limit factor ALF' = 8,
  hence an equivalent limiting secondary e.m.f. $E_{al} \geq 8 \times In \times (R_{CT} + R_b)$,
  where R_{CT} = CT secondary winding resistance (at 75°C)
  R_b = connected resistive burden
- or equivalent class PX CT with a kneepoint voltage $V_K \geq 0.85 \times E_{al}$

Transformer differential protection

For accuracy, Class PX, Class 5P or 5PR CTs should be used for transformer differential protection applications.

A series of tests with internal and external faults were performed to determine the CT requirements for the transformer differential protection function. These tests were performed according to IEC 60255-187-1 standard for different transformer configurations, primary system voltages and time constants (X/R ratios up to 64), CT ratios and burdens, fault currents, fault types and points on wave.

The protection was checked with both bias calculation modes provided from differential function at its default characteristic, as recommended by the IEC standard:

- Low set Id = 0.20 pu
- Slope 1 = 30%
- Ib for start of slope 2 = 2.00 pu
- Slope 2 = 70%
- High set Id = 30.00 pu

According to the test results, the CT dimensioning must comply with the following requirements:

- a CT class 5P with an equivalent limiting secondary e.m.f. E_{al} greater or equal to the maximum value calculated for the following conditions:
  - to achieve fast trip during internal faults:
    $E_{al.int} \geq 1.0 \times I_{f.int} / I_{pr} \times I_{sr} \times (R_{CT} + R_b)$
  - and to keep stability for external faults:
    $E_{al.ext} \geq 1.8 \times I_{f.ext} / I_{pr} \times I_{sr} \times (R_{CT} + R_b)$

  where:
  - $I_{f.int}$ = Maximum primary fault current in case of internal fault
  - $I_{f.ext}$ = Maximum primary (through-flowing) fault current in case of external fault
  - I_{pr} = CT rated primary current
  - I_{sr} = CT rated secondary current (1 A or 5 A)
  - R_{CT} = CT secondary winding resistance (at 75°C)
  - R_b = connected resistive burden
- or equivalent class PX CT with a kneepoint voltage $V_K \geq 0.85 \times \max(E_{al.int}, E_{al.ext})$.

Calculating the saturation current in class P

A class P CT is characterised by:

- $I_{prim.nom}$: Rated primary current (in A)
- $I_{sec.nom}$: Rated secondary current (in A)
- Accuracy class, expressed by a percentage, 5P or 10P, followed by the Accuracy-Limit Factor (ALF), whose usual values are 5, 10, 15, 20, 30
- VA_{CT}: Rated burden, whose usual values are 2.5/ 5/ 7.5/ 10/ 15/ 30 VA
- R_{CT}: Resistance of the secondary winding (in Ω)

The installation is characterised by the burden resistance R_b at the CT secondary (wiring + protection relay). If the CT load complies with the rated burden, which means $R_{b.nom} \times I_{sec.nom}^2 = VA_{CT}$, the saturation current is equal to $I_{sat} = ALF \times I_{prim.nom}$.

If the CT winding resistance R_{CT} is known, it is possible to calculate the actual CT ALF, which takes account of the actual CT load. The saturation current then equals actual ALF x $I_{prim.nom}$, where:

$$Actual\ ALF = ALF \times \frac{R_{CT} \times I_{sec.nom}^{\ 2} + VA_{CT}}{(R_{CT} + R_b) \times I_{sec.nom}^{\ 2}}$$

P533DCA

Hence if the actual CT load is less than its nominal burden ($R_{b.act} < R_{b.nom}$), a higher short-circuit current can be transmitted without saturation.

Example:

A CT with the following characteristics is given:

- Transformation ratio: 100 A / 5 A
- Accuracy class and accuracy limit factor: 5P20
- Rated burden: 2.5 VA
- Resistance of the secondary winding: 0.1 Ω

To get an ALF of at least 20, in other words, a saturation current of 20 x $I_{prim.nom}$ = 2 kA, the load resistance R_b of the CT must be less than:

$$R_{b,max} = \frac{VA_{CT}}{I_{sec.nom}^{\ 2}} = 0.1\ \Omega$$

P533PHA

This represents 12 m (39 ft) of wire with cross-section 2.5 mm² (AWG 14) for a resistance per unit length of 8 mΩ/m (2.4 mΩ/ft) approximately.

For an installation with 50 m (164 ft) of wiring with section 2.5 mm² (AWG 14), the actual resistance is R_b = 0.4 Ω, and hence actual ALF is:

$$Actual\ ALF = ALF \times \frac{R_{CT} \times I_{sec.nom}^{2} + VA_{CT}}{(R_{CT} + R_b) \times I_{sec.nom}^{2}} = \frac{0.1 \times 25 + 2.5}{(0.1 + 0.4) \times 25} = 8$$

P533DEA

Therefore, the saturation current for this CT installation is:
$I_{sat} = 8 \times I_{prim.nom} = 800$ A.

NOTE: The actual CT burden R_b connected on its secondary side is given as follows:

- For phase to ground faults: $R_b = 2 R_W + R_{rel}$
- For phase to phase faults: $R_b = R_W + R_{rel}$

Where the wire lead burden is calculated as:

$$R_W = \rho \times \frac{l}{A}$$

P533PIA

with ρ = specific conductor resistance, for example, for copper 0.021 Ω mm²/m at 75°C

l = wire length in [m]

A = wire cross section in [mm²]

The impedance of PowerLogic P5 protection relays current inputs (R_{rel} = 4 mΩ) is often negligible compared to the wiring resistance.

Calculating the saturation current in class PX

A class P CT is characterised by:

- $I_{prim.nom}$: Rated primary current (in A)
- $I_{sec.nom}$: Rated secondary current (in A)
- Vk: Rated knee-point voltage (in V)
- R_{CT}: Maximum resistance of the secondary winding (in Ω)

The saturation current is calculated with the actual load resistance R_b at the CT secondary (wiring + protection relay):

$$I_{sat} = \frac{Vk}{R_{CT} + R_b} \times \frac{I_{prim.nom}}{I_{sec.nom}}$$

P533PKA

Examples:

CT with transformation ratio 100 A / 5 A, Vk = 20 V, R_{CT} = 0.13 Ω, R_b = 0.4 Ω

$$I_{sat} = \frac{20}{0.13 + 0.4} \times \frac{100}{5} = 754\ A$$

P533PJA

CT with transformation ratio 100 A / 1 A, Vk = 90 V, R_{CT} = 3.5 Ω, R_b = 0.4 Ω

$$I_{sat} = \frac{90}{3.5 + 0.4} \times \frac{100}{1} = 2307A$$

P533PLA

LPCT configuration

Introduction

This section gives an overview of some reasons to move from traditional CT to LPCT, what is an LPCT and how to configure them in eSetup Easergy Pro (at least V3.0.0).

Further details, such as how to wire the LPCT or the VT adapter is described in the following section.

Benefits of LPCTs

In short, the use of Low Power Instrument Current Transformers (LPCTs) brings many benefits through-out the project lifecycle, which are detailed below.

Personal safety is improved during testing and operation

With LPCT technology, the safety risk of accidental opening of the secondary circuit is greatly reduced due to its special design, as the output is always low voltage:

- The 1 A or 5 A ICT secondary current is replaced by either 22.5 mV, 150 mV, or 225 mV in LPCTs.
- As these secondaries can be left open or short-circuited without risk, there is no longer the need for short-circuit devices that were designed to mitigate those risks.

One LPCT can replace the needs of dedicated measurement and protection CTs

As LPCTs commonly saturate much later than Inductive Current Transforms (ICTs), they can allow fault measurement ranging from 5 kA to 80 kA primary.

The measurement accuracy of an LPCT could range from 5% of rated primary current to the extended primary current. It may be specified as class 0.1, 0.2, 0.5, or 1.

However, its protection accuracy could range from the extended primary current to the accuracy limit of primary current. It may be specified as either class 5P, 10P or 5TPE.

For example, a 100 A LPCT may be labelled as 0.5/5P 25000 A, meaning:
M class = 0.5%, P class = 5P up to 25 kA (250 times primary current rating).

Since the LPCTs support a larger range of extended rated primary current, they can be applied to a larger scope. The primary rating of LPCT is not requested to be as close as possible to the nominal current, therefore, in specifications, the rated primary current become no longer a major determinant factor for the LPCTs.

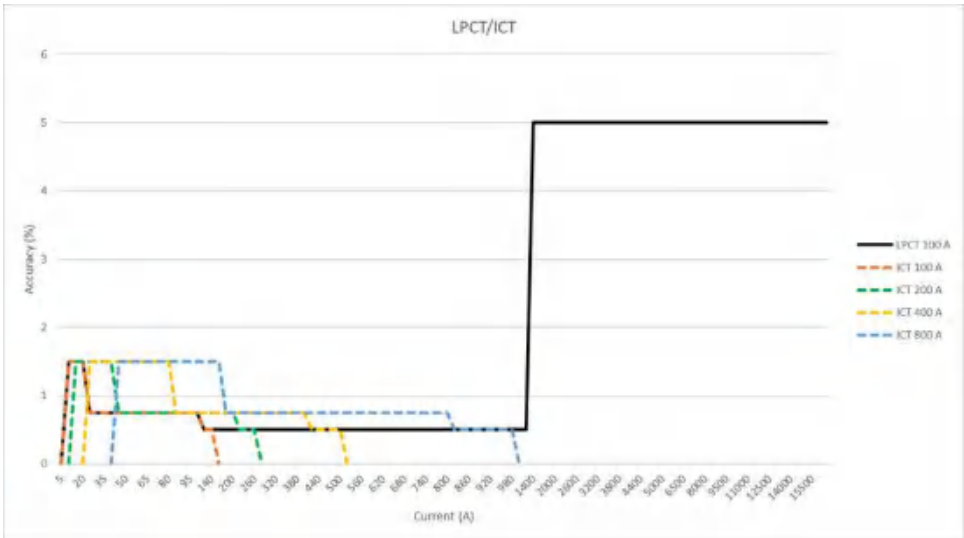
For measurement class

In this example, a multipurpose normalized LPCT with a rated primary current of 100 A and an extended primary current of 1000 A can be used in place of the 10 different ICTs with the following primary currents:
100, (125), 150, 200, (250), 300, (400), 500, (600), 750** (but not 1000**)

NOTE: ** The extended primary current of an ICT is limited to 120% of its rated current.

- 750 A x 1.2 = 900 A is less than the 1000 A extended primary current.
- 1000 A x 1.2 = 1200 A is greater than the 1000 A extended primary current.

Figure 126 - LPCT measurement accuracies for primary currents

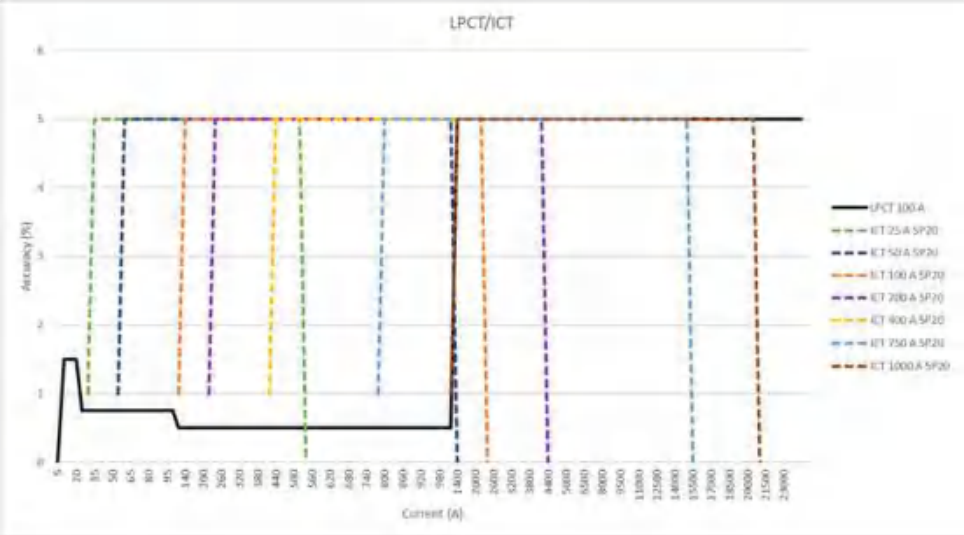


If we know that the initial nominal current to be measured is between 100 A and 750 A, we can take an LPCT of 100 A rated current and with 1000 A extended primary current which will still be flexible to last-minute changes or when load flow may increase subsequently.

For protection class

Same example, a multipurpose normalized LPCT with a 100 A rated primary current and a 1000 A extended primary current can be used in place of the 13 different ICTs with the following primary currents:
25, 50, 100, (125), 150, 200, (250), 300, (400), 500, (600), 750 and 1000

Figure 127 - LPCT protection accuracies for primary currents



If we know that the initial nominal current for protection is between 25 and 1000 A, we can take a LPCT of 100 A rated current and with 1000 A extended primary current which will still be flexible to last-minute changes or when load flow may increase subsequently.

Save time and money during project planning and execution

Standardized products can now be used for a wider range of application, providing faster and simpler integration. No longer do you need to wait for CT sizing clarifications, because fewer designs cover the majority of requirements, providing many other benefits.

- Reduced variation of ordering

- Simplified and improved quality of project documentation
- In-stock products with fast delivery
- Simplified installation

Compact switchgear with reduced footprint is more sustainable

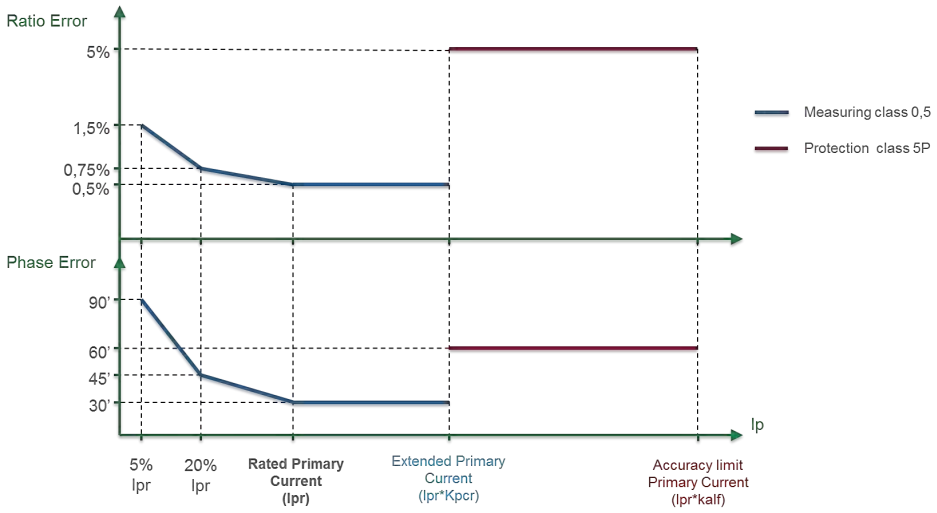
The size and weight of the LPCTs are reduced to less than 10% compared to ICTs. This allows future switchgear designs to be more compact, reducing materials used and the environmental impact. Switchgear handling, transport, installation and replacement are also much simplified.

LPCT characteristics

The multipurpose LPCT is designed to measure from 5% of Ipr to kalf x Ipr and is defined with a:

- Rated primary current (Ipr) (minimum current for measuring accuracy class)
- Rated extended primary current (Iepr = Ipr × Kpcr) (maximum current for measuring accuracy class)
- Rated accuracy limit (Ikpr = Ipr × kalf) (maximum current for protection accuracy class)

Figure 128 - Magnitude and phase errors across the measurement range



For example, the Schneider Electric LPCTs have the characteristics as shown below.

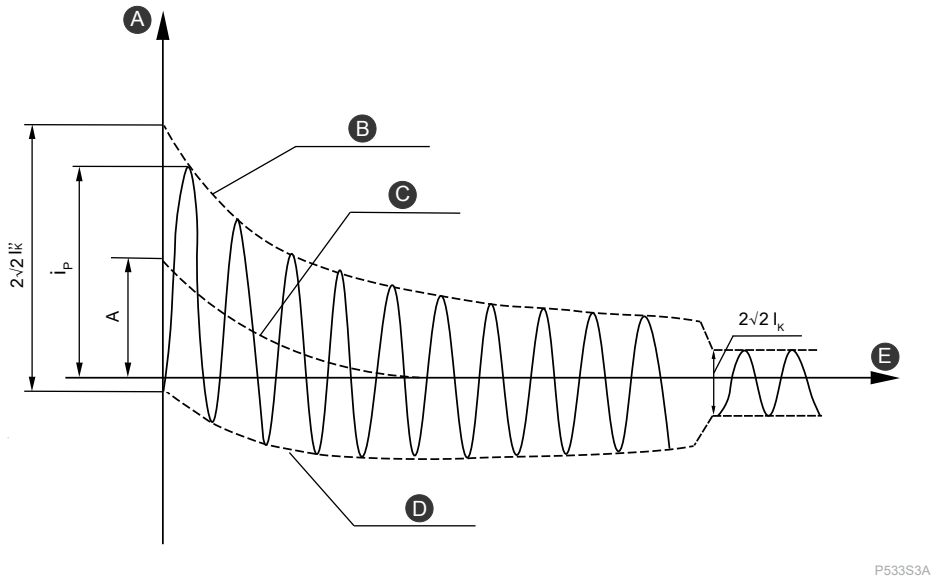
Table 26 - Characteristics of the LPCT

Characteristics	Ipr (A)	Iepr (A)	Ikpr (A)
CLV1	100	1250	16000
TLPU1	100	630	25000
TLP130	100	1250	25000
TLP160 or 190	100	2500	40000
CLP2 100 1250 40000	100	1250	40000
CLP3	100	2500	40000
CLP1	100	1250	50000

LPCT input characteristics

The LPCT input measuring range is 45 In. That means 25 In fully offset:

Figure 129 - Fault characteristic



A	Current	B	Top envelope
C	$i_{d.c.}$	D	Bottom envelope
E	Time		

NOTE:

- I''_K = initial symmetrical short-circuit current
- i_P = peak short-circuit current
- I_K = steady-state short-circuit current
- $i_{d.c.}$ = d.c. component of short-circuit current
- A = initial value of the d.c. component $i_{d.c.}$
- $2\sqrt{2}\ I''_K$ = For a fully offset fault current where I''_K is the rms of the initial fault current and $2\sqrt{2}\ I''_K$ is the peak to peak current
- $2\sqrt{2}\ I_K$ = the peak to peak value of the steady state short circuit current

LPCT configuration procedure

Unlike CTs that need to meet the application CT requirements, LPCTs do not have any saturation. LPCT suitability needs to be calculated according to the two following main rules:

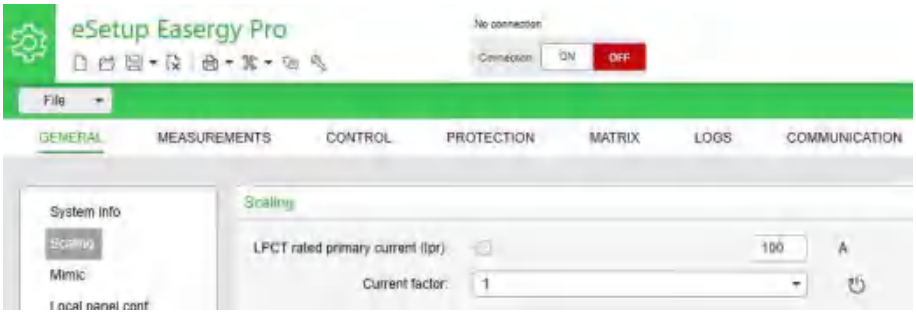
1. Select or check the LPCT suitability

   The maximum short circuit (IfMax) must be below the LPCT protection rated accuracy limit:

   - IfMax < Ikpr

2. In eSetup Easergy Pro (at least V3.0.0), under **GENERAL**/**Scaling** menu, you can find the LPCT setting.

Figure 130 - LPCT setting



The nominal current In is equal to (Ipr x Current factor)

a. For LPCT secondary nominal voltage (Vsec) = 22.5 mV
   - Set the LPCT rated primary current (Ipr), for example 100 A
   - Then set the “Current factor” to adjust the nominal current, for example, 2 for In = 200 A or 4 for In = 400 A

b. For other LPCT secondary nominal voltage (Vsec)
   - For (Vsec) = 150 mV select first 6.66 or for Vsec = 225 mA select first 10
   - Then set the LPCT rated primary current (Ipr) to (Ipr / Current factor)
   - Then finetune the “Current factor” to adjust the nominal current, for example, 5 instead of 6.66 for In = 75 A or 20 instead of 10 for 200 A

The nominal current In must be:

- Below the LPCT rated accuracy limit divided by 25: In < Ikpr/25
- Below the LPCT rated extended primary current: In < Iepr whenever possible
- Above 20% of the LPCT rated primary current In > Ipr/5
- As close as possible to the nominal load current. It does not need to be among the standardized values.

For example, with a multipurpose LPCT with a 100 A rated primary current, a 1250 A extended primary current and an accuracy limit of 16000 A:

Example 1: Maximum short circuit of 10 kA and a nominal current of 200 A

1. The maximum short circuit must be below the LPCT rated accuracy limit:
   - IfMax < Ikpr: 10 kA < 16 kA (OK)
2. The maximum nominal current to be set in the P5 relay must be:
   - Below the LPCT rated accuracy limit / 25: In < Ikpr/25: 16000/25 = 640 A (OK)
   - Below the LPCT rated extended primary current: In < Iepr: < 1250 A (possible)
   - Above 20% of the LPCT rated primary current In > Ipr/5: 20 A (OK)
   - As close as possible to the nominal load current. It does not need to be among the standardized values.

     200 A can be chosen (fine for measurement and protection).

Example 2: Maximum short circuit of 20 kA and a nominal current of 400 A

1. The maximum short circuit must be below the LPCT rated accuracy limit:
   - IfMax < Ikpr: 20 kA < 16 kA

   This is NOT OK. A different LPCT must be chosen. For example, a multipurpose LPCT with a 100 A rated primary current, a 1250 A extended primary current and an accuracy limit of 25000 A.

2. The maximum nominal current to be set in the P5 relay must be:
   - Below the LPCT rated accuracy limit / 25: In < Ikpr/25: 25000/25 = 1000 A (OK)
   - Below the LPCT rated extended primary current: In < Iepr: < 1250 A (possible)
   - Above 20% of the LPCT rated primary current In > Ipr/5: 20 A (OK)
   - As close as possible to the nominal load current. It does not need to be among the standardized values

     400 A can be chosen (fine for measurement and protection)

Example 3: Maximum short circuit of 50 kA and a nominal current of 1500 A

1. The maximum short circuit must be below the LPCT rated accuracy limit:
   - IfMax < Ikpr: 50 kA < 16 kA

   This is NOT OK. A different LPCT must be chosen. For example, a multipurpose LPCT with a 100 A rated primary current, a 1250 A extended primary current and an accuracy limit of 50000 A.
2. The maximum nominal current to be set in the P5 relay must be:
   - Below the LPCT rated accuracy limit / 25: In < Ikpr/25: 50000/25 = 2000 A (OK)
   - Below the LPCT rated extended primary current: In < Iepr: < 1250 A (not possible but optional)
   - Above 20% of the LPCT rated primary current In > Ipr/5: 20 A (OK)
   - As close as possible to the nominal load current. It does not need to be among the standardized values.

     2000 A can be chosen (fine only for protection)

LPVT configuration

Introduction

This section gives an overview of LPVTs, reasons to move from traditional VTs to LPVTs, and how to configure them in eSetup Easergy Pro (at least V3.0.0).

Further details, such as how to wire the LPCT or the VT adapter is described in the following section.

Benefits of LPVTs

In short, the use of Low Power Voltage Transformers brings many benefits throughout the project lifecycle, which are detailed below.

Personal safety is improved during testing and operation

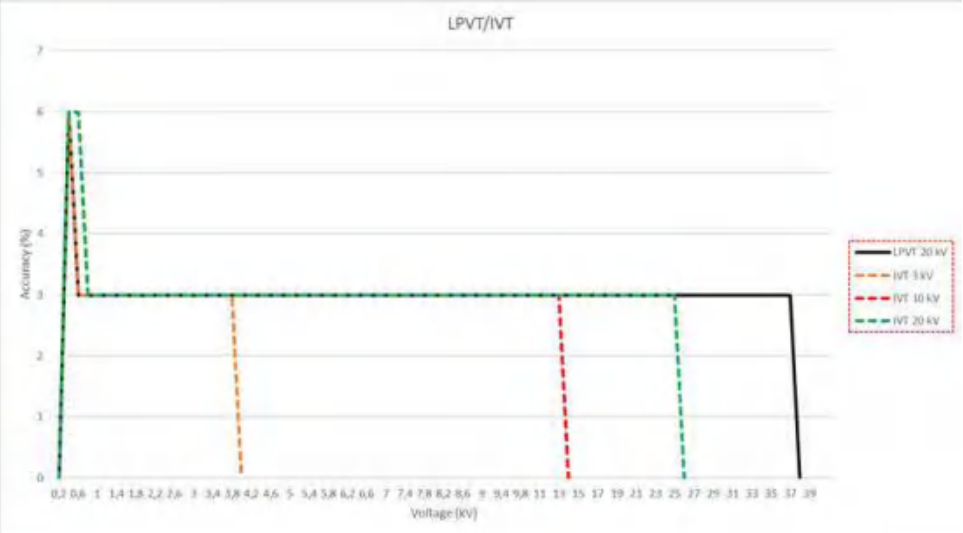
With LPVT technology, there is no risk in the event of touching the secondary circuit as the output is low voltage.

- The VT (phase to neutral) secondary rated voltages, ranging from 57.73 V to 69.3 V and/or 115.47 V to 132.79 V, are now reduced to 1.88 V (3,25/√3 V) in LPVTs.
- As the risk of short-circuited secondary disappears, it also removes the need for VT fuses.
- The effect of ferroresonance has disappeared as well.

One LPVT can replace the need of several nominal voltage rated VTs

An LPVT is now defined for a wider range of ratings compared to an Inductive Voltage Transformer (IVT), for example, 3 to 20 kV, class 0.5P, from 2% to 190% of its rated voltage which is better than the former 0.5 / 3P classification. The effect of ferroresonance has disappeared as well.

Figure 131 - LPVT accuracies for primary voltages



For protection, the above LPVT can be used in place of the 5 different VTs with the following primary voltages (in kV): 3, 6, 10, (15), 20.

Save time and money during project planning and execution

Standardized products can now be used with a wider range of application, providing faster and simpler integration. No longer do you need to wait for sizing clarifications, because fewer designs cover the majority of requirements, providing many other benefits.

- Reduced variation of ordering
- Simplified and improved quality of project documentation
- In-stock products with fast delivery
- Simplified installation

Compact switchgear with reduced footprint is more sustainable

The size and weight of the Low Power Voltage Transformers are reduced to less than 10% compared to IVTs. This allows future switchgear designs to be more compact, reducing materials used and the environmental impact. Switchgear handling, transport, installation and replacement are also simplified.

LPVT characteristics

The multipurpose LPVT is designed to measure from 2% of Vpri (min) to 1.9 x Vpri (Max) and is typically defined with a:

- Rated primary voltage Vpri
- Range of rated primary voltage (Vprimin, VpriMax) (minimum and maximum voltage for measuring and protecting accuracy classes)
- Rated secondary voltage Vsec

Figure 132 - Magnitude accuracy

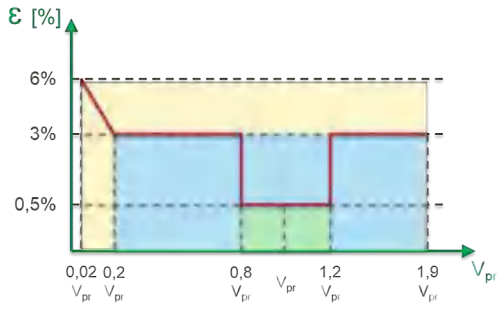
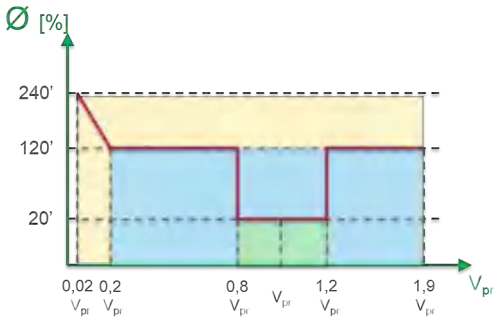


Figure 133 - Phase accuracy



For example, the Schneider Electric LPVTs have the following characteristics.

Table 27 - Characteristics of the LPVT

Characteristics	Vpri (kV)	Vprimin (kV)	VpriMax (kV)	VpriMax/Vpri
Ref.1	10	2.4	11	1.1
Ref.2	20	3	20	1
Ref.3	20	10	22	1.1
Ref.4	30	20	33	1.1

NOTE: The LPVTs need to be connected to the P5 by the LPVT hub connector, the figure below shows the look of LPVT hub connector. See the LPVT hub connector (reference EMS59573), page 112 section for supplementary information on this topic.

Figure 134 - LPVT hub connector



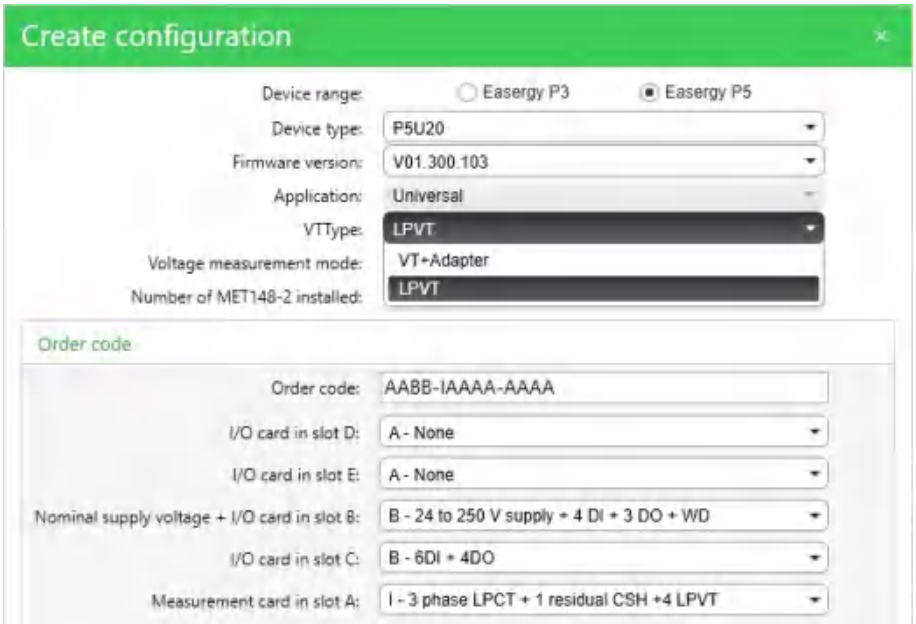
LPVT input characteristics

The PowerLogic P5 LPVT input measuring range is above 1.5 x 1.9 x Vsec (with 1.5 the biggest ratio between VpriMax and Vpri).

PowerLogic P5 can be connected to either an LPVT or a VT (thanks to the EMS59572 adapter).

The selection for the direct LPVT is done in eSetup Easergy Pro (at least V3.0.0), at the **Create configuration** window once the **Measurement card in slot A:** has been set to the LPIT option.

Figure 135 - Selection of the LPIT option

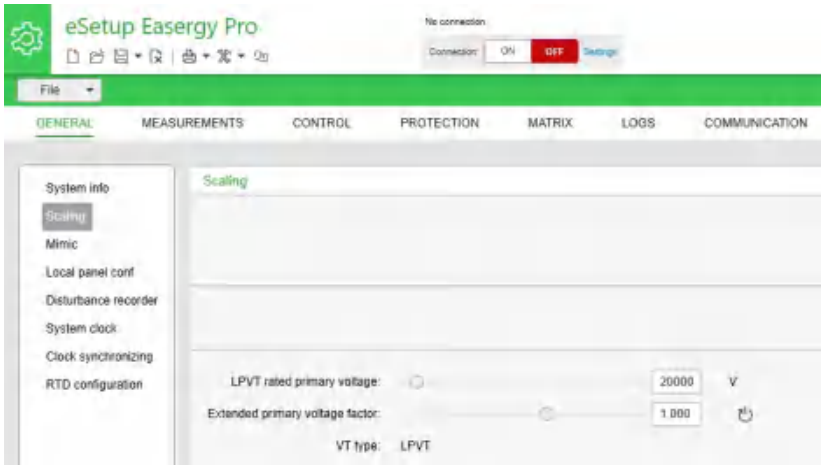


LPVT configuration procedure

Two main simple rules are required to follow:

1. Select or check the LPVT suitability
   The nominal voltage (Vn) must be within the LPVT range of rated primary voltage: IfMax < Ikpr
2. In eSetup Easergy Pro (at least V3.0.0), under **GENERAL**/**Scaling** menu, LPVTs are designed to be connected to devices with different measuring input burden.

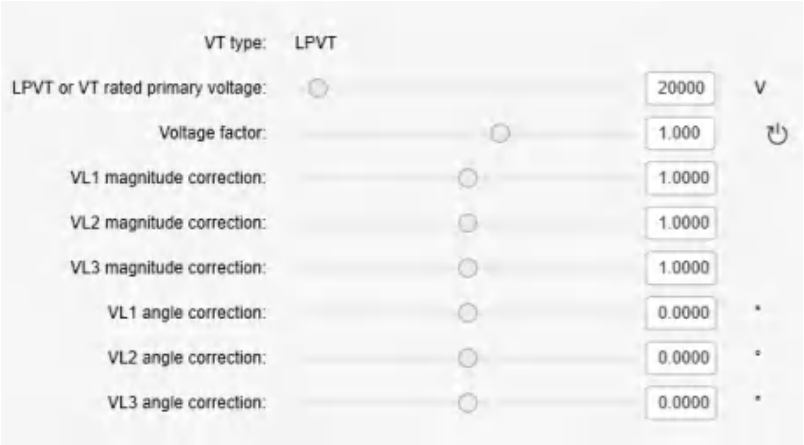
Figure 136 - LPVT settings



a. For both 2 MΩ (IEC 61869-11) and 10 MΩ (for example, Schneider Electric) LPVT output burden
   - Set the LPVT Rated primary Voltage (Vpri) in “LPVT rated primary voltage”
   - Set the nominal voltage (Vn) in “Extended primary voltage factor” by adjusting the coefficient to the primary rating (for example, if Vn is 10kV and Vpri is 20 kV then select 0.5)

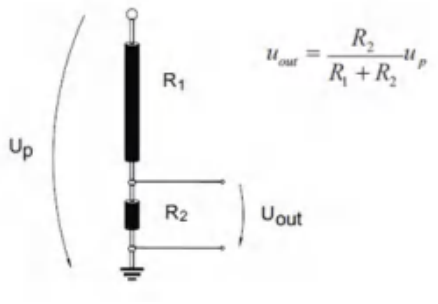
b. Only for 2 MΩ (IEC 61869-11) LPVT output burden

Figure 137 - Correction factors



- Measure the resistance of R_2 for each LPVT (RJ45 output pin 7&8)
- Set for each phase “VLx magnitude correction” to:
  - $((R_2+10000)/(R_2+2000))/5$ with R_2 in kΩ
  - For example, if R_2 = 32.51 kΩ then VLx correction = 0.987

Figure 138 - Resistive divider



LPVT configuration with VT adapter

Introduction

This section gives an overview of some reasons to use the EMS59572 adapter, what it is, and how to configure it in eSetup Easergy Pro (at least V3.0.0).

Further details, such as how to wire the LPCT or the VT adapter is described in the following section.

Benefits of VT adapter

Traditionally, a protection relay is either designed to be connected to CTs and VTs or LPCTs and LPVTs. When the switchgear is equipped with LPCTs and VTs, it is easier to adapt the VT outputs to low level signals compatible with the relay LPVT inputs.

EMS59572 adapter characteristics

The VT (phase to neutral) secondary rated voltages, ranging from 57.73 V to 69.3 V and/or 115.47 V to 132.79 V, need to be converted to signals close to the rated 1.88 V (3,25/√3 V) in LPVTs.

The EMS59572 adapter is made of resistive dividers to connect VTs to the PowerLogic P5 LPVT inputs.
See the Voltage adapter (reference EMS59572), page 114 section for supplementary information on this topic.

Figure 139 - EMS59572 adapter



The nominal ratio is 50.6 and the accurate ratios are written on its label for each phase.

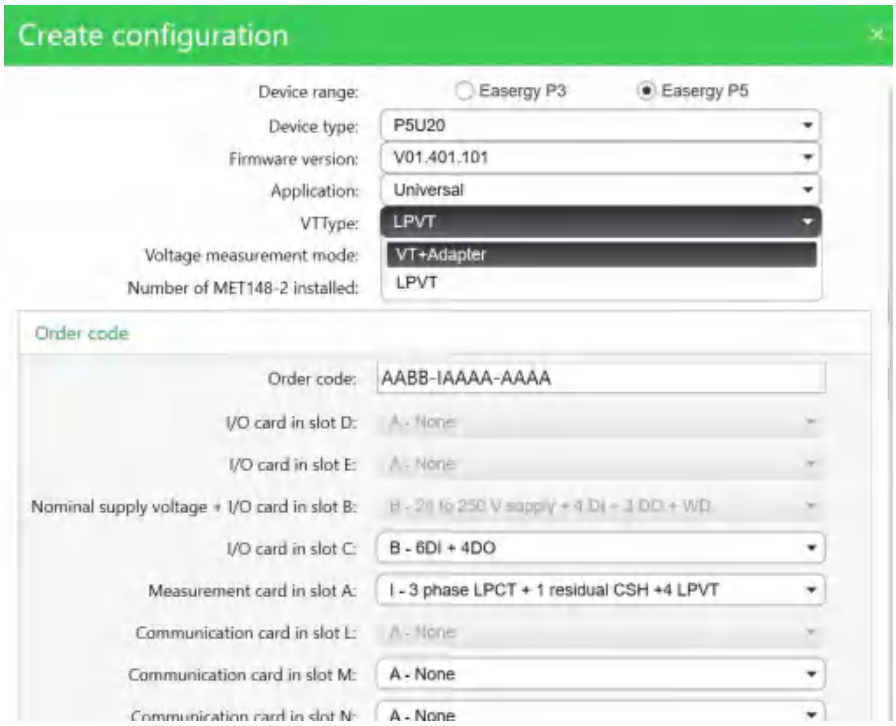
LPVT input characteristics

The PowerLogic P5 LPVT input measuring range is above 1.9 x 132.79 / 50.6 = 5 V.

It can be connected to either a LPVT or a VT by the EMS59572 adapter.

The selection to connect VT through the dedicated EMS59572 is done in eSetup Easergy Pro (at least V3.0.0), at the **Create configuration** window, once the **Measurement card in slot A:** has been set to the LPIT option, by selecting *VT +Adapter*.

Figure 140 - Selection of the VT+Adapter option

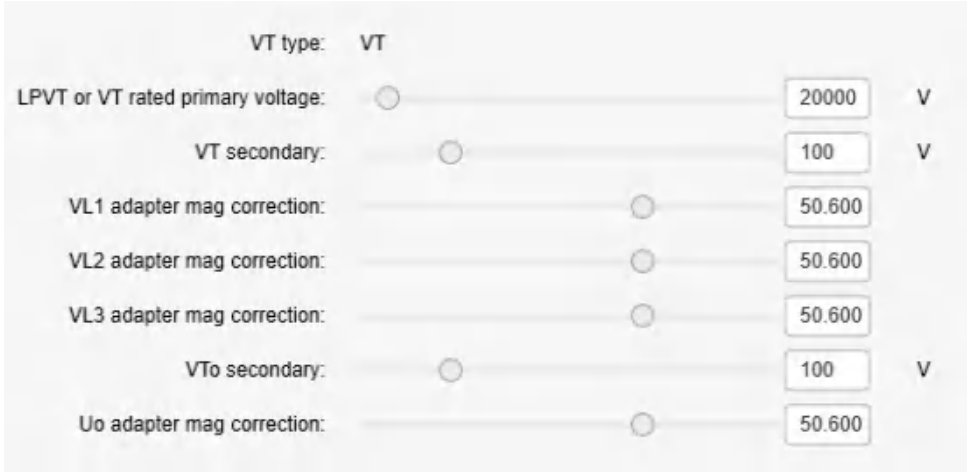


EMS59572 VT adapter configuration

One simple rule is required to follow.

Go to **GENERAL**/**Scaling** menu in eSetup Easergy Pro (at least V3.0.0), perform the configuration of VT adapter.

Figure 141 - Settings of the VT adapter



1. Set the VT rated primary Voltage in **LPVT or VT rated primary voltage**
2. Set the VT rated secondary Voltage in **VT secondary**
3. Copy the values written on the EMS59572 for VL1, VL2 and VL3 in **VIx adapter mag correction**

LPVT voltage sharing application

Similarly to conventional scheme, LPVT signals can be shared across multiple PowerLogic P5 protection relays (up to 10 per LPVT transducer). All connections are made with screened RJ45 cables resilient to potential electromagnetic disturbances met in medium voltage compartments.

LPVT transducer (P7M12025)

The LPVT Transducer allows an accurate transmission of the low voltage output signal from LPVT sensors (3.25/√3 V) across up to 10 PowerLogic P5 protection relays equipped with LPVT measuring inputs. The low voltage input is provided through a single RJ45 connector that brings the 3 phase LPVT signals merged by LPVT hub connector EMS59573. P7M12025 can be installed on DIN rails complying with EN/IEC 60715.

The connections between all the elements are done with RJ45 wires that can be ordered with commercial references: 59660 (0.6 m) 59661 (2 m), 59662 (4 m). The branching between LPVT bus and each PowerLogic P5 protection relay is done with a 3-way RJ45 junction box (T-box) REL51095.

Table 28 - Characteristics of LPVT transducer

Order code	Description
Nominal voltage input / output	1.876 V (3.25/√3 V) / 1.876 V (3.25/√3 V)
Voltage factor	1.2 nominal voltage continuously 1.9 nominal voltage for 8 hours
Accuracy	Measurement class 0.5 Protection class 3P Input burden 10 MΩ // 2.2 pF For -5°C...+40°C
Power supply	24...48 V DC, 125 V DC or 120 V AC
Operating temperature	-25°C...+70°C
Dimensions (L x W x H)	160 x 60 x 90 mm (6.30 x 2.36 x 3.54 in)

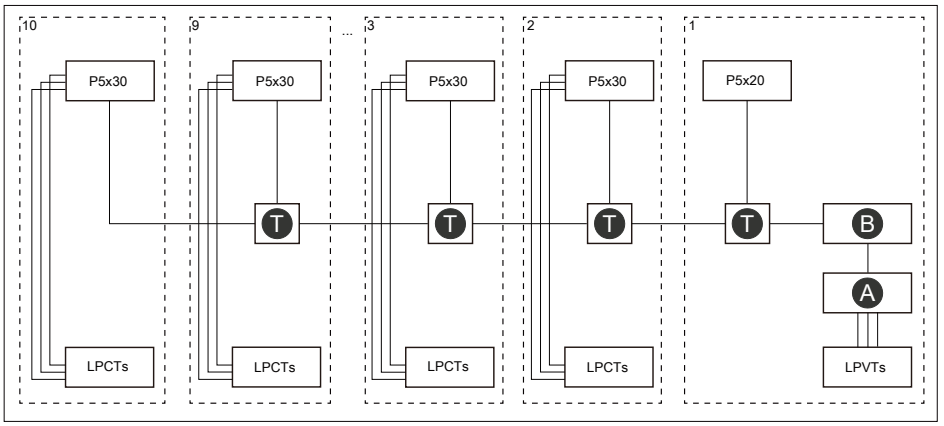
Figure 142 - LPVT transducer



Voltage sharing applications

For LPVTs voltage sharing applications, refer to the following cases.

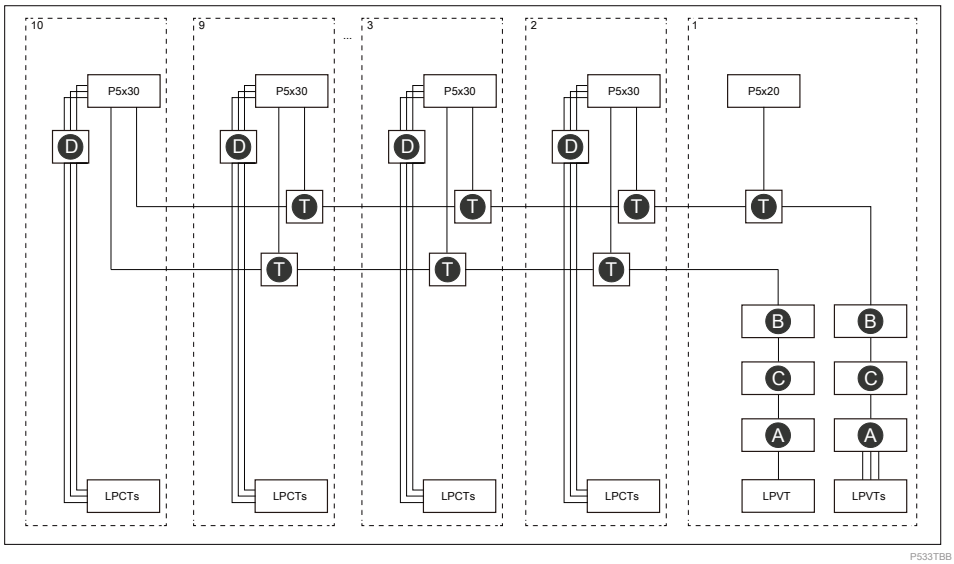
Figure 143 - LPVT sharing application without test sockets/plugs



A	LPVT hub connector	EMS59573	B	LPVT transducer	P7M12025
T	T-box 3 way RJ45 junction	REL51095			

- 0.6 m remote module connection cord: 59660
- 2 m remote module connection cord: 59661
- 4 m remote module connection cord: 59662

Figure 144 - LPVT sharing application including the 4th voltage (sync-check) and with test sockets/plugs



A	LPVT hub connector	EMS59573	B	LPVT transducer	P7M12025
C	LPVT test plug LPVT test socket with cover	REL51093 REL51092	D	LPCT test plug LPCT test socket with cover	REL51090 REL51089
T	T-box 3 way RJ45 junction	REL51095			

Commissioning

Principles

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- NEVER work alone.
- Only qualified personnel should commission this equipment. Such work should be performed only after reading this entire set of instructions.
- Obey all existing safety instructions when commissioning and maintaining high-voltage equipment.
- Beware of potential hazardous voltages from open circuited current transformers, any voltage transformers and any capacitors which could be charged to hazardous voltages.
- Before energising check that the protection relay and other devices are connected to a protective earth/ground in accordance with the instructions provided.

Failure to follow these instructions will result in death or serious injury.

⚠DANGER

FIRE HAZARD

Apply proper tightening torque to all wire connections.

Failure to follow these instructions will result in death or serious injury.

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Never open the secondary circuit of a live CT since the high voltage produced may be lethal to personnel and could damage insulation.
- The secondary of the line CT must be shorted before opening any connections to it.

Failure to follow these instructions will result in death or serious injury.

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. See NFPA 70E, CSA Z462 or national equivalent.
- Do not choose lower personal protective equipment (PPE) while working on energised equipment.

Failure to follow these instructions will result in death or serious injury.

PowerLogic P5 protection relays are tested prior to commissioning, with the dual aim of maximizing availability and minimizing the risk of malfunctioning of the assembly being commissioned.

PowerLogic P5 protection relays are fully numerical in their design, implementing all protection and non-protection functions in the firmware. The protection relays use a high degree of self-checking and give an alarm. Therefore, the commissioning tests do not need to be as extensive as with non-numeric electronic or electro-mechanical relays.

To commission PowerLogic P5 protection relays, it is necessary to verify that the hardware is functioning correctly and the application function settings have been

applied as expected. To confirm that the protection relay is operating correctly once the settings have been applied, it is necessary to perform basic functional tests on each active protection element one by one.

The main tasks for the commissioning test are as follow:

- PowerLogic P5 protection relay check
- Secondary injection test
- Primary injection test
- Final check

⚠WARNING

UNEXPECTED OPERATION

Do not energise the primary circuit before this protection relay is properly configured.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

Testing tools and equipment

The following tools and equipment are needed in the commissioning:

- AC current and voltage injection sources
  - For secondary injection test, on conventional CTs and VTs, to check the protection relay functions, the injection source should be at such a rating that the current is adjustable up to at least 5 A and the voltage is adjustable up to at least 110 V.
  - For secondary injection test, on LPCT and LPVT, to check the protection relay functions, the injection source should be at such a rating that the voltage is adjustable up to at least 10 V for LPVT and at least 30 V for LPCT to be able to test with the maximum setting ranges.
  - If the primary injection test is necessary to check the CT/LPCT, VT/LPVT primary connection and polarity, the injection source should be at such a rating that the minimum current at the CT secondary is larger than 20 mA (2% of the nominal current) and the minimum voltage at the secondary is larger than 750 mV (1% of the nominal voltage).
- DC voltage source

  Adjustable from 48 to 250 V DC, for adaptation to the voltage level of the logic input being tested.
- Multimeters
  - With suitable AC current range, and AC/DC voltage ranges
  - Phase angle meter
- A portable PC with eSetup Easergy Pro installed
- USB cable with mini-USB type B interface or RJ45 Ethernet cable
- For CT/VT, test block and test plug for secondary injection testing
  - Plug with cord to match the "current" test block installed
  - Plug with cord to match the "voltage" test block installed
- For LPCT/LPVT, test plug for secondary injection testing
  - Cable with RJ45 terminal compliant with IEC 61869-10/11
  - LPVT hub connector (to be used if the LPVT hub connector installed in the cubicle is not accessible)

Check the digital outputs

Before any functional testing, it is needed to check the contact relays of the PowerLogic P5 protection relays:

- Set the IED mode to Test mode

  The PowerLogic P5 protection relay has its dedicated test modes (See Mode of use for testing purposes, page 258).

- Force output relay contacts

  With eSetup Easergy Pro, setting the output relay fields to 1 or 0 in the Relays view of the Device/Test menu forces the output relay to On or Off.

  There are menu cells which allow the status of the opto-isolated inputs, output relay contacts, and internal digital signals to be monitored.

PowerLogic P5 protection relay check

Check with the PowerLogic P5 protection relay de-energised

The following group of tests should be carried out without the auxiliary power supply applied to PowerLogic P5 protection relay and with the trip circuit isolated. The current and voltage transformer connections must be isolated from the protection relay for these checks. It is suggested to apply the test block to isolate the primary system, as shown in Typical test block connection diagram, page 149.

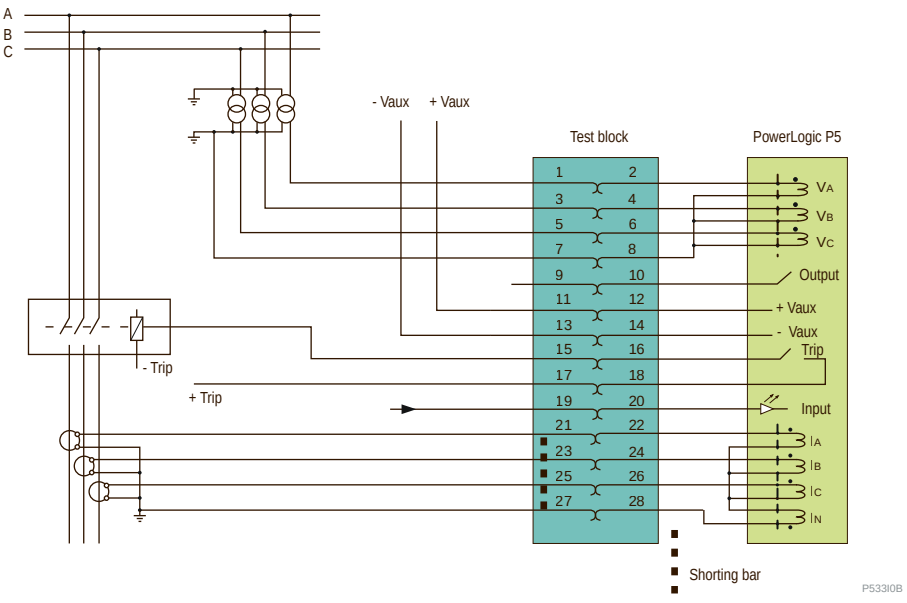
⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Never open-circuit the secondary circuit of a current transformer because the high voltage produced may be lethal. It could also damage the insulation.
- Before the test plug is inserted into the test block, make sure the sockets in the test plug which correspond to the current transformer secondary windings are linked.

Failure to follow these instructions will result in death or serious injury.

Figure 145 - Typical test block connection diagram



Before inserting the test plug, refer to the scheme diagram. For example, the test block may be associated with protection current transformer circuits. If a PowerLogic P5 protection relay is installed in the switchgear, the test block is not always provided. In the application case without a test block, it is mandatory to isolate the voltage transformer supply to the PowerLogic P5 protection relay using the panel links or connecting blocks, and to short-circuit and disconnect the line current transformers from the protection relay terminals. Where means of isolating the auxiliary power supply and trip circuit (such as isolation links, fuses and MCB) are provided, these should be used. If this is impossible, the wiring to these circuits must be disconnected and the exposed ends suitably terminated.

Visual inspection

The visual inspection should include the following aspects:

- Check the rating information on the PowerLogic P5 protection relay.
- Check that the PowerLogic P5 protection relay being tested is correct for the protected objective.
- Check that the circuit reference and system details are entered onto the setting record sheet (not provided).
- Carefully examine the PowerLogic P5 protection relay to see that no physical damage has occurred since installation.
- Check that the case earthing/grounding connections, at the rear of the protection relay case, are used to connect the protection relay to a local earth/ground bar using an adequate conductor (see Connecting earth/ground, page 88).

External wiring

- Check that the external wiring is correct to the relevant protection relay diagram and wiring scheme. Check that the phase rotation appears as expected.
- Check the connections against the wiring diagram if a test block is provided.
- Check the connected tripping circuit(s) are correct to the wiring scheme.

Auxiliary power supply

PowerLogic P5 protection relay can be operated from either a DC or AC auxiliary power supply. The acceptable voltage variation is ±20%.

- For PowerLogic P5x20 protection relay, the rated voltage is 24 to 250 V DC/100 to 230 V AC. So, the incoming voltage must be within the operating range specified as 19.2 to 300 V DC/80 to 276 V AC.
- For PowerLogic P5x30 protection relay, the rated voltage is 48 to 250 V DC/100 to 230 V AC. So, the incoming voltage must be within the operating range specified as 38.4 to 300 V DC/80 to 276 V AC.
- Another option for PowerLogic P5x30 protection relay, the rated voltage is 24 to 48 V DC. So, the incoming voltage must be within the operating range specified as 38.4 to 57.6 V DC.

Without energising the protection relay, measure the auxiliary power supply to help ensure it is within the operating range.

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH

The power supply must be turned off for at least 5 s before power supply module is removed. Otherwise there is the danger of an electric shock.

Failure to follow these instructions will result in death or serious injury.

NOTICE

POWER SUPPLY DAMAGE

Before connecting the auxiliary voltage to the PowerLogic P5 protection relay, make sure the nominal value of the auxiliary device voltage corresponds with the nominal value of the auxiliary system voltage.

Failure to follow these instructions can result in equipment damage.

Watchdog

Using a continuity tester, check that the watchdog contacts (DO4 of slot B) are in the states shown in the Watchdog contact status table for a de-energised protection relay.

Testing with the PowerLogic P5 protection relay energised

The following group of tests verify that the PowerLogic P5 protection relay hardware and software is functioning correctly and should be carried out with the auxiliary power supply applied to the protection relay.

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- The current and voltage transformer connections must remain isolated from the protection device for these checks.
- The trip circuit must remain isolated to help prevent accidental operation of the associated circuit breaker.

Failure to follow these instructions will result in death or serious injury.

Energising the protection relay

The PowerLogic P5 protection relay initialises in the following procedure after being energised:

- Switch on the auxiliary power supply.
- Check that PowerLogic P5 protection relay performs the following initialisation sequence:

  1. LED is illuminated green and LED is illuminated red. The screen will display the self-test progress.
  2. The screen will display the progress of "Firmware Loading" and LED is illuminated yellow.
  3. When the initialisation of PowerLogic P5 protection relay is complete, LED is off.
     The default screen (Single Line Diagram of one bay) is displayed.

  NOTE: If a backup memory (extension board) is present in the PowerLogic P5 protection relay, the device checks the consistency of the settings and configuration stored in the protection relay and in the backup memory. If there is any gap, the protection relay will invite the operator to select the options for handling the backup memory content.

  Only when this operation is successfully completed will the LED turn off and the default screen (Single Line Diagram of one bay) is displayed.

Watchdog

Using a continuity tester, check that the watchdog contacts (DO4 of slot B) are in the states shown in the Watchdog contact status diagram for an energised protection relay.

Date and time

The data and time should be set.

With IRIG-B module

If the IRIG-B module is connected and time clock signal is received by the PowerLogic P5 protection relay, the synchronisation source field in the Clock synchro view of the General menu will show "IRIG-B" and the protection relay will adjust the Date and Time automatically. If the IRIG-B signal is lost, the protection relay will change the time synchronisation source from "IRIG-B" to "internal" after 400 seconds.

Without IRIG-B module or SNTP

If the time and date is not being maintained by an IRIG-B signal, set the date and time to the correct date and local time using the Date setting field and the Time of day setting field in the System clock view of the General settings menu.

LED and screen

On the local panel of PowerLogic P5 protection relay, press the *i* and then the ◁ key to test the local panel HMI, the protection relay automatically tests all the LEDs and the screen. The triple color LEDs are lit from green, yellow to red. The LCD is tested under different colors and contrast values.

Digital inputs

This test checks that all the PowerLogic P5 protection relay's digital inputs (opto-isolated) are functioning correctly. Check the terminal configuration schemes in PowerLogic P5 rear panel, page 58 for terminal numbers. Check the polarity and connect the external 48 V DC supply voltage to the appropriate terminals for the input being tested. Energise the opto-isolated input one by one.

> **NOTE:** The external power supply is used for this test, but only after confirming that it is suitably rated, with the variation less than 20%.

The status of each opto-isolated input can be viewed in the Digital inputs view of the Control menu; a "1" indicating an energised input and a "0" indicating a de-energised input. When each opto-isolated input is energised, the related DI status changes to indicate the new state of the inputs.

Digital outputs

This test checks that all the output contact relays are functioning correctly using the Test mode.

Connect a continuity tester across the terminals corresponding to output relay as shown in the relevant terminal configuration schemes in PowerLogic P5 rear panel, page 58. To operate the output relay DO1 in Slot B, via **Home** menu / **Control** sub-menu / **digital outputs** menu item / **digital output Slot X** view, set the field DO1(B) to 1. Operation is confirmed by the continuity tester operating for a normally open contact and ceasing to operate for a normally closed contact. Measure the resistance of the contacts in the closed state. Reset the output relay by setting the DO1(B) field to 0. Repeat the test for the rest of the output relays then return the PowerLogic P5 protection relay to service by setting the IED mode back to "Normal".

NOTE: Ensure that the thermal ratings of anything connected to the output relays during the contact test procedure are not exceeded by the over-operated output contact relays. Keep the time between application and removal of contact test to a minimum.

Communication ports

The PowerLogic P5 protection relay supports both serial communication ports and Ethernet communication ports.

There are five protocols that can be selected and used to communicate through the serial ports.

- DNP3
- IEC 60870-5-101
- IEC 60870-5-103
- Modbus slave
- Modbus master

If one of these protocols is configured, the PowerLogic P5 protection relay can exchange data with protocol master. The serial port parameters, e.g. baud rate, parity, wire number, can be selected and will take effect after reboot.

There are five protocols that can be selected and used to communicate through the Ethernet ports.

- IEC 61850
- DNP3
- Modbus
- EtherNet/IP
- Digital CB

Three Ethernet protocols can be selected at the same time, and for each protocol IP address needs to be selected to communicate with clients.

Virtual injections

Enable virtual injection

The PowerLogic P5 protection relay has the capability to test all the functionalities according to the relevant access rights by:

- Simulation of voltage and current signals
- Injection of a Comtrade file

The virtual injection is done using eSetup Easergy Pro connected to the local panel.

NOTE: To use the virtual injections the first time, eSetup Easergy Pro proposes to install WinPcap library delivered with the software. This installation is mandatory to simulate injections.

To enable virtual injection in eSetup Easergy Pro:

1. Click on the green button with a left arrow on right-hand side to expand the injector view that is by default hidden in eSetup Easergy Pro.
2. Check the **Enable virtual injections** option.
3. Select Test mode or Test Block mode for the virtual injection test.

   Virtual injections are available only in Test mode or Test Block mode (see Mode of use for testing purposes, page 258 for more information).
4. Set **Auto read** to On in the menu bar of eSetup Easergy Pro in order to read the measurements.

Manual injection

In the **Manual** tab of the **Virtual injection** setting view, set the following parameters:

- **Cycles:**

  Set the value to the number of signal period to apply for the signal simulation.
- **Frequency:**

  Set the frequency of the signal to inject.
- **Scalings:**

  Set the maximum values and angles.
- **Measurements:**

  Set the injection values for the testing.

The injection time can be set in cycles or in real time. For example, for 50 Hz nominal frequency, one cycle is 20 ms, so 100 cycles equal to 2 s of injection time.

All the signals are simulated with their fundamental value (no harmonics) and instantaneously displayed in the Graph section of the view.

Comtrade file play-back

In the **File** tab of the Virtual injection view, it is possible to replay the analogue signals recorded in a Comtrade file (ASCII format, IEC 60255–24, IEEE Std C37.111, edition 1999 and 2013):

1. Select the Comtrade file using the **Open** button in the bottom right corner of the setting view.
2. Select the mode of injection:
   - **Single injection**: play the comtrade file once.
   - **Loop mode**: repeated the injection until a manual stop.
   - **Followed by zero**: single injection of the comtrade file followed by 0.
3. Select the assigned injection for each analogue channel.

Injection

Press on the **Start** button in the upper section of the view for the injection.

Any protection function that is enabled and of which the threshold setting is below the injection will activate, with the magnitudes displayed in the **MEASUREMENTS** section of the view.

The PowerLogic P5 protection relay will trip and activate digital outputs physically in the Test mode and will stay frozen in the Test-block mode.

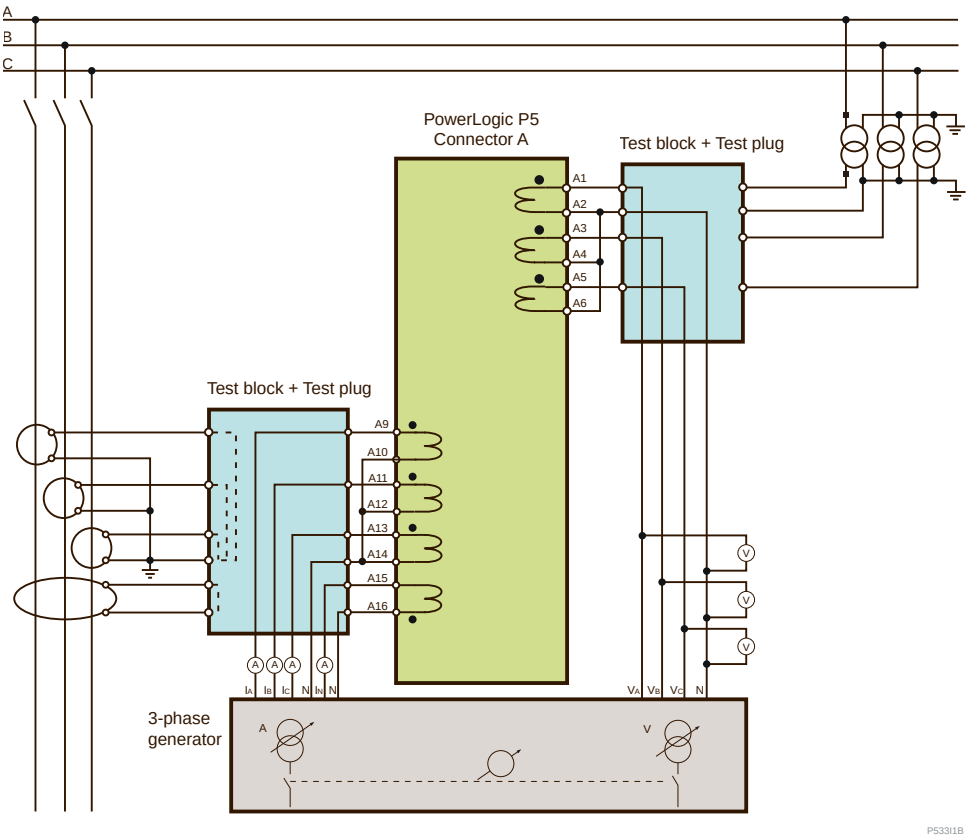
NOTE: Do not try to manually change the mode while using the injector.

Secondary injection test

The secondary injection test is to check the protection relay analogue input modules and check the basic protection functions with the application-specific settings.

The connection diagram for the secondary injection test with test block and test plug mounted is illustrated in the Secondary injection test connection diagram with test block, page 156.

Figure 146 - Secondary injection test connection diagram with test block



In the application case without test block, it is mandatory to remove the voltage transformer cable. The trip circuit shall be disconnected to avoid the spurious circuit breaker trip during the secondary injection test. The secondary injection test can be performed by injecting the current and voltage into the related analogue connection terminals on the rear panel of the PowerLogic P5 protection relay via the test block.

Apply application-specific settings

There are different methods of applying the settings:

- Local panel

  If the application is simple without specific logic and only limited specific settings are applied, the setting configuration can be easily performed via the PowerLogic P5 protection relay's local panel by entering the settings manually.

- eSetup Easergy Pro

  If specific logic (not the default logic) is applied, or many specific settings are applied, setting configuration via eSetup Easergy Pro is the recommended method for configuring as it is much faster and there is less margin for error.

  NOTE: If the application-specific settings are not available, the secondary injection test can be performed based on the default settings.

After the setting configuration, it is suggested to disable all the protection functions applied before the current and voltage injection, to help ensure that spurious CB trips will not happen. During the protection function test, only the protection function under test can be enabled. After the completion of the injection tests, all the protection functions applied must be enabled during the final check stage.

Current inputs

This test verifies that the accuracy of current measurement is within acceptable tolerances.

- Double check the connection and then start the injection test.
- Apply current equal to the related CT secondary rated current.
- Check its magnitude using a multimeter or reading from the test equipment.
- Check the current magnitude displayed on the local panel of the PowerLogic P5 protection relay.
- Calculate the current measurement accuracy, it shall be within ±1%.

Typical voltage measurement modes in PowerLogic P5

According to the ordered analogue module in slot A of a PowerLogic P5 protection relay, the application of voltage measurement modes can be various.

Following table indicates the selection of the voltage measurement modes based on the voltage inputs type of PowerLogic P5 protection relays.

Voltage inputs type		Voltage measurement mode									
		3VP	3VP + VN	3VP/ VPPy	3VP/VPy	2VPP + VN	2VPP + VN + VPPy	VPP/ VPPy	VP	VPP	VN
P5F30	VT	■	■	■	■	■	■	■			
	LPVT	■			■						
	LPVT + VT Adapter	■	■	■	■						
P5M30	VT	■	■			■					
	LPVT	■									
	LPVT + VT Adapter	■	■								
P5V20	VT	■	■	■	■	■	■	■			
P5U20	LPVT	■			■						
	LPVT + VT Adapter	■	■	■	■						
P5T30	VT								■	■	■

Voltage inputs

This test verifies that the accuracy of voltage measurement is within the acceptable tolerances.

Seven modes of connection are available on the PowerLogic P5 protection relay:

Mode	U1	U2	U3	U4
3VP	VA	VB	VC	-
3VP + VN	VA	VB	VC	VN
3VP/VPPy	VA	VB	VC	VABy
3VP/VPy	VA	VB	VC	VAy
2VPP + VN	VAB	VBC	-	VN
2VPP + VN + VPPy	VAB	VBC	VABy	VN
VPP/VPPy	VAB	-	VABy	-

The following tests will be realised with the VT Connecting Mode set to 3 VT which is the most used configuration.

- Double check the connection and then start the injection test.
- Apply voltage equal to the related VT secondary rated voltage.
- Check its magnitude using a multimeter or reading from the test equipment.
- Check the voltage magnitude on the local panel of the PowerLogic P5 protection relay.
- Calculate the voltage measurement accuracy, it shall be within ±1%.

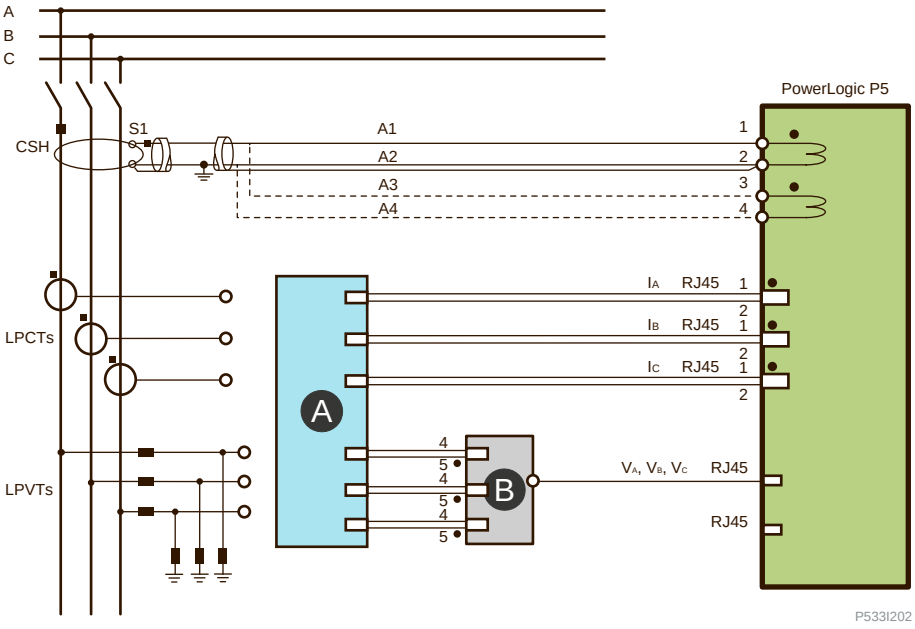
LPCT and LPVT inputs

These tests verify that the accuracy of the LPCT/LPVT measurements are within acceptable tolerances.

Connection diagram for testing the LPCT and LPVT measurement accuracy, page 158 shows the connection diagram that includes the PowerLogic P5 protection relay and a low frequency generator as described in Testing tools and equipment, page 148.

NOTE: To avoid any slow fluctuation of current measurements during testing, it is recommended to disconnect the signal generator earth/ground link or use an isolator transformer.

Figure 147 - Connection diagram for testing the LPCT and LPVT measurement accuracy



A	Voltage Generator	B	LPVT hub

LPCT measurement

This test verifies that the accuracy of LPCT measurement is within acceptable tolerances.

- Disconnect the secondary of LPCTs from the PowerLogic P5 protection relay.
- Use a generator with low voltage output (30 V max) and connect it directly to the PowerLogic P5 protection relay as described in Testing tools and equipment, page 148.
- Apply current equal to the related LPCT secondary rated current.
- Check its magnitude using a multimeter or reading from the test equipment.

- Check the current magnitude displayed on the local panel of the PowerLogic P5 protection relay.
- Calculate the LPCT measurement accuracy, it shall be within ±1%.

  NOTE: To be sure everything is well reconnected after test, it is recommended to perform a primary injection, at low level.

LPVT measurement

This test verifies that the accuracy of LPVT measurement is within acceptable tolerances.

- Disconnect the secondary of LPVTs from the LPVT hub.

  If the LPVT hub is not accessible inside the cubicle, disconnect the secondary of the LPVT hub from the PowerLogic P5 protection relay, and connect another one to replace it during the tests.
- Use a generator with low voltage output (10 V max) and connect it directly to the LPVT hub as described in Testing tools and equipment, page 148.
- Apply voltage equal to the related LPVT secondary rated voltage.
- Check its magnitude using a multimeter or reading from the test equipment.
- Check the voltage magnitude on the local panel of the PowerLogic P5 protection relay.
- Calculate the LPVT measurement accuracy, it shall be within ±1%.

  NOTE: To be sure everything is well reconnected after test, it is recommended to perform a primary injection, at low level.

Check the protection functions

The tests described in PowerLogic P5 protection relay check, page 149, Current inputs, page 157, LPCT and LPVT inputs, page 158, and Voltage inputs, page 157 have already demonstrated that the protection relay inputs and outputs work correctly and the analogue inputs are within calibration, thus the purpose of the tests for protection functions is as follows:

- To determine that each active protection function of the protection relay can trip according to the correct application settings.
- To verify correct assignment of the trip and alarm contacts by monitoring the response to the related fault injection.

The following sections only present the test procedures for current protection and voltage protection. The basic test procedures are similar for the other protection functions.

Current protection

This test, performed on stage 1 of the overcurrent protection function in setting group 1, is to check that the protection relay is operating correctly at the application-specific settings.

1. Determine which output relay has been selected to operate when an I> trip occurs.
2. Connect the output relay so that its operation will trip the test set and stop the timer of the injection box.
3. Connect the current outputs of test set (current injection source) to the protection relay current input terminals.
4. Apply a current of 120% of the current setting to the protection relay and the relay shall trip according to the operation time setting.
5. Check the tripping time from the test set and compare with the operation time setting.

6. Check the related fault recorder, events, and the related LEDs for trip indications.

A similar test procedure can be applied for the secondary injection test to check the other protection functions with the application-specific settings.

Voltage protection

This test, performed on stage 1 of the undervoltage protection function in setting group 1, is to check that the protection relay is operating correctly at the application-specific settings.

1. Determine which output relay has been selected to operate when a U< trip occurs.
2. Connect the output relay so that its operation will trip the test set and stop the timer.
3. Connect the voltage outputs of the test set (voltage injection source) to the protection relay voltage input terminals.
4. Apply normal voltage first and then a voltage of 80% of the voltage setting to the protection relay. The relay shall trip according to the operation time setting.
5. Check the tripping time from the test set and compare with the operation time setting.
6. Check the related fault recorder, events, and the related LEDs for trip indications.

A similar test procedure can be applied for the secondary injection test to check the other protection functions with the application-specific settings.

Testing with LPIT test box (reference REL51037)

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- This equipment must be only be installed and serviced by qualified electrical personnel.
- Turn off all power supplying this equipment before working on or inside it.
- Always use a properly rated voltage sensing device to confirm that all power is off.
- Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices.
- Do not install this product in ATEX zone 0 or 1 areas.

Failure to follow these instructions will result in death or serious injury.

Introduction

The secondary injection tests can be carried out with the LPIT test box. This test box is an adapter for secondary testing of PowerLogic P5 protection relays with LPCT/LPVT measuring inputs. It is an interface between the OMICRON[27] testing kit's low-power outputs and PowerLogic P5 inputs. Thanks to this adapter, the testing is comfortable and the right accuracy in the entire measuring range is ensured. For the LPCT signal testing, the LPIT Test Box offers 4 sets of current and 2 sets of voltage outputs depending on the measuring ranges tested. The LPIT test box is delivered with all cables required to perform the tests.

The OMICRON CMC 356, CMC 256plus and CMC 353 low level output allows 2 sets of three phase injections (LL1,2,3 and/or LL4,5,6).

The injection accuracy of these outputs is 0.07% from 0.71 V to 7.10 V (phase to neutral).

The overall accuracy (OMICRON + LPIT test box) is 0.25%[28] from 0.71 V to 7.10 V (phase to neutral).

Figure 148 - LPIT test box



For the order code of the LPIT test box, refer to Order codes of LPIT test box and test sockets/plugs, page 167 section for details.

The LPIT test box can be connected to the OMICRON low-level outputs with 3 inputs as shown below.

27. Omicron is a trademark of OMICRON Electronics GmbH, Oberes Ried 1, 6833 Klaus, Austria
28. Typical value at 25°C and variable in range of ultimate operation temperature 0°C-50°C.

Figure 149 - The rear panel of LPIT test box

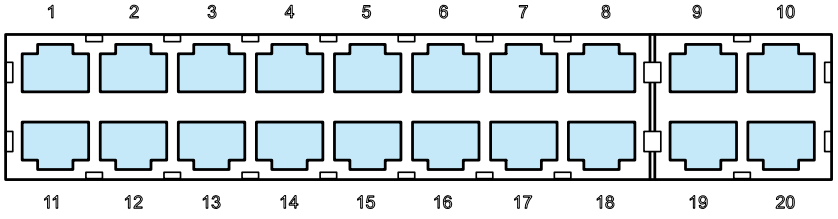


The LPIT test box can output different voltages in relation to the rated voltages of LPCTs (22.5 mV or 225 mV) and/or LPVTs (3.25 V (phase to phase)/1.88 V (phase to neutral)) linked to the three inputs shown above.

Figure 150 - The front panel of LPIT test box



Table 29 - Output ports on LPIT test box front panel

Current/ voltage	IA	IB	IC	IA,B,C	IA	IB	IC	IA,B,C	VA,B,C	VA,B,C
Input Output	2 V 225 mV				1 V 22.5 mV				1.88 V 1.88 V	1.88 V 1.88 V
LPCT/ LPVT	LPCT Input 1 (a: LL 1,2,3)				LPCT Input 1 (b: LL 4,5,6)				LPVT (2a)	LPVT (2b)
Port	1	2	3	4	5	6	7	8	9	10
										
Port	11	12	13	14	15	16	17	18	19	20
LPCT/ LPVT	LPCT Input 3 (a: LL 1,2,3)				LPCT Input 3 (b: LL 4,5,6)				LPVT (2c)	Test
Current/ voltage	IA	IB	IC	IA,B,C	IA	IB	IC	IA,B,C	VA,B,C	
Input Output	2 V 22.5 mV				1 V 1 V				1 V 1 V	Pin 1 to 8

NOTE: The 20th RJ45 is not an output but an input. As an example, it distributes its pins to the pin connections listed below of the LPIT output for test purposes. See Test input (20th RJ45), page 166 section for more details.

The outputs 1, 2, 3, 5, 6, 7, 11, 12, 13, 15, 16 and 17 are dedicated to single phase LPCT direct injections to IEDs.

The outputs 4, 8, 14 and 18 are dedicated to three phase LPCT injections through ESSAILEC® test plugs.

The outputs 9, 10 and 19 are dedicated to three phase LPVT injections.

When Input 1 is used, the possible LPCT outputs are:

- 2 V OMICRON outputs 1 to 3 to 225 mV scaling for outputs 1 to 3 (single phase) and 4 (three phase) LPCT
- 1 V OMICRON outputs 4 to 6 to 22.5 mV scaling for outputs 5 to 7 (single phase) and 8 (three phase) LPCT

When Input 2 is used, the possible LPVT outputs are:

- 3.25 V/1.88 V OMICRON outputs 1 to 3 with no scaling for outputs 9 (three phase) LPVT
- 3.25 V/1.88 V OMICRON outputs 4 to 6 with no scaling for outputs 10 (three phase) LPVT

When Input 3 is used, the possible LPCT and LPVT outputs are:

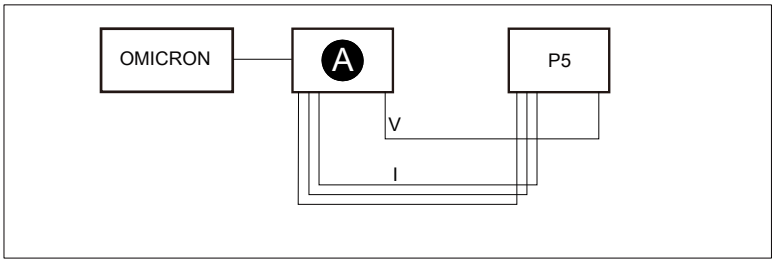
- 2 V OMICRON outputs 1 to 3 to 22.5 mV scaling for outputs 11 to 13 (single phase) and 14 (three phase) LPCT
- OMICRON outputs 4 to 6 with no scaling for outputs 15 to 17 (single phase) and 18 (three phase) LPCT and 19 (three phase) LPVT

LPCT/LPVT testing diagram

There are two cases for LPCT/LPVT testing:

- direct testing without test socket/plugs
- with test socket/plugs

Figure 151 - LPCT/LPVT direct testing without test sockets/plugs



P533SNA

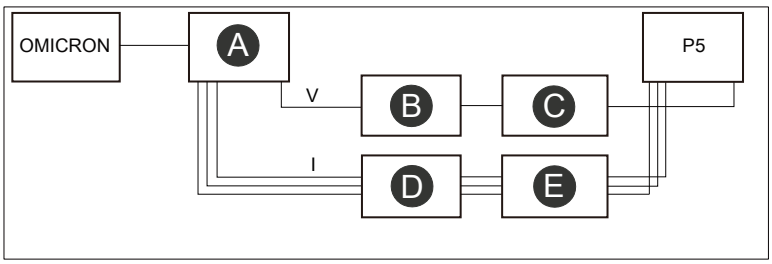
A	LPIT test box	REL51037

NOTE:

- For current, use 1st/2nd/3rd connector of each scaling block.
- Test cables are connected in place of LPCT/LPVT cables during the testing.
- To find out the order codes, refer to Order codes of LPIT test box and test sockets/plugs, page 167 section for details.

.

Figure 152 - LPCT/LPVT testing with test sockets/plugs



P533SOA

A	LPIT test box	REL51037	B	LPVT test plug	REL51093
C	LPVT test socket (with cover)	REL51092	D	LPCT test plug	REL51090
E	LPCT test socket (with cover)	REL51089			

NOTE:

- For current, use 4th connector of each scaling block.
- To find out the order codes, refer to Order codes of LPIT test box and test sockets/plugs, page 167 section for details.

Current injection test

For a 22.5 mV rated LPCT

1. From 0 to 3.5 In with accuracy needed from 0.35 In to 3.5 In
   - Connect to input 3
   - Outputs to be used are 11 to 14
   - Set 2 V rated OMICRON output on LL1,2,3
   - Example In = 100 A, injection is from 0 A to 350 A (accuracy from 35 A to 350 A)
2. From 0 to 7.1 In with accuracy needed from 0.71 In to 7.1 In
   - Connect to input 1
   - Outputs to be used are 5 to 8
   - Set 1 V rated OMICRON output on LL4,5,6
   - Example In = 100 A, injection is from 0 A to 710 A (accuracy from 71 A to 710 A)
3. From 0 to 35 In with accuracy needed from 3.5 In
   - Connect to input 1
   - Outputs to be used are 1 to 4
   - Set 2 V rated OMICRON output on LL1,2,3
   - Example In = 100 A, injection is from 0 A to 3500 A (accuracy from 350 A to 3500 A)

For a 225 mV rated LPCT

1. From 0 to 0.35 In with accuracy needed from 0.035 In to 0.35 In
   - Connect to input 3
   - Outputs to be used are 11 to 14
   - Set 2 V rated OMICRON output on LL1,2,3
   - Example In = 100 A, injection is from 0 A to 35 A (accuracy from 3.5 A to 35 A)
2. From 0 to 0.71 In with accuracy needed from 0.071 In to 0.71 In
   - Connect to input 1
   - Outputs to be used are 5 to 8
   - Set 1 V rated OMICRON output on LL4,5,6
   - Example In = 100 A, injection is from 0 A to 71 A (accuracy from 7.1 A to 71 A)

3. From 0 to 3.5 In with accuracy needed from 0.35 In to 3.5 In
   - Connect to input 1
   - Outputs to be used are 1 to 4
   - Set 2 V rated OMICRON output on LL1,2,3
   - Example In = 100 A, injection is from 0 A to 350 A (accuracy from 35 A to 350 A)
4. From 0 to 35 In with accuracy needed from 3.5 In to 35 In
   - Connect to input 3
   - Outputs to be used are 15 to 18
   - Set 1 V rated OMICRON output on LL4,5,6
   - Example In = 100 A, injection is from 0 A to 3500 A (accuracy from 350 A to 3500 A)

Voltage injection test

For a 3.25 V (phase to phase) rated LPVT (= 1.88 V (phase to neutral))

1. From 0 to 3.8 Vn with accuracy needed from 0.38 Vn to 3.8 Vn

   Method 1:
   - Connect to input 2
   - Outputs to be used are 9 and 10
   - Set 3.25 V rated OMICRON output on LL1,2,3 or LL4,5,6

   Method 2:
   - Connect to input 3
   - Output to be used is 19
   - Set 3.25 V rated OMICRON output on LL4,5,6
2. If lower voltage injection is needed:
   a. From 0 to 0.42 Vn with accuracy needed from 0.042 Vn to 0.42 Vn
      - Connect to input 1 to obtain 0.188 V rated output
      - Output to be used is 4
      - Set 1.668 V rated OMICRON output on LL1,2,3

   b. From 0 to 0.042 Vn with accuracy needed from 0.0042 Vn to 0.042 Vn
      - Connect to input 1 to obtain 0.188 V rated output
      - Output to be used is 14
      - Set 1.668 V rated OMICRON output on LL1,2,3

Current and voltage injections test

NOTE: The simultaneous current and voltage injection test is only possible connected to input 3 of the LPIT test box.

Use one of the above solutions described in current injection test and voltage injection test for outputs 11 to 19.

Test input (20th RJ45)

This input allows for an easy multimeter connection to measure either voltages or resistances between different pinouts of an IEC 61869-11 LPVT (or an IEC 61869-10 LPCT) connected to this RJ45 input.

Table 30 - Pin assignment for RJ45 connectors

RJ45 Pin	1	2	3	4	5	6	7	8
LPCT	S1	S2						
LPVT							a	n
LPVT (old)				n	a			

LPCT/LPVT Test Sockets and Plugs ESSAILEC®

Description

The Essailec® LPCT/LPVT test sockets and plugs from TE Connectivity allow the PowerLogic P5 protection relay LPCT/LPVT measuring inputs to be tested using RJ45 cable connections. The test socket is installed on the front panel of medium voltage switchgear, interconnecting the LPCT/LPVTs and PowerLogic P5 protection relay. The solution offers "make before break" principle so the test procedure is exactly the same as for protection relays with conventional measuring inputs.

- RJ45 connection type (Cat.5)
- Allow easy measurement and injection operations
- Signal protection against EMI/RFI thanks to a screened cover on the screened socket
- Shielding tests according to IEC 62271-1 Annex J
- Earthing/grounding point: M5 screw to be wired with an adapted ring lug termination. Ø = 4 mm (0.16 in.), torque = 1.2 Nm (10.8 lb.in).

Make before break principle:

- The circuits are automatically disconnected with the insertion of the plug,
- The circuits close automatically when the plug is removed.

Figure 153 - LPCT/LPVT Test Sockets and Plugs ESSAILEC®



Test socket cover LPCT test socket LPCT test plug



Test socket cover



LPVT test socket



LPVT test plug

Main technical data

Connecting capacity	IEC 947-1
Body	Polycarbonate UL94 V0
Conductive parts	Silver-plated
Rated voltage	125 V
Impulse withstand voltage	1000 V
Rated current	1.5 A
Accuracy	0.5 %
Storage temperature range	-40 ... +85 °C
Working temperature range	-40 ... +85 °C
Protection without lid / with lid	IP20 / IP40
Pollution degree	3

Ordering table

Please refer to Order codes of test sockets/plugs, page 168 for ordering information of test sockets/plugs.

Order codes for LPCT/LPVT accessories

The order codes for the LPIT test box and test sockets/plugs are listed in the following two tables.

Table 31 - Order codes of LPIT test box

Order code	Description
REL51037	LPIT test box including: Test box × 1 Test cable for test box × 1 RJ45 2m cable × 8
REL51088	Spare cable for LPIT test box
59660	0.6 m remote module connection cord
59661	2 m remote module connection cord
59662	4 m remote module connection cord

Table 32 - Order codes of test sockets/plugs

Order code	Description
REL51089	LPCT test socket with cover
REL51090	LPCT test plug
REL51091	Spare cover for LPCT test socket
REL51092	LPVT test socket with cover
REL51093	LPVT test plug
REL51094	Spare cover for LPVT test socket

Primary injection test

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

The primary injection test shall be performed by the qualified electrical engineers and strictly follow the related primary injection testing instructions from the utility.

Failure to follow these instructions will result in death or serious injury.

Primary injection testing is recommended to:

- Confirm the external wiring to the current and voltage inputs is correct
- Check the polarity of the current transformers at each end is consistent
- Check the directionality of the directional elements

For the application where the directional overcurrent or earth/ground fault protection, distant protection or current differential protection is installed, it is mandatory to check the correct polarity of the current transformers. If the current or voltage positive or negative sequence components are applied in the protection functions, it is mandatory to help ensure the correct phase sequence of current or voltage inputs.

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

If any of the external wiring was disconnected from the protection device to run any tests, make sure that all connections are restored according to the external connection or scheme diagram.

Failure to follow these instructions will result in death or serious injury.

For primary injection testing on conventional CT's, it is necessary to calculate the current and voltage magnitudes to be injected in the primary side according to the actual application scenario, check that the current magnitude is more than 20 mA and the voltage magnitude is more than 100 mV on the secondary side. Normally the auxiliary 380 V power supply in the substation or power plant can be applied for primary injection tests.

Voltage connections

NOTICE

CIRCUIT OVERLOAD

- Using a multi-meter, measure the voltage transformer secondary voltages to help ensure they are compliant with the PowerLogic P5 protection relay's input ratings.
- Check that the system phase rotation is correct using a phase rotation meter.

Failure to follow these instructions can result in equipment damage.

Primary Voltage Injection:

- Inject the voltage into the voltage transformer primary connection terminals.
- Check that the voltage magnitudes and angles are displayed on the protection relay's HMI in primary values.
- The voltage magnitudes should be equal to the applied voltage.
- The voltage angles should be correct according to the phase sequence.

Thus, the VT ratio, polarity, phase sequence and the external wiring from the primary system to the protection relay can be verified by the primary voltage injection.

Current connections

NOTICE

CIRCUIT OVERLOAD

Measure the current transformer secondary values for each input using a multimeter connected in series with corresponding protection device current input.

Failure to follow these instructions can result in equipment damage.

Primary Current Injection:

- Inject current into the primary system through the phase under test.
- Check that the current magnitudes and angles are displayed on the protection relay's HMI in primary values.
- The current magnitudes should be equal to the applied current.
- The current angles should be correct according to the phase sequence.
- Check that the current transformer polarities are correct against a phase meter already installed on site and known to be correct by measuring the phase angle between the current and voltage, or by contacting the system control center for the direction of power flow.

When using a neutral current transformer (core balance) or a sensitive current transformer, inject a single phase to validate the functionality.

Therefore, the CT ratio, polarity, phase sequence and the external wiring from the primary system to the protection relay can be verified by primary current injection.

LPCT connections

NOTICE

MEASUREMENT LOSS

Make sure that LPCTs are connected to all 3 phases with low power sensors or with RJ45 plug.

Failure to follow these instructions can result in no current measured.

Primary Current Injection:

- Inject current into the primary system through the phase under test.
- Check that the current magnitudes and angles are displayed on the protection relay's HMI in primary values.
- The current magnitudes should be equal to the applied current.
- The current angles should be correct according to the phase sequence.
- Check that the current transformer polarities are correct against a phase meter already installed on site and known to be correct by measuring the phase angle between the current and voltage, or by contacting the system control center for the direction of power flow.

Therefore, the CT ratio, polarity, phase sequence and the external wiring from the primary system to the protection relay can be verified by primary current injection.

Demonstrate circuit breaker operation

The correct operation of the circuit breaker shall be verified sufficiently during the commissioning test. CB operation can be controlled by the local or remote-control commands.

CB Operation Test:

- Check the actual CB position and read the CB position status from the protection relay HMI if the related CB position (52a, 52b) has been connected to the protection relay opto-isolated inputs.
- Perform a local CB control command to trip and close the CB, the CB shall operate correctly per the control command.
- Read the CB position status from protection relay HMI after one control command, the CB position information shall be the same as the actual CB status.

Arc-flash detection system setup and testing

Setting up the arc-flash system

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. See NFPA 70E, NOM-029-STPS-2011, or CSAZ462.
- The arc fault detection system is not a substitute for proper PPE when working on or near equipment being monitored by the system.
- Information on this product is offered as a tool for conducting arc-flash hazard analysis. It is intended for use only by qualified persons who are knowledgeable about power system studies, power distribution equipment, and equipment installation practices. It is not intended as a substitute for the engineering judgement and adequate review necessary for such activities.
- Only qualified personnel is allowed to install and service this equipment. Read this entire set of instructions and check the technical characteristics of the device before performing such work.
- Perform wiring according to national standards (NEC) and any requirements specified by the customer.
- Observe any separately marked notes and warnings.
- NEVER work alone.
- Before performing visual inspections, tests, or maintenance on this equipment, disconnect all sources of electric power. Assume all circuits are live until they are completely de-energised, tested, and tagged. Pay particular attention to the design of the power system. Consider all sources of power, including the possibility of back feeding.
- Always use a properly rated voltage sensing relay to ensure that all power is off.
- The equipment must be properly grounded.
- Connect the device's protective ground to functional earth according to the connection diagrams presented in this document.
- Do not open the device. It contains no user-serviceable parts.
- Install all devices, doors and covers before turning on the power to this device.

Failure to follow these instructions will result in death or serious injury.

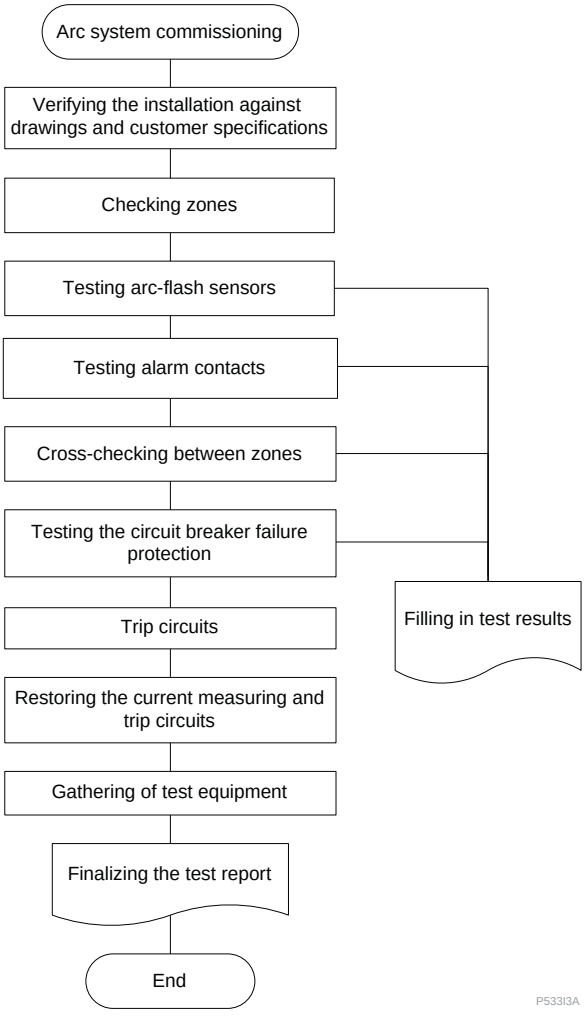
Before setting up the arc flash system:

- Mount and connect all components and sensors.
- Make sure that you understand the customer application.
- Identify the wiring connection of sensors to the device's connectors.
- Identify the wiring connection to breaking devices.
- Power up the device.
- Verify LED indication as described with consideration of the customer application.

Commissioning and testing

This section contains the commissioning testing instructions. The figure below shows the testing sequence.

Figure 154 - Testing sequence



Checking zones

- Check the protected zones where sensors have been installed and compare them against the drawings.
- Consult the customer if the configuration does not match with the drawings.

Disconnecting trip circuits

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH

Removing trip wires may cause loss of protection. Review system drawings and diagrams before disconnecting trip circuits.

Failure to follow these instructions will result in death or serious injury.

- Disconnect the trip signals to the circuit breakers that may disturb other parts of the system during the test.
- Also disconnect trip signals routed to other parts of the system, such as the breaker failure (ANSI 50BF) backup trip to upstream breakers and the transfer trip signals.
- Test the disconnected trip signals with a multimeter.

Test the arc-flash sensors

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. See NFPA 70E, NOM-029-STPS-2011, or CSAZ462.
- The arc fault detection system is not a substitute for proper PPE when working on or near equipment being monitored by the system.
- Information on this product is offered as a tool for conducting arc-flash hazard analysis. It is intended for use only by qualified persons who are knowledgeable about power system studies, power distribution equipment, and equipment installation practices. It is not intended as a substitute for the engineering judgement and adequate review necessary for such activities.
- Only qualified personnel is allowed to install and service this equipment. Read this entire set of instructions and check the technical characteristics of the device before performing such work.
- Perform wiring according to national standards (NEC) and any requirements specified by the customer.
- Observe any separately marked notes and warnings.
- NEVER work alone.
- Before performing visual inspections, tests, or maintenance on this equipment, disconnect all sources of electric power. Assume all circuits are live until they are completely de-energised, tested, and tagged. Pay particular attention to the design of the power system. Consider all sources of power, including the possibility of back feeding.
- Always use a properly rated voltage sensing relay to ensure that all power is off.
- The equipment must be properly grounded.
- Connect the device's protective ground to functional earth according to the connection diagrams presented in this document.
- Do not open the device. It contains no user-serviceable parts.
- Install all devices, doors and covers before turning on the power to this device.

Failure to follow these instructions will result in death or serious injury.

Testing the arc flash sensors with the light-only criteria operates the trip outputs of the device.

Testing the arc flash sensors with the light and current criteria, without an injected current, only generates an indication on PowerLogic P5 that protects the zone.

NOTE:

Testing the arc-flash sensors using a light source can trip the neighboring zones.

Because of their placement, some sensors cannot be tested without dismantling parts of the system. After completing the testing, reassemble the parts and validate the compliance with original mounting. Consult the equipment manufacturer before dismantling any parts.

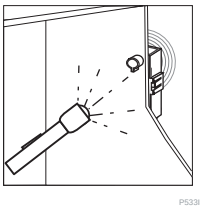
Testing the standard or pipe type sensors

Test the sensors with the PowerLogic P5 protection relay. Reset the PowerLogic P5 protection relay before the test.

NOTE:

Because of their placement, some sensors cannot be tested without dismantling parts of the system. After completing the testing, reassemble the parts and validate the compliance with original mounting. Consult the equipment manufacturer before dismantling any parts.

Figure 155 - Testing point sensors



1. Point a powerful light source such as a flashlight or camera flash unit to each arc-flash sensors until the sensor is activated.
2. Check the arc-flash sensor indication from the PowerLogic P5 protection relay.
3. Check the address of the activated arc-flash sensor from the PowerLogic P5 protection relay.
4. Compare the arc-flash sensor address information from the protection relay with that on the sensor location map.
5. Fill in the test result in the test report.
6. Reset the protection relay.
7. Repeat the procedure with the next arc-flash sensor.

Testing the supervision of arc-flash sensors

Test the sensors with PowerLogic P5 protection relay.

1. Disconnect one wire from the standard arc-flash sensor (or one end of the pipe type arc-flash sensor) to see that the sensor status supervision recognises the fault in the arc-flash sensor.
2. Wait until the fault indication appears.
3. Check that the internal fault relay operates and that the event information is communicated to any external systems.
4. Fill in the test result in the test report.
5. Reconnect the arc-flash sensor and reset the system.
6. Repeat the procedure with the other arc-flash sensors.

Connecting a current injection device with/without time measurement

⚠CAUTION

CIRCUIT OVERLOAD

Do not open a loaded current measuring circuit before the secondary circuit of the current transformer is reliably short-circuited.

Failure to follow these instructions can result in injury or equipment damage.

1. Short circuit the secondary circuit of the current transformer and disconnect the PowerLogic P5 protection relay from the measuring circuit.
2. Connect a current injection device, one phase at a time, to the PowerLogic P5 protection relay of the current measuring circuit.
3. For a current injection device with time measurement, connect the injection device either to inject the current continuously or when triggered by the time measuring circuit:
   a. Use the digital input of the current injection device for the stop trigger in the time measurement circuit.
   b. Connect the trip output of the tested unit to the digital input of the current injection device for the stop trigger. For measuring the total operating time, use the NO contact of the circuit breaker, which indicates that status of circuit breaker is open, for the stop trigger.
   c. Connect the time measuring start signal output to the flashlight. Configure the time measuring start signal to either trigger only the flashlight or both the flashlight and the current injection.

      Preferably, the current injection should be triggered before the flashlight.
   d. Measure the operate time between the start trigger and stop trigger.

Testing the alarm contacts

Alarm signals generated by the arc-flash protection system (trip and self-supervision alarms) can be forwarded to higher-level switchgear supervision and control systems through the output contacts.

1. Activate an alarm by generating an arc fault trip or sensor status supervision alarm.
2. Check the alarm contact operation from the higher-lever system. The alarm signals can also be sent via communication.
3. Reset the protection relay.
4. Repeat the procedure with the next alarm contact.

Testing the pick-up setting of the arc-flash protection function

1. Check the pick-up setting of the current criteria by injecting a current to the PowerLogic P5 protection relay.
2. Increase the current until the overcurrent criterion picks up.
3. Reset the protection relay.
4. Compare the current settings with the results.

Testing the arc-flash protection function without the time measurement

1. Inject a current, two times greater than the pick-up current level, to the PowerLogic P5 protection relay. Inject a current in each phase, one phase at a time.
   Verify that the technical characteristics of the channels are not exceeded.

2. While injecting the current, apply light with a flashlight to at least one of the arc-flash sensors, one at a time.
3. Check that the arc-flash protection function activates.
4. Generate at least one trip with current for the PowerLogic P5 protection relay.
5. Reset the protection relay.

Testing the arc-flash protection function with the time measurement

1. Inject a current, two times greater than the pick-up current level, to the PowerLogic P5 protection relay. Inject current to all three phases.
   The current can be injected in two ways:
   - Continuous injection
   - Injection triggered by the time measurement start signal.

   Verify that the technical characteristics of the channels are not exceeded
2. Position a flashlight to each of the light sensors in sequence. Start the time measurement to trigger the flash.
3. Check that the arc-flash protection function operates.
4. Check the operation time from the time measuring device.
5. Generate at least one trip with current.
6. Reset the protection relay and repeat for other light sensors.

Testing the circuit-breaker failure protection

1. Inject a current above the overcurrent setting value to the PowerLogic P5 protection relay.
2. Point light to one of the light sensors in the protected zone with flash light. The light pulse has to be longer than the CBFP time setting. Thus, the light pulse from a camera flash is too short.
3. Check that the circuit breaker failure protection function operates.
4. Reset the protection relay.

   NOTE:

   Use a torch to test the CBFP because the light pulse from a flashlight is too short.

   Ensure that the light pulse is not too long. If the light pulse is longer than 3 seconds, the daylight blocking function generates an alarm.

Testing the selectivity of the arc-flash protection

1. Test the selectivity of the protection zones, one at a time, by pointing light to an arc-flash sensor in a protection zone.
2. Compare the operation against the protection plans.
3. Inject current and at the same time point light to one arc-flash sensor in the tested zone.
4. Compare the operation against the protection plans.
5. Repeat the procedure for the other zones.

Test report

- Check the protected zones where sensors have been installed and compare them against the drawings.
- Consult the customer if the configuration does not match with the drawings.

Filling in the test report

Fill in all the required information about the system, the tested arc flash units and the test results.

Test report example

Figure 156 - Test report example

PowerLogic P5x3x Arc stage commissioning and testing report					
Customer Information	Customer name			Substation	
	Customer address			Bay	
Unit	Device name:		Device location:		
	Serial number:		Order code:		
	FW version:		IP Address:		
	NetMask:		Gateway:		
	MAC address:		NTP Server:		
Scaling	CT primary current input:		A	Pick-up setting:	xIn
	CT secondary current input:		A	Pick-up value:	A
	CT residual current primary input:		A	Pick-up setting:	xIn
	CT residual current secondary input:		A	Pick-up value:	A
Arc sensors	Sensor	Arc sensor status	Tested	Remarks	
	1	☐ OK ☐ NA	☐		
	2	☐ OK ☐ NA	☐		
	3	☐ OK ☐ NA	☐		
	4	☐ OK ☐ NA	☐		
	5	☐ OK ☐ NA	☐		
	6	☐ OK ☐ NA	☐		
Arc stages	Stage number	Activation criteria	Tested	Remarks	
	1	☐ Light ☐ I>int ☐ I_N>int	☐		
	2	☐ Light ☐ I>int ☐ I_N>int	☐		
	3	☐ Light ☐ I>int ☐ I_N>int	☐		
	4	☐ Light ☐ I>int ☐ I_N>int	☐		
	5	☐ Light ☐ I>int ☐ I_N>int	☐		
	6	☐ Light ☐ I>int ☐ I_N>int	☐		
	7	☐ Light ☐ I>int ☐ I_N>int	☐		
	8	☐ Light ☐ I>int ☐ I_N>int	☐		
CBFP	Stage number	Delay setting / ms	Tested	Remarks	
	1		☐		
Trip relays	Trip relay	Tested	CBFP	Remarks	
	D01(B)	☐ OK ☐ NA	☐		
	D02(B)	☐ OK ☐ NA	☐		
	D03(B)	☐ OK ☐ NA	☐		
	D01(D)	☐ OK ☐ NA	☐		
	D02(D)	☐ OK ☐ NA	☐		
	D01(E)	☐ OK ☐ NA	☐		
	D02(E)	☐ OK ☐ NA	☐		
Led indications	Led name	Tested	Led name	Tested	
	A	☐ Yes ☐ NA	F	☐ Yes ☐ NA	
	B	☐ Yes ☐ NA	G	☐ Yes ☐ NA	
	C	☐ Yes ☐ NA	H	☐ Yes ☐ NA	
	D	☐ Yes ☐ NA	I	☐ Yes ☐ NA	
	E	☐ Yes ☐ NA	J	☐ Yes ☐ NA	
Testing device	Device		Calibration date		
Signatures	Commissioner(s)				
	Supervisor				
	Date				

P533I5B

Final check

NOTICE
CIRCUIT OVERLOAD • Remove all test or temporary shorting leads. • If it has been necessary to disconnect any of the external wiring from the protection relay to perform the wiring verification tests, make sure that all connections are replaced according to the relevant external connection or scheme diagram. **Failure to follow these instructions can result in equipment damage.**

The commissioning is now complete, but before putting the protection relay into normal operation, check the following items:

- Ensure that the protection relay is restored to service.
- CB maintenance and current counters should be zero. These counters can be reset.
- Double check the application-specific settings, to help ensure that all the desired protection and control functions are enabled with the correct settings. Extract the final setting file from the protection relay.
- Check the Date and Time of the protection relay, to help ensure the date and time are exactly synchronised.
- Reset all event records, fault records, and disturbance records. Make sure that alarms and LEDs have been reset before leaving the protection relay.

The device is now ready for operation.

Cybersecurity

Cybersecurity overview

This chapter contains up-to-date information about cybersecurity of PowerLogic P5. Network administrators, system integrators and personnel that commission, maintain or dispose of a device should:

- Apply and maintain the device's security capabilities. See Device security capabilities, page 182 for details.
- Review assumptions about protected environments. See Protected environment assumptions, page 183 for details.
- Address potential risks and mitigation strategies. See Potential risks and compensating controls, page 184 for details.
- Follow recommendations to optimise cybersecurity.

To communicate a security topic affecting a Schneider Electric product or solution, go to https://www.se.com/ww/en/work/support/cybersecurity/vulnerability-policy.jsp.

The PowerLogic P5 device is delivered with auto-login feature. It will be disabled when the passwords for all three levels are changed from the default ones.

⚠WARNING

POTENTIAL COMPROMISE OF SYSTEM AVAILABILITY, INTEGRITY, AND CONFIDENTIALITY

- Change default passwords to help prevent unauthorised access to device settings and information.
- Disable unused ports/services and default accounts, where possible, to minimise pathways for malicious attacks.
- Place networked devices behind multiple layers of cyber defenses (such as firewalls, network segmentation, and network intrusion detection and protection).
- Use cybersecurity best practices (for example: least rights, separation of duties) to help prevent unauthorised exposure, loss, modification of data and logs, interruption of services, or unintended operation.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

Security policy

NOTICE

ACCESSIBILITY LOSS

- Setup a security policy and procedure to back up the security administrator user account.
- Do not share a single user account with multiple users. Set one user account associated to roles and rights per user.
- Do not excessively decrease "user parameters" values.

Failure to follow these instructions can result in loss of access to the protection relay.

Cybersecurity helps provide:

- Confidentiality (to help prevent unauthorised access)
- Integrity (to help prevent unauthorised modification)
- Availability/authentication (preventing the denial of service and assuring authorised access)
- Non-repudiation (preventing the denial of an action that took place)
- Traceability/detection (logging and monitoring)

For an efficient security, the instructions and procedures should structure the roles and responsibilities in terms of security within the organisation; in other words, who is authorised to perform what and when. These should be known by the users.

The anti-intrusion and anti-physical access to any sensitive installation should be set up.

All the security rules implemented in the PowerLogic P5 protection relays are in complement of the points above.

In the PowerLogic P5 protection relays, the control of accessibility to the settings, parameters, configuration and logs is done with a user authentication after "Log in", with a name and password.

The PowerLogic P5 protection relay controls the access:

- through the local panel
- through eSetup Easergy Pro (front and rear connection)
- through the web HMI server
- through the EcoStruxure Power Device application

The Ethernet communication with the EcoStruxure Power Device application and eSetup Easergy Pro are encrypted.

The access through the communication protocols is not controlled by the PowerLogic P5 protection relay but by the SCADA system. The protocols do not include any specific secured commands.

NOTICE

CYBER SECURITY RISK OF INFORMATION DISCLOSURE, BEING TAMPERED WITH, OR DENIAL OF SERVICE

- Except for private GetSet protocol over the secured communication (SSH), the device can not transmit data encrypted with the following protocols: IEC 61850, DNP3 over Ethernet, Modbus slave over Ethernet, EtherNet/IP, IEC 60870-5-103 serial, IEC 60870-5-101 serial, DNP3 serial, Modbus slave serial, Modbus master serial, PTP and SNTP.
- Only personnel with authentication can access to your device network, if unauthorized personnel got the access, the transmitted information can be disclosed or subject to tampering.
- For transmitting data over an internal network, physically or logically segment the network. The access to the internal network needs to be restricted by using standard controls, such as firewalls, and other relevant features supported by your device, such as IP Table whitelisting.
- For transmitting data over an external network, encrypt protocol transmissions over all external connections using an encrypted tunnel, TLS wrapper or a similar solution.

Failure to follow these instructions can increase the risk of unauthorised access.

The access through the digital inputs is not controlled.

Any SCADA system, and any computer using eSetup Easergy Pro, CAE software and a central server, should have an updated anti-virus, anti-malware, anti-ransomware application activated during the use.

If a central server is used, a backup is recommended.

Even if PowerLogic P5 protection relay has an extension module with backup memory, it is recommended to archive any setting and files in a secured area.

A password policy should be implemented with:

- Change of the default passwords before the PowerLogic P5 protection relay is put into operation (see Password complexity, page 190).
- Periodic change of the passwords
- Revocation of the passwords of users who leave or do not need to use the device any more

Product defense-in-depth

Use a layered network approach with multiple security and defense controls in your IT and control system to minimise data protection gaps, reduce single-point of failure and create a strong cybersecurity posture. The more layers of security in your network, the harder it is to breach defenses, take digital assets or cause disruption.

Device security capabilities

This section describes the security capabilities available with your device.

Information confidentiality

These security capabilities help protect the confidentiality of information through secure protocols that employ cryptographic algorithms, key sizes and mechanisms used to help prevent unauthorised users from reading information in transit, i.e. SSH, SFTP and HTTPS.

Physical security

In order to help prevent unauthorised access, lock the shutter on the local panel of the PowerLogic P5 protection relay with a wired lead seal. See Lock the shutter and handle, page 50 for details.

Cybersecurity configuration

These security capabilities support the analysis of security events, help protect the device from unauthorised alteration and records configuration changes and user account events:

- Internal time synchronisation.
- Time source integrity protection and the PowerLogic P5 protection relay configuration event logging.
- Timestamps, including date and time, match the PowerLogic P5 protection relay clock.
- SSH server hosts an internal SFTP site and stores files in the PowerLogic P5 protection relay’s flash memory, such as: COMTRADE records and firmware files.
- Embeds user information with changes.
- Offload information to syslog or a protected storage or retention location.

User accounts and rights

These security capabilities help enforce authorisations assigned to users, segregation of duties and least rights:

- User authentication is used to identify and authenticate software processes and devices managing accounts.
- User account lockouts configurable with number of unsuccessful login attempts.
- Password strength feedback using CAE.

Port hardening

The communication port of PowerLogic P5 protection relay can be disabled. Each logical port can be independently disabled. Port hardening configuration can be set from the local panel of PowerLogic P5 protection relay, from eSetup Easergy Pro, or from the web HMI, with the ENGINEER access right.

Firmware upgrades

This security capability helps protect the authenticity of the firmware running on the PowerLogic P5 protection relay and facilitates protected file transfer: digitally signed firmware is used to help protect the authenticity of the firmware running on the PowerLogic P5 protection relay and only allows firmware generated and signed by Schneider Electric.

Device backup creation and restore

This security capability helps PowerLogic P5 participate in system level backup operations by creating backups of the device state. In case of need, PowerLogic P5 can recover with help of those backups to a known good operational state. The protection, control and communication settings can be saved with eSetup Easergy Pro; the security configuration can be saved with CAE.

For how to create such backups and to use them to restore the protection relay please refer to the corresponding sections in eSetup Easergy Pro and CAE user manuals.

Security event logging

These security capabilities help provide a method to generate security-related reports and manage event log storage:

- Machine and human-readable reporting options for current device security settings.
- Audit event logs to identify:
  - The PowerLogic P5 protection relay configuration changes.
  - Energy management system events.
- PowerLogic P5 keeps the security logs with cyclic non-volatile memory, when the limit of the memory size is reached the oldest entries will be replaced by new ones.
- Time source integrity protection and event logged when changed.

Protected environment assumptions

- Cybersecurity governance – available and up-to-date guidance on governing the use of information and technology assets in your company.
- Perimeter security – installed devices, and devices that are not in service, are in an access-controlled or monitored location.
- Emergency power – the control system provides the capability to switch to and from an emergency power supply without affecting the existing security state or a documented degraded mode.
- Firmware upgrades – the PowerLogic P5 protection relay upgrades are implemented consistently to the current version of firmware.
- Controls against malware – detection, prevention and recovery controls to help protect against malware are implemented and combined with appropriate user awareness.

- Physical network segmentation – the control system provides the capability to:
  - Physically segment control system networks from non-control system networks.
  - Physically segment critical control system networks from non-critical control system networks.
- Logical isolation of critical networks – the control system provides the capability to logically and physically isolate critical control system networks from non-critical control system networks. For example, using VLANs.
- Independence from non-control system networks – the control system provides network services to control system networks, critical or non-critical, without a connection to non-control system networks.
- Encrypt protocol transmissions over all external connections using an encrypted tunnel, TLS wrapper or a similar solution.
- Zone boundary protection – the control system provides the capability to:
  - Manage connections through managed interfaces consisting of appropriate boundary protection devices, such as: proxies, gateways, routers, firewalls and encrypted tunnels.
  - Use an effective architecture, for example, firewalls protecting application gateways residing in a DMZ.
  - Control system boundary protections at any designated alternate processing sites should provide the same levels of protection as that of the primary site, for example, data centers.
- No public internet connectivity – access from the control system to the internet is not recommended. If a remote site connection is needed, for example, encrypt protocol transmissions.
- Resource availability and redundancy – ability to break the connections between different network segments or use duplicate devices in response to an incident.
- Manage communication loads – the control system provides the capability to manage communication loads to mitigate the effects of information flooding types of DoS (Denial of Service) events.
- Control system backup – available and up-to-date backups for recovery from a control system failure.

Potential risks and compensating controls

Address potential risks using these compensating controls:

Area	Issue	Risk	Compensating controls
User accounts	Default account settings are often the source of unauthorised access by malicious users.	If you do not change the default password, unauthorised access can occur.	Change the default password for all accounts to help reduce unauthorised access. See Passwords, page .
Secure protocols	IEC 61850, DNP3 over Ethernet, Modbus slave over Ethernet, EtherNet/IP, IEC 60870-5-103 serial, IEC 60870-5-101 serial, DNP3 serial, Modbus slave serial, Modbus master serial, IEEE 1588 and SNTP protocols are unsecure. The device does not have the capability to transmit data encrypted using these protocols.	If a malicious user gained access to your network, they could intercept communications.	For transmitting data over an internal network, physically or logically segment the network. For transmitting data over an external network, encrypt protocol transmissions over all external connections using an encrypted tunnel, TLS wrapper or a similar solution. See Protected environment assumptions, page 183.

Cybersecurity configuration

The PowerLogic P5 with firmware V01.500.101 or higher are delivered with Basic Cybersecurity level. The User can upgrade them to Advanced Cybersecurity level with a setting parameter available in the relay's local panel. Both levels can be described in the following way:

- **Basic Cybersecurity level**: Cyber Security Level 0 (CSL0)
  Most of cybersecurity rules are fixed by default configuration which cannot be customized. User accounts also fixed. Changing of password directly on device HMI. No security logs. Advanced features such as sending logs to Syslog server and centralized authentication mode are not provided.
- **Advanced Cybersecurity level**: Cyber Security Level 1 (CSL1)
  Customized cybersecurity rules option provided. Management of user accounts and update password [29] for all PowerLogic P5 devices in batch mode in a same local area network. Security logs provided, and the logs can be transmitted to Syslog server. Supports centralized authentication with Microsoft Active Directory as backend.

The Advanced Cybersecurity level of the protection relay holds certification for IEC 62443-4-1 for Secure Development Lifecycle and IEC 62443-4-2 Security Level 1 (SL1) for security features provided.

An overview of the differences between security features offered with Basic and Advanced levels is listed in the following table.

Security features	Basic CS level	Advanced CS level
Connect with Cybersecurity Admin Expert (CAE)[30]	-	■
Change/add/remove user account	-	■
Change password of user account	■[31]	■[29]
Generate security Logs	-	■
Backup security logs to Syslog server	-	■
Customize role privileges	-	■
Batch update user passwords of multiple PowerLogic P5	-	■
Communication ports hardening	■	■
Secure connection with eSetup Easergy Pro software	■	■
Discoverable by eSetup Easergy Pro	-	■
Centralized authentication	-	■
Web HMI via HTTPs	■	■
Cybersecurity reset without losing settings and records	■	■

The cybersecurity level used to be an order option. In the products delivered with firmware versions prior to V01.500.101 (earlier version V01.30x.yyy or V01.40x.yyy), the cybersecurity level was fixed. The character no. 17 in the model number informed about cybersecurity level available in the product:

P 5 x 2 0 - _ _ _ _ - _ _ _ _ _ - _ _ **A** _

P 5 x 3 0 - _ _ _ _ - _ _ _ _ _ - _ _ **B** _

29. In Advanced Cybersecurity level, changing password of user account can only be done on device HMI.
30. CAE is a free engineering tool software which is used to manage cybersecurity rules for PowerLogic P5.
31. In Basic Cybersecurity level, changing password of user account can only be done on device HMI.

Second last character of reference number	Security features		
	V01.30x.yyy and previous	V01.40x.yyy	V01.50x.yyy and next
A	CS Basic	CS Basic	N/A
B	CS Advanced	CS Advanced	
C	N/A	CS Basic + Advanced logic	
D		CS Advanced + Advanced logic	
E		N/A	Settable CS
F			Settable CS + Advanced logic

NOTE:

- From firmware version V01.500.101, only E or F options are available.
- In case of a firmware upgrade of a device with older firmware version to V01.50x.yyy, the options A and B will evolve to E. The options C and D will evolve to F.

To configure CS level:

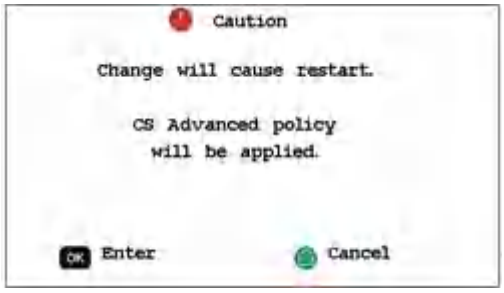
1. With the local panel, enter the **Home menu**/**General** sub-menu/ **Cybersecurity**/**CS level config**, you can upgrade the level from *CS Basic* to *CS Advanced*.



   The change is always possible from *CS Basic* to *CS Advanced* under condition of having right access level.

   NOTE: After changing *CS Basic* to *CS Advanced* and pushing RBAC with CAE tool, it's not possible to downgrade the product back to *CS Basic*.

2. The pop-up page displays to inform this change, press **OK** key to confirm the restart operation.



   After the restart, the new CS level configuration is valid.

HMI Auto-login

To facilitate the commissioning work by panel builder and system integrator, PowerLogic P5 is provided with an Auto-login feature when manufactured. This feature grants privilege of the role of INSTALLER for HMI access, without request of password. All roles and their rights are described in chapter of Roles and rights, page 188.

This feature is applicable for both Basic and Advanced CS levels.

The Auto-login feature will be disabled when:

- **For Basic CS level**: the auto-login will be disabled when password has been changed for InstallerLevel account. Password change for other accounts does not impact the auto-login feature.
- **For Advanced CS level**: when security rules are pushed to device by CAE software, the auto-login feature will be immediately disabled.

The following chapters will describe how the cybersecurity rules of PowerLogic P5 can be managed for Basic and Advanced CS levels. Before that, the roles and rights definitions must be described.

Roles and rights

PowerLogic P5 operations are protected by Role-Based Access Control (RBAC) concept. The roles are assigned with rights. The user accounts are then created upon those roles with granted rights which are associated with the corresponding roles. The following table provides an overview of the roles and their default rights. For Basic CS level the rights of role cannot be changed from default. For Advanced CS level the rights of role can be customized with CAE software.

Table 33 - List of roles for cybersecurity

Role	Description
VIEWER (Advanced CS level only)	Can view information except for security logs. Viewer cannot modify any settings and files.
OPERATOR	In addition of VIEWER's rights, OPERATOR can perform control actions and change setting groups.
ENGINEER	In addition of OPERATOR's rights, ENGINEER can make setting change, retrieve events, and fault records.
INSTALLER	In addition of ENGINEER's rights, INSTALLER can update the device firmware
SECAUD (Advanced CS level only)	Can read security logs.
SECADM (Advanced CS level only)	Can change security rules, this is the only role which can be used to work with CAE software.

All user accounts are password protected and granted up to 256 concurrent sessions.

The PowerLogic P5 default RBAC setting is compliant with IEC 62351-8 guidelines. With CAE it can be modified and extended depending on user requirements. The default RBAC setting is as the following table.

Table 34 - Roles vs. their access rights

	VIEWER	OPERATOR	ENGINEER	INSTALLER	SECADM	SECAUD
Logs					■	■
Security			■	■	■	
Configuration change			■	■		
Control		■	■	■		
Clear statistics data		■	■	■		
Internal data	■	■	■	■		
Configuration read	■	■	■	■		
Settings read	■	■	■	■		
Control status read	■	■	■	■		
Read statistics data	■	■	■	■		
Read data	■	■	■	■		
Debug system				■		

Table 34 - Roles vs. their access rights (Continued)

	VIEWER	OPERATOR	ENGINEER	INSTALLER	SECADM	SECAUD
Debug application				■		
Secure communication	■	■	■	■		
Device cybersecurity data full access				■		
Backup memory copy				■		
Device user data file read		■		■		
Device user data file full access				■		
Device system data file full access				■		
Function key control		■		■		
Setting change			■	■		
Firmware update				■		
Firmware verify				■		

Please find detailed explanation of the rights from following table.

Table 35 - List of rights

Right	Name of right in CAE[32]	Description
Logs	LOGS	Permission to retrieve security logs from PowerLogic P5 with CAE
Debug application	P5_RightApplicationDebug	Permission to execute firmware (application level) debug command (internal manufacturer user)
Backup memory copy	P5_RightBackupRootDirDefaultAccess	Permission to read, write, delete, transfer through SFTP, back up memory data in /backup/ directory of file system embedded in the device.
Configuration read	P5_RightConfigDft	Permission to read the configuration which need a reboot of the device, for example, scaling values like CT ratio or voltage connection mode.
Configuration change	P5_RightConfigMgt	Permission to modify the configuration, it means we can change any setting which need a reboot of the device, for example, scaling values like CT ratio or voltage connection mode.
Control status read	P5_RightCtrlObjDft	Permission to read the status of controllable objects such as status of switches, alarms, digital inputs/outputs, LED mode, etc.
Control	P5_RightCtrlObjMgt	Permission to change the status of controllable objects such as switches, alarms, digital inputs/outputs, LED mode, etc.
Device cybersecurity data full access	P5_RightCybSecRootDirDefaultAccess	Permission to read, write, delete, transfer through CAE, cybersecurity data in /cyb_sec/ directory of file system embedded in the device.
Read data	P5_RightDataDft	Permission to read all the data (i.e., measurements, fixed parameters (i.e. model number, ….), logs, …
Internal data	P5_RightDescMgt	Permission to read and write internal data (internal manufacturer user)
Firmware update	P5_RightFirmwareProgram	Permission to update firmware
Firmware verify	P5_RightFirmwareVerify	Permission to verify firmware authenticity and integrity before updating the firmware to the device
Function key 1-8 control	P5_RightFnkey01-07	Permission to operate with the function keys. There is one permission per function key Fx (x = 1 to 7)
Secure communication	P5_RightSecureComm	Permission to connect eSetup Easergy Pro to PowerLogic P5
Settings read	P5_RightSettingDft	Permission to read any setting which do not need a reboot of the device, for example, protection threshold or operation time.

32. The name of right in CAE is needed when the rights will be assigned for new roles or to be customized for existing roles.

Table 35 - List of rights (Continued)

Right	Name of right in CAE[33]	Description
Settings change	P5_RightSettingMgt	Permission to modify any setting which does not need a reboot of the device, for example, protection or communication settings. Includes also logic and Mimic configuration in eSetup Easergy Pro, switching device mode (normal use or tests mode) and allowing test execution.
Read statistics data	P5_RightStatDft	Permission to read only statistics data like counters, demand, max, min., thermal capacity, …, etc.
Clear statistics data	P5_RightStatMgt	Permission to read and clear statistics data like counters, demand, max, min., thermal level, …, etc.
Debug system	P5_RightSystemDebug	Permission to execute firmware (low level) debug command (internal manufacturer user)
Device user data file read	P5_RightUserRootDirDefaultAccess	Permission to read through SFTP or eSetup Easergy Pro, user data in /usr/ directory of file system embedded in the device like disturbance records, …, etc.
Device user data file full access	P5_RightUserRootDirFullAccess	Permission to read, write, delete, transfer through SFTP or eSetup Easergy Pro, user data in /usr/ directory of file system embedded in the device like disturbance records, …, etc., except security logs.
Device system data file full access	P5_RightUserRootDirFullAccess	Permission to read, write, delete, transfer through SFTP, system data in /sys/ directory of file system embedded in the device (internal manufacturer user); permission to update, through eSetup Easergy Pro and the device firmware.
Security	SECURITY	Permission to change security settings including RBAC, password complexity, and timeout options…, etc.

Password complexity

The following rule of password complexity is available for both Basic CS level and Advanced CS level.

- Length of password must be 1 to 8 characters
- Passwords can be composed by the following ASCII [33 to 122] characters:
  - Latin capital letters from A to Z
  - Latin lowercase characters from a to z
  - Figures from 0 to 9
  - Non-alphabetic characters: [\ ] ^ _ ’ ! “ # $ %` & ‘ ( ) * + , - . / : ; < = > ? @

  NOTE: Passwords cannot contain the user account name or parts (no more than two consecutive characters) of the user's full name. To help to secure the PowerLogic P5 protection relay, the password should be as long as possible, mixing lowercase and uppercase characters, figures and non-alphabetic characters.

It is possible to configure password with CAE according to NERC and IEEE 1686 standard recommendations.

Standard	Configuration
NERC	8 characters minimum with ASCII [33 to 122] characters. The lesser of three or more different types of characters (e.g., uppercase alphabetic, lowercase alphabetic, numeric from 0 to 9, non-alphabetic characters)
IEEE std1686	8 characters minimum with ASCII [33 to 122] characters 1 lowercase letter, 1 uppercase letter, 1 digit from 0 to 9 and 1 non-alphabetic character

33. The name of right in CAE is needed when the rights will be assigned for new roles or to be customized for existing roles.

Password reset and factory reset

The PowerLogic P5 protection relay supports password reset and factory reset, with different cybersecurity levels, the reset will be limited to different levels:

- For Basic Cybersecurity level, the reset will be only of the password, the settings will be kept.
- For Advanced Cybersecurity level, the reset will execute a factory reset of the device.

For Advanced Cybersecurity level, the reset can be disabled, however, the reset cannot be disabled for Basic Cybersecurity level. The type of the resets, and the resets are disable or not are as listed in the following table:

Type of reset	Basic CS level	Advanced CS level
Password reset	Yes	No
Factory reset	No	Yes, by default
Reset can be disabled	No	Yes, INSTALLER only

Both password reset and factory reset are operated on local HMI of PowerLogic P5, by full physical access authorised solution.

The cybersecurity level of the device is displayed at the upper right corner of the local HMI. stands for the Basic Cybersecurity level, stands for the Advanced Cybersecurity level.

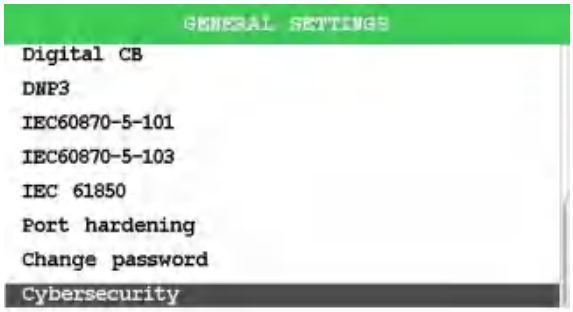
Figure 157 - Padlock icons standing for the cybersecurity levels



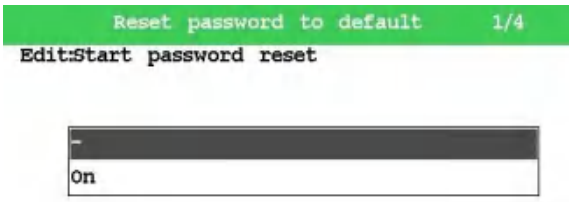
Basic Cybersecurity level: password reset

When the PowerLogic P5 with Basic Cybersecurity level is in operation mode, the password reset can be made on the local HMI:

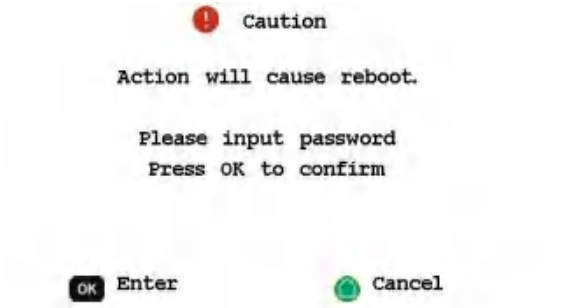
1. From the **main menu**, move the focus to **General**, then press the OK key to enter the submenu.
2. Select **Cybersecurity** option and press the OK key.



3. On **Reset password to default** screen, press the OK key twice to enter the edit page.



4. Select **On** option and press the OK key.
   A caution message will be pop-outed to prompt a password input.

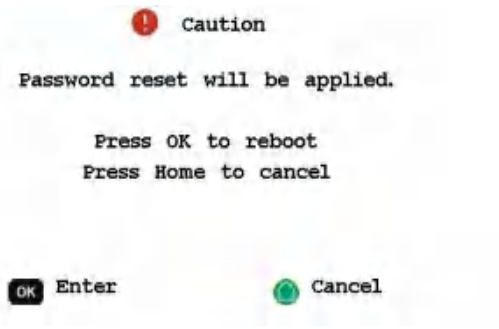


5. Press the key in sequence ◁ △ ▷ ▽ ◁ △ ▷ ▽ and press the OK key.

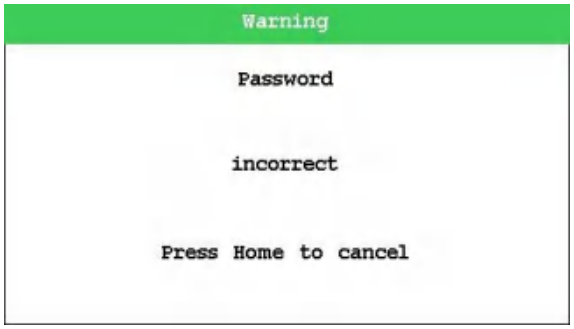
   NOTE:

   - After inputting the password (◁ △ ▷ ▽ ◁ △ ▷ ▽), make sure press the OK key in five minutes. Otherwise the system will switch to the Mimic screen.
   - The PowerLogic P5 allows up to five attempts of password mistake. If you have reached the limitation, you will have to wait for four minutes for next five attempts.

6. If the password is correct, a **Caution** message will be pop-outed as below. Press the OK key to reboot.



If the password is incorrect, a **Warning** message will be pop-outed as shown below. Press the ⌂ key to cancel and input the correct password again.

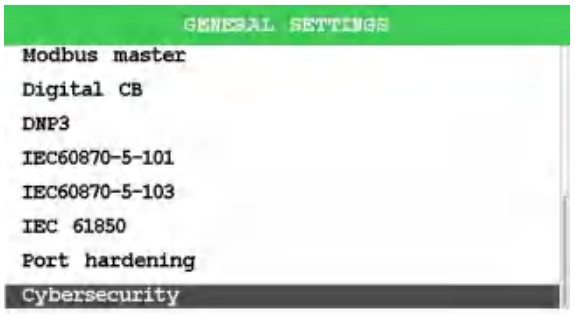


Please wait until the reboot completes.

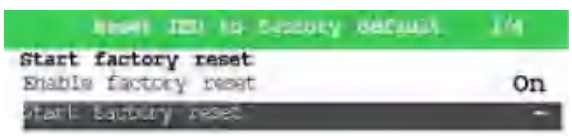
Advanced Cybersecurity level: factory reset

By default, **enable factory reset** setting is enabled. In case of the **enable factory reset** setting is enabled, and the PowerLogic P5 with Advanced Cybersecurity level is in operation mode, the factory reset can be made on the local HMI:

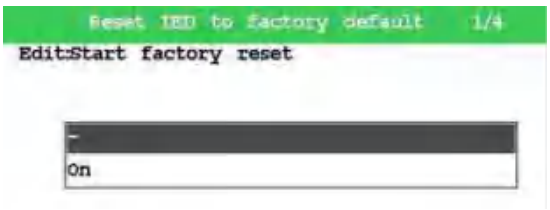
1. From the **main menu**, move the focus to **General**, then press the OK key to enter the submenu.
2. Select **Cybersecurity** option and press the OK key.



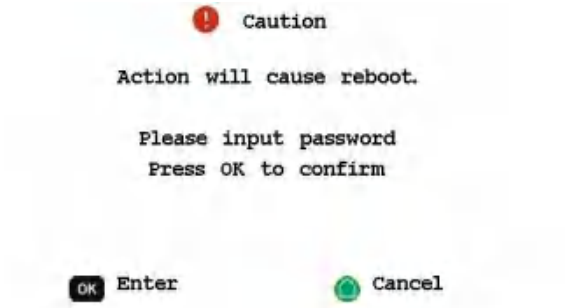
3. On **Reset IED to factory default** screen, press the OK key, then press the ▽ key to select **Start factory reset** option as shown below.



4. Press the OK key to enter the edit page.



5. Select **On** option and press the OK key.
   A caution message will be pop-outed to prompt a password input.

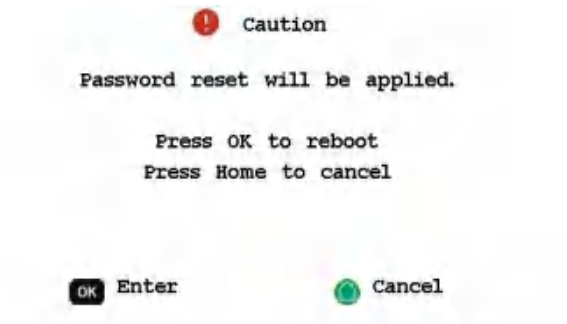


6. Press the key in sequence ◁ △ ▷ ▽ ◁ △ ▷ ▽ and press the OK key.

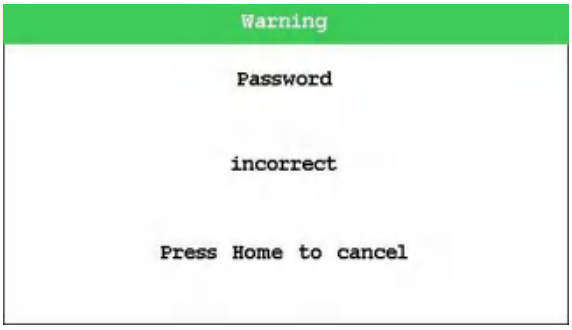
   NOTE:

   - After inputting the password (◁ △ ▷ ▽ ◁ △ ▷ ▽), make sure press the OK key in five minutes. Otherwise the system will switch to the Mimic screen.
   - The PowerLogic P5 allows up to five attempts of password mistake. If you have reached the limitation, you will have to wait for four minutes for next five attempts.

7. If the password is correct, a **Caution** message will be pop-outed as below. Press the OK key to reboot.



   If the password is incorrect, a **Warning** message will be pop-outed as below. Press the ⌂ key to cancel and input the correct password again.



   Please wait until the reboot completes. All the settings and passwords will be reset to default values.

Advanced Cybersecurity level: disable the factory reset

The disable of the factory reset in PowerLogic P5 is not opened to all the roles. Only the INSTALLER users are permitted to disable the factory reset by setting the **Enable factory reset** to *Off*.

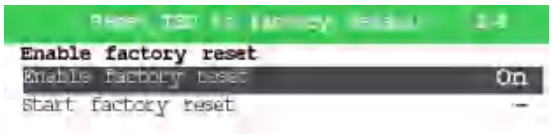
NOTE: Once the factory reset is disabled, in case of the user's credentials lost, it will be impossible to perform a factory reset from PowerLogic P5 local HMI, please contact with Schneider Electric to get the technical support.

The operations to disable the factory reset are:

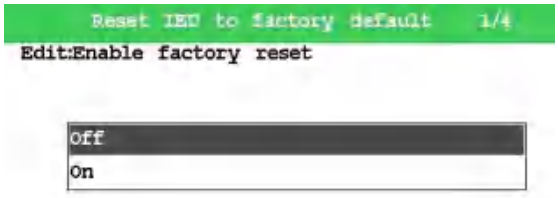
1. From the **main menu**, move the focus to **General**, then press the OK key to enter the submenu.
2. Select **Cybersecurity** option and press the OK key.



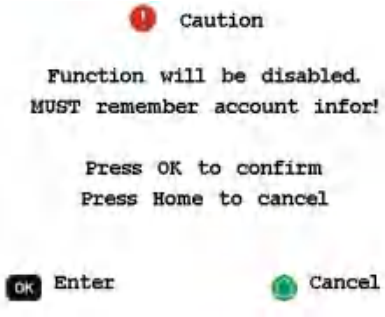
3. On **Reset IED to factory default** screen, press the OK key.



4. Press the OK key, then press the △ key to select **off**, press OK key after.



A caution message will be pop-outed with warning that the factory reset function will be disabled and account information must be remembered.



5. Press the OK key to confirm.
Now the **Enable factory reset** setting is set to *Off*.



Login and logout

Basic CS level comes with three fixed user accounts. Users cannot change name of those accounts. The available access interfaces for the three user accounts are as follows:

Table 36 - Accessible interfaces for user accounts of Basic CS level

User account	Role	Web HMI	Device HMI	Easergy Pro	SSH
OperatorLevel	OPERATOR	Y	Y	Y	Y
EngineerLevel	ENGINEER	Y	Y	Y	Y
InstallerLevel	INSTALLER	Y	Y	Y	Y

Advanced CS level allows user to manage user accounts and assign roles for them. The available access interfaces for roles of Advanced CS level are as follows:

Table 37 - Accessible interfaces for user accounts of Advanced CS level

Role	Web HMI	Device HMI	Easergy Pro	SSH	CAE
OPERATOR	Y	Y	Y	Y	N
ENGINEER	Y	Y	Y	Y	N
INSTALLER	Y	Y	Y	Y	N
SECAUD	Y	Y	N	N	Y (only for retrieving logs)
SECADM	N	N	N	N	Y

Login

- **Local HMI panel**: go to User Login menu from HMI main menu, then select account and enter password. Refer to Login and logout, page 235 for more information.
- **Easergy Pro software (via SSH)**: refer to Connecting to a single protection relay using USB cable, page 246 or Connecting to protection relays via Ethernet, page 246 for more information.
- **Web HMI (via HTTPS)**: Web HMI feature is disabled by default. Before use, it must be enabled in Communication menu by selecting the Ethernet port for HTTPS server. Refer to the communication user manual, search for “HTTPS server” for more information.
- **CAE (via HTTPS, only for Advanced CS level)** : only a Security Admin role (SECADM) can login to a CAE project.

Logout

For security reasons, it is recommended to logout after any operation on the PowerLogic P5 protection relay.

On the main menu screen, Login screen and Mimic screen, a padlock icon is presented at top-right corner of the title bar to signify that there is no user logged in to PowerLogic P5 protection relay. The padlock icon disappears when any user logs in.

Basic CS level setting

For Basic CS level, the cybersecurity rules setting is straightforward:

1. The device is provided with three hardcoded account names and the names cannot be changed. Only the passwords can be changed.
2. To change the passwords, there is no need of any software including CAE nor eSetup Easergy Pro, all settings can be done (and can only be done) from the PowerLogic P5 HMI.

Default settings

Basic CS level comes with three fixed user accounts. CS rules are as follows:

Table 38 - Accessible interfaces for user accounts of Basic CS level

User account	Role	Default password	Login session timeout (min)	Maximum login attempts	Password attempts timer (min)	User account locking duration (s)	Password complexity
OperatorLevel	OPERATOR	AAAA	15	5	3	240	Not required
EngineerLevel	ENGINEER	AAAA					
InstallerLevel	INSTALLER	AAAA					

The name of user account cannot be changed. Rights of account cannot be modified from default ones as specified in above table. By default, the eSetup Easergy Pro and the P5 local HMI support maximum five consecutive failed login attempts. Once exceed the attempts, you have to wait for 240 seconds to unlock. Password attempts timer means the login attempts counter is reset after entering the passwords. The login will expire after 15 minutes of inactivity.

NOTE:

- It is strongly recommended to change default passwords of all accounts before PowerLogic P5 is put to operation.
- More information about the definition of user account parameters, refer to EcoStruxure™ Cybersecurity Admin Expert User Manual.

Changing password

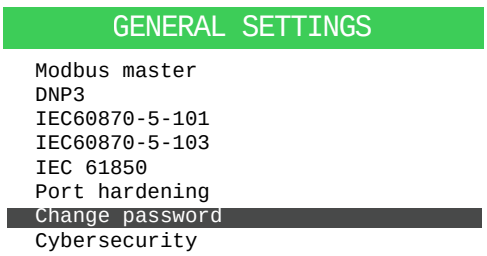
For Basic CS level, the length of the password is 1 to 8 ASCII characters [33 to 122].

The scope of the rights of changing password for the three accounts are:

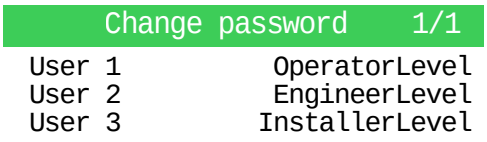
- InstallerLevel can change password for self, OperatorLevel and EngineerLevel.
- EngineerLevel can change password for self and OperatorLevel.
- OperatorLevel can change password only for self.

The password change is managed directly via the device local HMI as the following procedures:

1. Login to device by entering password. If the auto-login feature is still active, then the device is already logged in with InstallerLevel account.
2. Enter the **GENERAL SETTINGS** menu and select **Change password** option.



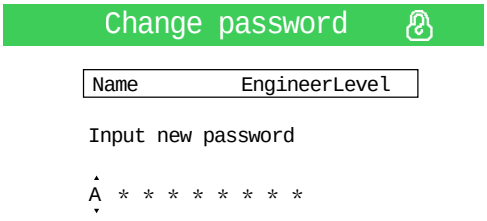
3. Select user.



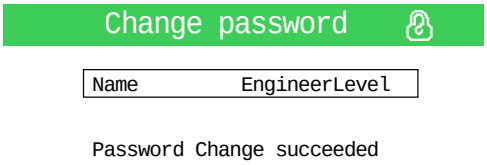
NOTE:

- The user cannot select another user with a higher access right in order to change the password for that user. A “Permission denied” message will appear on the screen.
- The user can select another user with a lower access right in order to change the password for that user. This is useful and convenient for changing password for other users when they have lost their passwords.

4. Enter new password and then enter once again to confirm.



5. A “Password Change succeeded” message will be displayed on screen.



Special access control

Only for Basic CS level, PowerLogic P5 protection relay provides special access functions to further simplify commissioning with HMI and to enhance security:

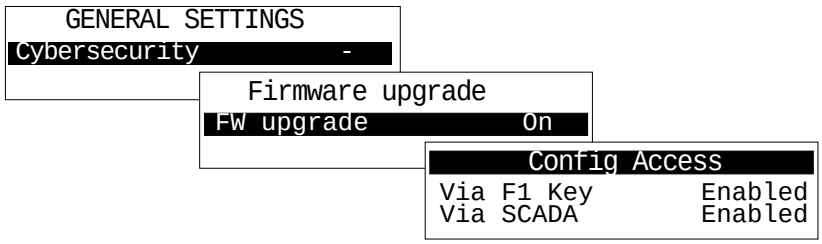
1. **Via F1 key** can be used to switch the protection relay temporarily into a mode in which the device is opened for setting change via LHMI without request of authentication.
2. **Via SCADA** can be used to switch the protection relay between local/remote modes. Therefore, once the device is set to local mode all remote setting change requests and control commands will be rejected.

PowerLogic P5 protection relay provides special access functions:

- **F1 key access control**: while “Via F1 key” disabled, F1 key works as normal function key. When “Via F1 key” is enabled. PowerLogic P5 can be switched between locked and unlocked states with F1 key. In locked state, all settings of the device become read-only, the front USB communication port is disabled, too. In unlocked state, settings of PowerLogic P5 become modifiable, settings can be modified via local panel HMI directly without username and password, front USB communication port also gets enabled. Please note that login is still required when using Easergy Pro and Web HMI in unlocked state. By setting PowerLogic P5 to unlocked state, it will bring convenience for users to configure the device during commissioning.
- **Communication SCADA access control**: the setting “Via SCADA” provides option to forbid any setting change and control command from SCADA communication protocols (Modbus, IEC61850, IEC103). If the setting is set to disabled, PowerLogic P5 rejects all SCADA protocol setting changes and control commands. However, this setting will not effect on local panel HMI, front USB communication port, eSetup Easergy Pro and Web HMI.

The settings “Via F1 Key” and “Via SCADA” can be configured from local panel HMI. This special access control is operational in Basic Cybersecurity level only.

Figure 158 - Config access Via F1 Key and Via SCADA shown on HMI



F1 key access control

PowerLogic P5 can be switched between lock/unlock states by F1 key.

NOTICE

IMPROPER EQUIPMENT OPERATION

If F1 key is configured as the quick switch of PowerLogic P5 lock/unlock, it will be not available for other functions.

Failure to follow these instructions can result in improper operation.

Table 39 - Via F1 Key configuration parameters

Via F1 Key			
	Disabled[34]	Enabled	
		Locked	Unlocked
Access via HMI	Read/Write	Read	Read/Write
Access via USB (Easergy Pro)	Read/Write	Cannot login	Read/Write
Access via rear comms (Easergy Pro)	Read/Write	Read	Read/Write
Access via rear comms (Web HMI)	Read/Write	Read	Read/Write

Communication SCADA access control

For communication SCADA (Modbus, IEC 61850, IEC 103), when “Via SCADA” is disabled, setting change or control command are disabled for PowerLogic P5, whether in locked or unlocked state, with or without communication board.

Table 40 - Via SCADA configuration parameters

Via SCADA		
	Disabled	Enabled
Access via rear comms SCADA (IEC 61850)	Read	Read/Write
Access via rear comms SCADA (Modbus)	Read	Read/Write
Access via rear comms SCADA (IEC 103)	Read	Read/Write

34. When F1 key is disabled which means it is used as a normal function key, the read/write permission is decided by existing RBAC setting.

Auto log-out

While “Via F1 Key” is enabled, PowerLogic P5 will be switched to locked state automatically in below conditions, which is called “auto log-out”:

- if PowerLogic P5 is not connected with Easergy Pro, nor with WebHMI, and without any operation on HMI for 3 minutes;
- if PowerLogic P5 is disconnected from Easergy Pro for 3 minutes;
- if PowerLogic P5 is disconnected from WebHMI for 18 minutes.

Table 41 - Login requirements and auto log-out time out

Access	Login required	Auto log-out time out		
		If without operation	If log out	If disconnected without log out
via HMI	No	3 minutes	N/A	N/A
via rear comms (Easergy Pro)	Yes	Depends on “Automatic Disconnection” setting in Easergy Pro	3 minutes	3 minutes
via rear comms (Web HMI)	Yes	Never	3 minutes	18 minutes[35]

As long as connected with Easergy Pro or WebHMI, PowerLogic P5 will not be switched to locked state.

Advanced CS level setting

With Advanced CS level, all PowerLogic P5 security rules are managed with Cybersecurity Admin Expert (CAE) software.

Please be advised that CAE offers an independent user manual which describes its function in a higher detailed level, which can be downloaded from website of Schneider Electric in more detail.

The purpose of describing CAE software in this manual is to help PowerLogic P5 users start with the Advanced CS level configuration without having to read the complete CAE user manual. For this reason, only basic operations of the software will be described. For a thorough understanding of the CAE functions, please refer to CAE user manual.

Before configuring with CAE, PowerLogic P5 device of Advanced CS level is equipped with default security settings.

Default settings

When delivered from the factory, PowerLogic P5 Advanced CS level will be equipped with following settings:

Table 42 - Accessible interfaces for user accounts of Advanced CS level

User account	Role	Default password	Login session timeout (min)	Maximum login attempts	Password attempts timer (min)	User account locking duration (s)	Password complexity
OperatorLevel	OPERATOR	AAAA	15	5	3	240	Not required
EngineerLevel	ENGINEER	AAAA					
InstallerLevel	INSTALLER	AAAA					
SecurityAdmin	SECADM	AAAAAAAA					

35. It is proposed to click on “Logout” button at top right of WebHMI before closing the web browser, the auto log-out will be launched in 3 minutes.

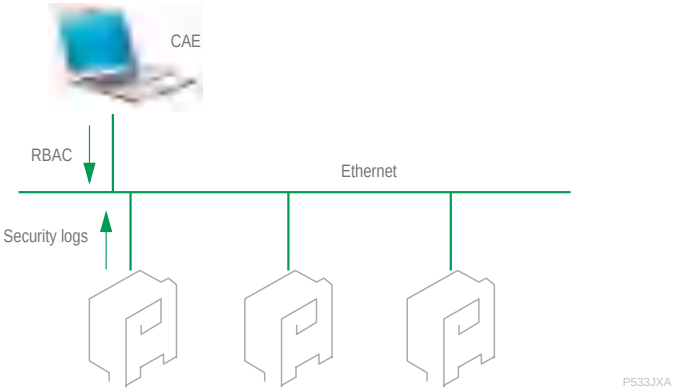
By default, the eSetup Easergy Pro and the P5 local HMI support maximum five consecutive failed login attempts. Once exceed the attempts, you have to wait for 240 seconds to unlock. Password attempts timer means the login attempts counter is reset after entering the passwords. The login will expire after 15 minutes of inactivity.

More information about the definition of user account parameters, refer to EcoStruxure™ Cybersecurity Admin Expert User Manual.

Introduction of CAE software

CAE allows users to centrally update usernames and passwords for all PowerLogic P5 devices in the same local area network without having to do it bay-by-bay. It can customize the rights of user roles and user accounts. More advanced features of CAE include configuring the Syslog server, extracting locally saved security logs from PowerLogic P5 devices, and centralized authentication over RADIUS/LDAP protocol with a Microsoft Active Directory as the back end.

NOTE: CAE projects can be only opened and edited by SECADM (Security Administrator) accounts.



System requirements

CAE is a software with no requirement of license nor cost. It can be downloaded for free from Schneider Electric's website.

CAE runs in Windows® 10 Professional version 32/64 bit.

Administrator's privilege is required to install CAE application components to Windows. After installed, non-administrator users will be also able to use the software.

To connect and manage PowerLogic P5 devices with CAE, the computer with CAE shall be in the same local area network with the devices.

CAE download and install

Go to https://www.se.com/ww/en/all-products and search for Cybersecurity Admin Expert to find the product page of CAE, click to enter product page.

Figure 159 - Product page of CAE



Click **See software** to choose package between x86 and x64 versions according to operating system of the computer to install CAE. The latest version of CAE at the time when this chapter was written is 2.2.1.2304.

NOTE: CAE only runs in Window 10. It will not run in Windows 7.

After downloading the installation package, unzip the package and run the **Cybersecurity Admin Expert Installer.exe** file to install. The files in folder ISSetupPrerequisites will be installed automatically.

Changing initial password

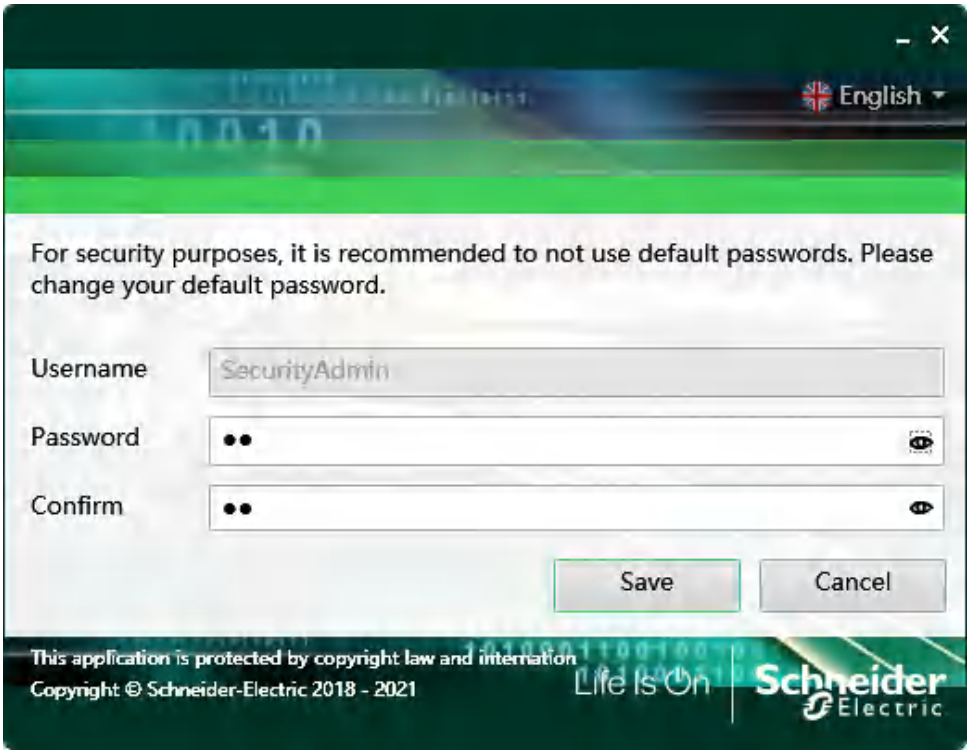
When launching CAE for the first time it will prompt for a username and password. The default username is *SecurityAdmin* with default password: AAAAAAAA. The username and password are both case sensitive.

Figure 160 - Initial password of CAE



Account will be locked if password is entered incorrectly up to 5 times. If this is the only SECADM account of a project, a few minutes of waiting is obliged before any further attempts with the same account. Alternatively, the blocked account can be unblocked with another SECADM account immediately by using it to open the project. Once the project is opened, all blocks of SECADM accounts will be cancelled immediately.

After correctly entering the default username and password, CAE will ask for the default password of the SecurityAdmin account to be changed.

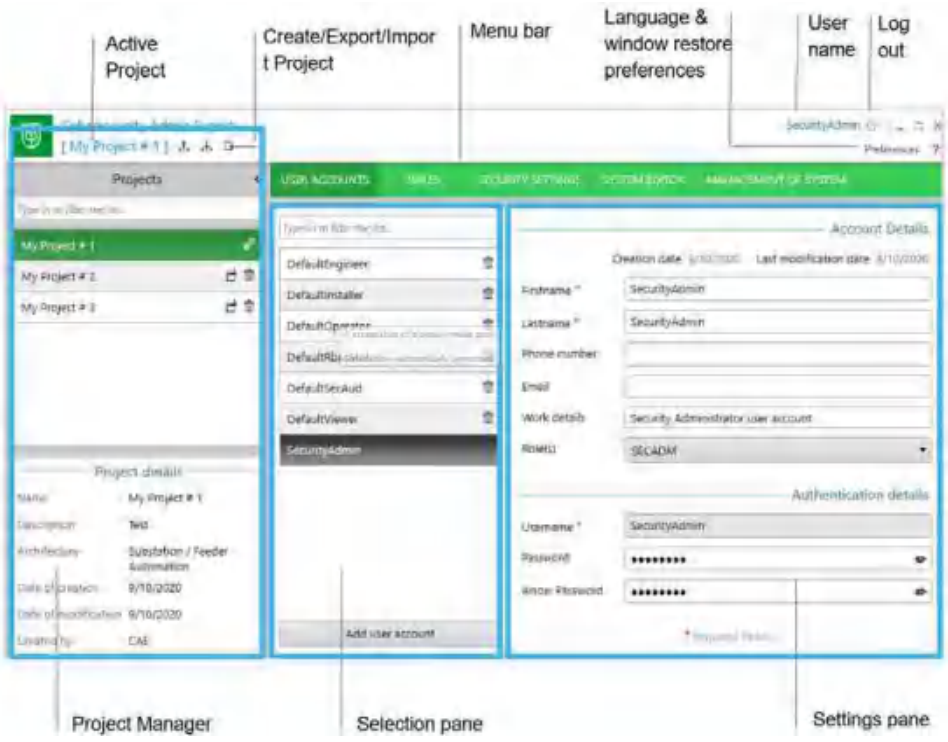


There is no password complexity requirement for a new project. When entering password input, you can click and hold the icon of eye to verify input.

CAE user interface overview

Cybersecurity Admin Expert (CAE) user interface window is composed of three main work areas:

1. Project Manager pane at left
2. Selection pane in the center
3. Settings pane at right



- **Menu Bar**: From the menu bar user can select required function. The organization of functions follows a typical configuration workflow, however, user can jump from one to another.

- **Preferences**: Click to choose language and activate/deactivate window restore preferences.
- **Username**: Logged in username is displayed in this area.
- **Log out**: To log out from the application, click on the power **on/off** icon.
- **Help**: click **?** icon then **Audit Logs** to see CAE application logs.
- **Create/Export/Import**: Use those buttons to create, export or import CAE security configuration project database.

Most of the CAE functions can be used without connection to PowerLogic P5 devices. Connection with devices in the same local area network is only required when using function of **MANAGEMENT OF SYSTEM** for pushing new CS rules to devices.

CAE functions are grouped in the following menu bars:



- **USER ACCOUNTS**: the functions for account edit such as create, rename, remove account, change password of account, and assign accounts to roles. Please note that one user account can be assigned to multiple roles. This user account will then have the rights of all corresponding roles combined.
- **ROLES**: edit PowerLogic P5 user roles and rights. User's rights are decided by the roles the user accounts are assigned to.
- **SECURITY SETTINGS**: set miscellaneous security-related features, such as session time out duration, password complexity requirement, Syslog server, account locking.
- **SYSTEM EDITOR**: list the discovered protection relays so that CAE can push new CS settings to the devices. Please note that PowerLogic P5 devices can be discovered automatically by CAE, since PowerLogic P5 supports DPWS and UDP. Therefore declaring of devices is optional. For devices that do not support UDP they must be added to the list otherwise CAE cannot find them.
- **MANAGEMENT OF SYSTEM**: discover PowerLogic P5 devices so that new CS settings can be pushed.

CAE recommended workflow

The CS rules of devices are managed with CAE by projects. Each project contains a set of roles and user accounts, with various security-related settings. The project can be worked offline, meaning there is no need to connect to PowerLogic P5 devices when changing the settings. When offline work is done, CAE can be connected to devices and push the project settings to them.

NOTE: changing CS rules with CAE is a one-direction process. It means new settings can be pushed from CAE to PowerLogic P5, but existing CS settings cannot be pushed back to CAE.

The recommended workflow with CAE for PowerLogic P5 is as follows:

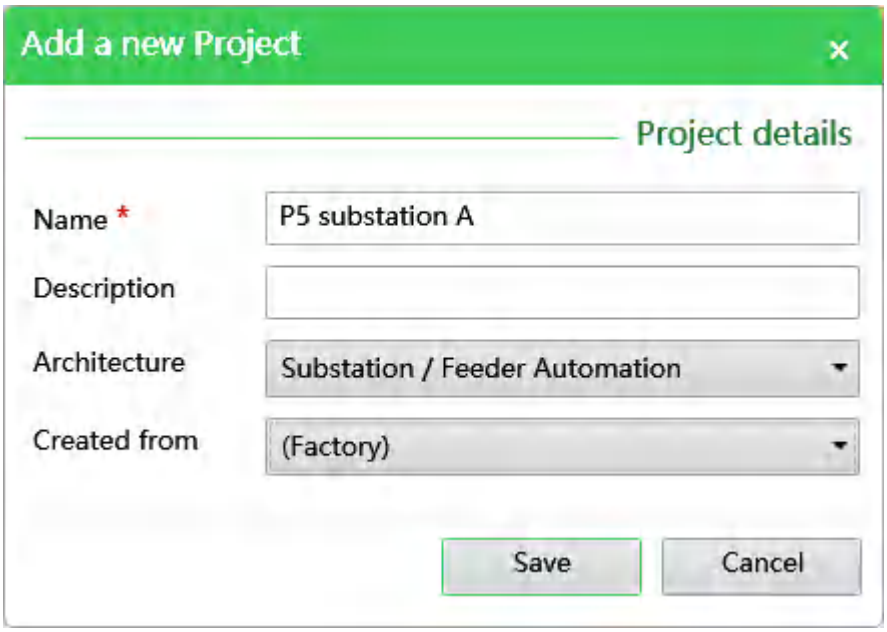
1. Manage the project: use the Project manager to open an existing CAE project or to create a new one.
2. Manage the user accounts: go to USER ACCOUNTS menu to create/remove/modify user accounts, assign roles to the accounts, and set passwords for accounts.
3. Manage the roles: go to ROLES menu to check whether the default rights of roles are in line with your organization cybersecurity policy. Rights can be changed for existing roles. New roles can be created. Existing roles can be removed.
4. Manage other security settings: go to SECURITY SETTINGS menu to set options including timeout, user account locking, password complexity, Syslog server, Security banners, and centralized authentication methods.

5. Define the devices: go to SYSTEM EDITOR to provide IP addresses of devices to CAE to let CAE connect with them. This step is optional for PowerLogic P5 because CAE can discover PowerLogic P5 devices automatically via DPWS and UDP.
6. Prepare the connection between computer with CAE and PowerLogic P5 device: CAE can connect with PowerLogic P5 through Ethernet and the front USB port. To connect through Ethernet connection make sure the computer with CAE is in the same local area network with PowerLogic P5 devices to be managed. Ensure quality of connection by USB cable if connect with front USB port. Use only one type of connection at a time.
7. Push new CS rules to PowerLogic P5: go to MANAGEMENT OF SYSTEM, use discover function to automatically find all PowerLogic P5 devices, and push new CS rules to them.

CAE menu: Projects

Click **Create a new project** button to create new project.

Example settings are as follows:



Selection in **Architecture** will impact the Security Settings menu which will be described in CAE menu: Security settings, page 208.

If the selection *Factory* is selected in **Created from** setting, the default CAE template will be used. Alternatively, it can be created from one of existing projects.

Click **Save** to save the project. Then double-click the new project in the project manager pane to switch to the project. CAE will ask for authentication upon opening the new project.

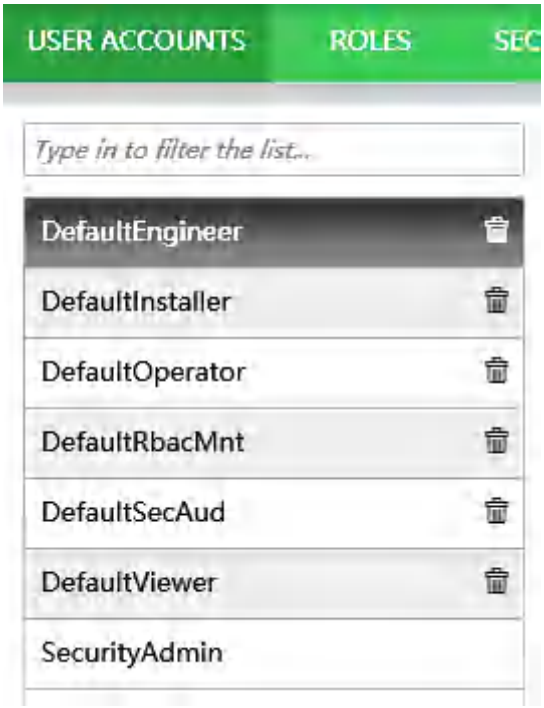
Use the account name *SecurityAdmin* and default password “AAAAAAAA” to login. CAE will then force changing of the initial password. There is no password complexity requirement for a new project.

After the password of SecurityAdmin has been changed, the project will be loaded with CAE default template settings if *Factory* is chosen to create the project from.

NOTE: CAE projects can only be opened by accounts of SECADM (Security Administrator) role.

CAE menu: User accounts

The default user accounts for any new project created from *Factory* template are as follows:



It is advised to delete the “DefaultRbacMnt” account, because this role is not supported by default in PowerLogic P5’s roles template.

New created accounts can be assigned with roles. Each account can be assigned with multiple roles. It will then get the rights of all the assigned roles combined. The “Username” is the account name which will be used for authentication.

The default alphanumeric password for all user accounts is “AAAAAAAA”.

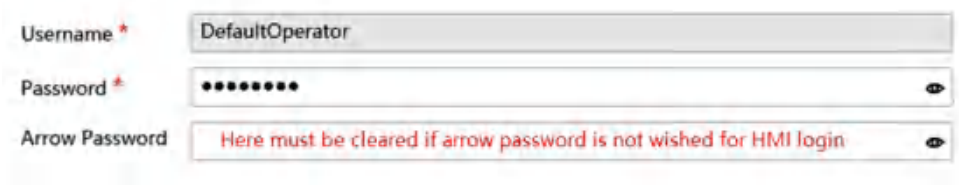
The arrow password facilitates operation of password input on the device HMI with arrow buttons.

Default passwords for all default accounts are as follows.

Table 43 - Default CAE alphanumeric and arrow passwords for PowerLogic P5

Account name	Role	Alphanumeric password	Arrow password
DefaultEngineer	ENGINEER	AAAAAAAA	↓←↑→↓←↑→ (then press OK key)
DefaultInstaller	INSTALLER		
DefaultOperator	OPERATOR		
DefaultSecAud	SECAUD		
DefaultViewer	VIEWER		
SecurityAdmin	SECADM		

If the arrow password is set in CAE, the PowerLogic P5 always prompts this authentication mode in the local HMI. If the feature is not required, please make sure to clear the arrow password for all the accounts as shown in below example.



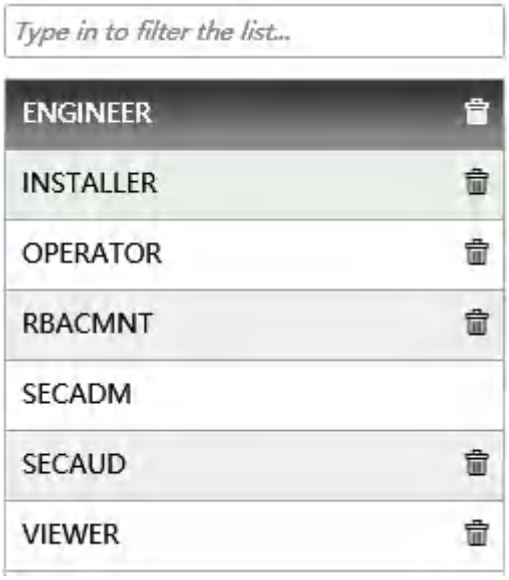
Alphanumeric password will always be asked for authentication requests from Easergy Pro and Web HMI.

NOTE:

1. It is strongly recommended to change the default passwords for all accounts before PowerLogic P5 is put to operation.
2. It is strongly recommended to create a 2nd user account assigned with SECADM role, so that in case of SecurityAdmin password lost, the 2nd SECADM account can be used to open the CAE project and recover passwords.
3. In case of managing multiple CAE projects in parallel, keep at least one SECADM account with the same password in all projects, so that to switch easily between CAE projects.
4. SecurityAdmin is the account with a hardcoded username for all CAE projects as well as for the devices. The username cannot be changed or deleted. Other roles cannot be assigned to this account (except SECADM).
5. Make sure to save changes for each account.

CAE menu: Roles

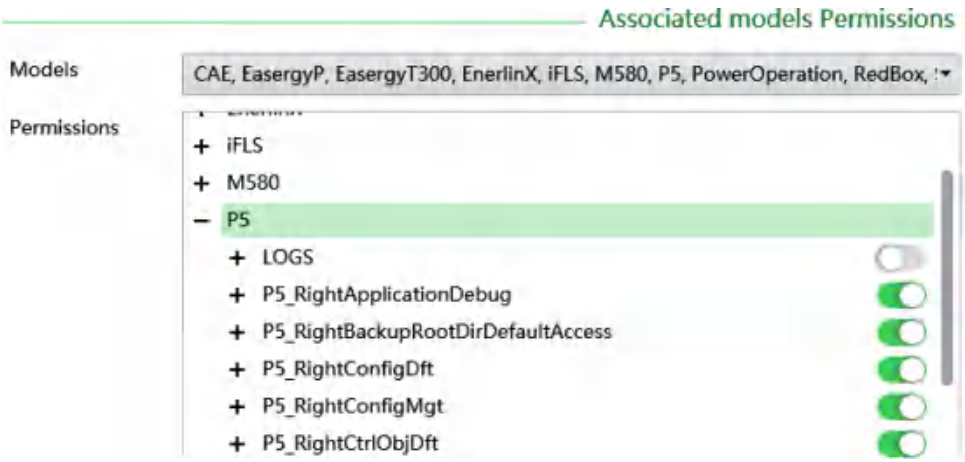
The default roles for CAE projects are as follows:



It is recommended to remove the role RBACMNT unless it is absolutely needed.

The rights of existing roles can be modified in the **Role Details** fields. Please note that CAE is designed to manage CS rules for multiple Schneider Electric products. To modify rights of PowerLogic P5, please click on the **+** sign at left of **P5** and leave the other products.

NOTE: the setting **EasergyP** is not for PowerLogic P5.



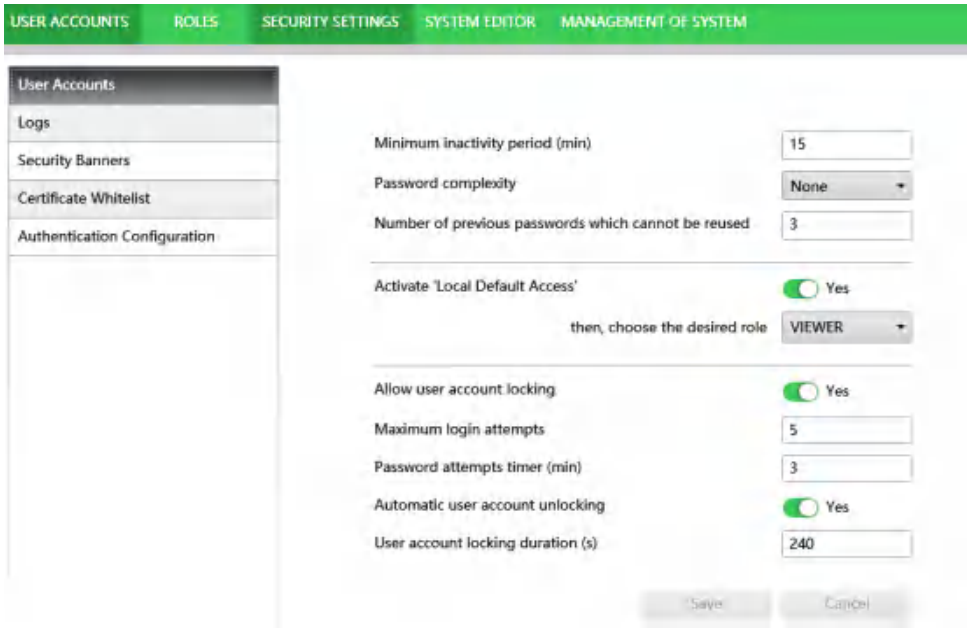
New roles can be added as needed.

CAE menu: Security settings

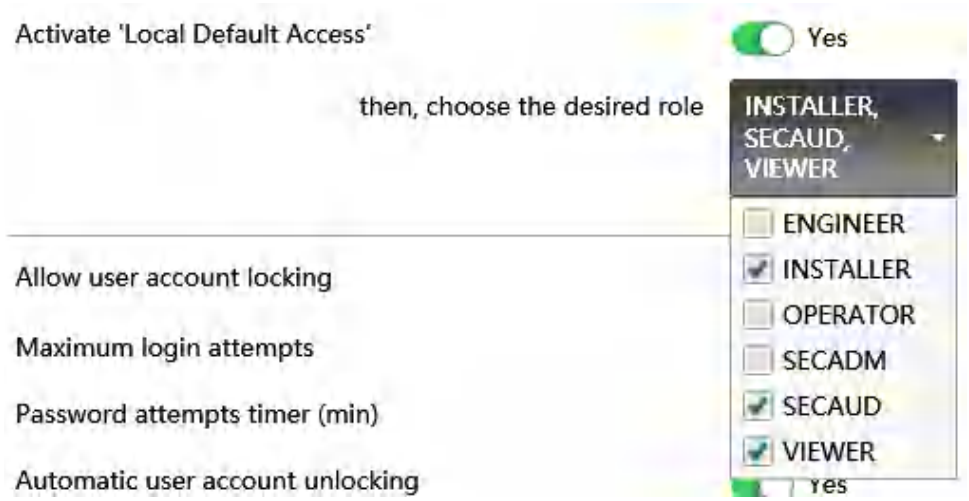
The functions in this menu make settings of various security parameters.

User Accounts

CAE is delivered with default security parameters as follows:



To facilitate operation and setting via local HMI, **Activate 'Local Default Access'** can be set to *Yes* to automatically grant selected rights of the role. Anyone who can access to the PowerLogic P5 local HMI will have the rights of the roles assigned with *'Local Default Access'*. The default setting is VIEWER, but it can be extended to multiple ROLES if needed as follows:



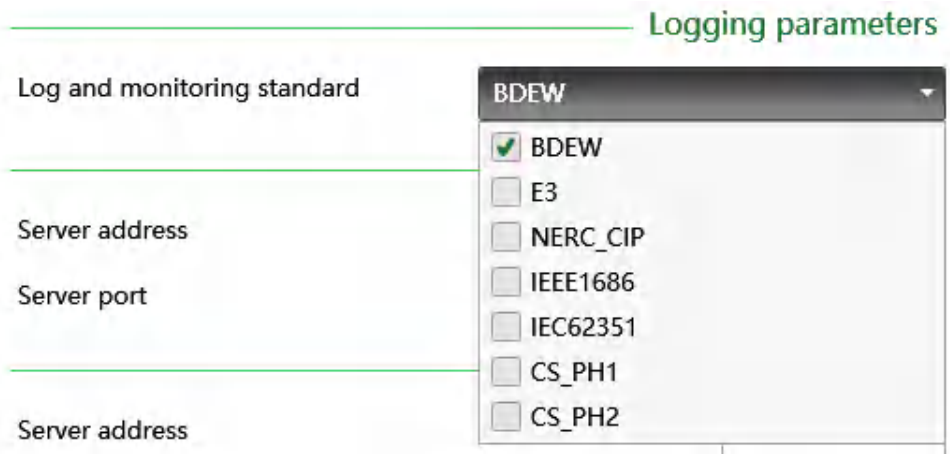
Please note that the *'Local Default Access'* option is only available for Substation / Feeder Automation architecture.

NOTE: The setting of project architecture will also impact the following options:

- **Allow user account locking**: can only be *YES* for Critical Power and Plant Automation.
- **Automatic user account unlocking**: can be only *YES* for Critical Power and Plant Automation.

Logs

- **Logging parameters**: no standard logging parameters were enabled when PowerLogic P5 was released from factory. It will not generate any security log before being managed with CAE. During creation of a new CAE project the default standard enabled by CAE is BDEW. PowerLogic P5 also supports security logs according to IEEE 1686 standards. For type of logs and which will be generated for both standards refer to Security event logging, page 222.

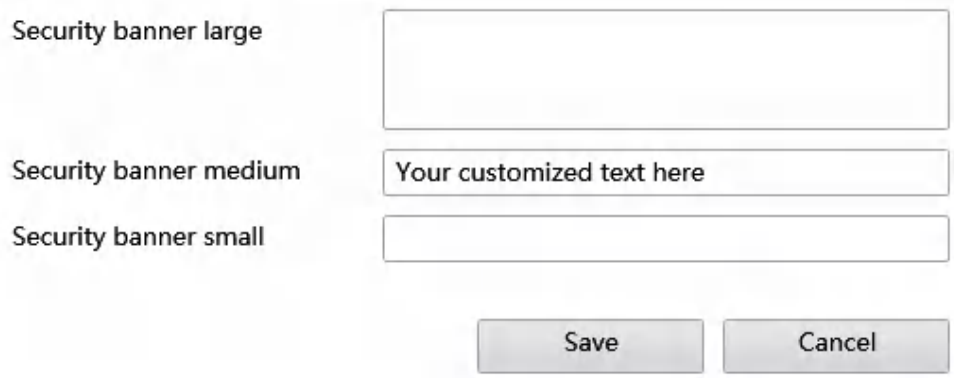


- **Syslog parameters**: input remote Syslog server address and port in this section. PowerLogic P5 will send all the internally generated security logs to the server for backup after address and port defined.
- **SNMP parameters**: the options shall not be used since PowerLogic P5 does not support SNMP.

Security Banners

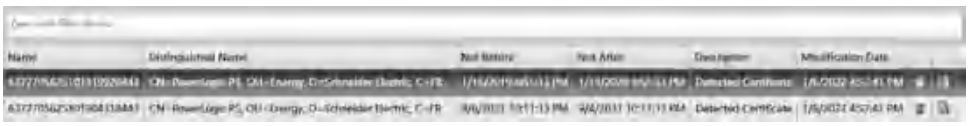
The security banners are warning messages displayed on the device HMI and Web HMI login interface for system use notification.

PowerLogic P5 will display *Authorized User Access Only* before authentication takes place in the device HMI and Web HMI. The displayed message can be customized in **Security banner medium** of CAE.



Certificate whitelist

PowerLogic P5 connects with CAE via HTTPs. PowerLogic P5 works as a server with device self-signed HTTPs certificate to help ensure the credentials and contents will not be transmitted in clear text.



During network discovery period, CAE discovers a new PowerLogic P5 device and makes connection. You will be prompted to add HTTPs certificate to the white list. Verify the validity of the certificate of the device. Select it, then click **Accept** to accept a new certificate of the device.

CAE menu: System editor

This function is optional for PowerLogic P5 because CAE can discover PowerLogic P5 devices in the same local area network automatically with Advanced CS level thanks to support of DPWS and UDP protocols.

NOTE: in rare occasions CAE may not discover all PowerLogic P5 devices in same network. In this case, declaring them will help CAE find them. Specifying the **Model** and **IP Address** is sufficient, leave the **Port** by default to *9867*. The remaining of information can be free text as follows:



After making the settings, CAE should be able to find the devices.

CAE menu: Management of system

After all Cybersecurity rules have been defined, the rules will be pushed to PowerLogic P5 devices.

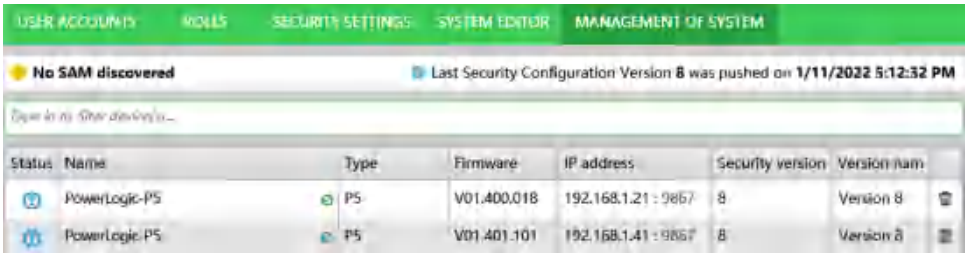
Connecting to PowerLogic P5 with CAE

CAE can connect to PowerLogic P5 via Ethernet or front USB port. To make Ethernet connection, ensure the computer with CAE is on the same local area network as the PowerLogic P5 devices to be managed. To connect through front USB port, ensure the connection quality of the USB cable between computer and PowerLogic P5.

It is recommended to use the PING command to verify the connection between PowerLogic P5 and computer with CAE when using an Ethernet connection to PowerLogic P5.

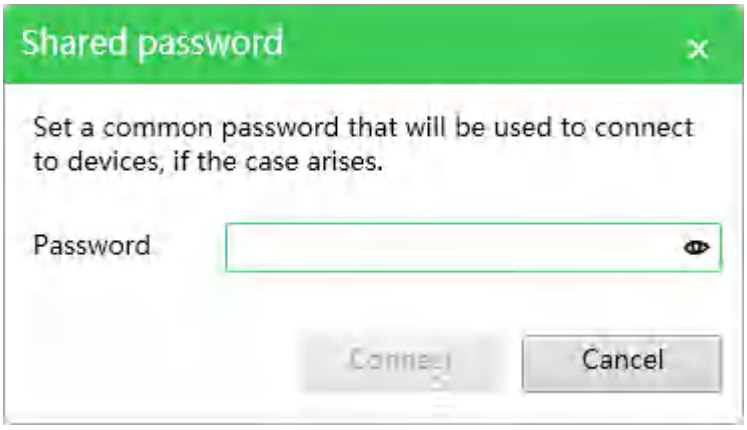
Push the new CS rules to PowerLogic P5

Click **Discover** button to find all PowerLogic P5 devices automatically in the same network as shown in image:



Click **Send security configuration** to push new CS rules to the devices.

NOTE: for PowerLogic P5 devices that have already been managed by a CAE project, the passwords of SecurityAdmin in P5 devices and the CAE project must be the same. It means if the password of SecurityAdmin of PowerLogic P5 is “ABCD”, the password of SecurityAdmin account in the CAE project must be also “ABCD”. Otherwise the user will be prompted to provide SecurityAdmin’s password. In that case the password “ABCD” must be entered to enable connection with PowerLogic P5 devices. As in image below:



As an example, if password of SecurityAdmin is changed to “EFGH”, CAE will attempt to connect with PowerLogic P5 devices with existing password “ABCD”. If it succeeds the new password “EFGH” will be pushed to PowerLogic P5 devices.

Please note that the new password and new security settings will be pushed to PowerLogic P5 devices only by clicking **Send security configuration** button again.

Retrieving PowerLogic P5 device internal security logs

Right click on PowerLogic P5 in the list of discovered devices to retrieve security logs saved internally to device. The duration of operation takes about 30 seconds.

PowerLogic P5 stores security logs in a non-volatile memory. If the memory is full, the oldest log is replaced by the newest one.

Centralized authentication

PowerLogic P5 supports centralized authentication via RADIUS and LDAP protocols, so that its user account and privilege management can be merged into an existing authentication infrastructure of the customer network. This means that the existing RADIUS server or Active Directory server in the customer network can also manage the user account and privilege for PowerLogic P5. Users can use their existing username for other devices in their network, such as other protection relays, network switches, workstations on PowerLogic P5. Once the account settings are changed at the RADIUS or LDAP server, all PowerLogic P5 devices will take account of the changes for user authentication and authorization.

Solution overview

Depending on the existing authentication mechanism used in your network, and the firmware version of the PowerLogic P5, different solutions are available:

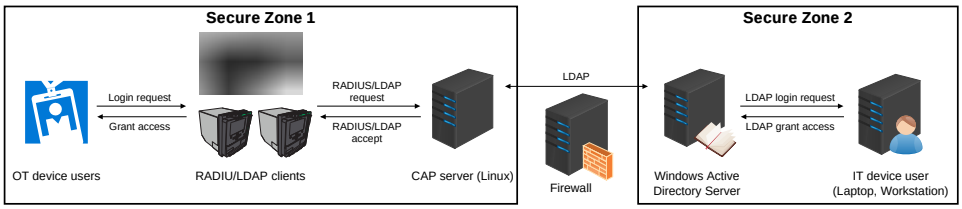
- If your existing authentication server is Microsoft Active Directory Server (referred to AD server hereinafter)
  - for the firmware version V01.500.101 and newer, you can connect to AD server directly, or with the Cybersecurity Application Platform (CAP) as a proxy. It is recommended to use the CAP as a proxy because it can simplify your firewall setup.
  - for the firmware version V01.402.201 and earlier, which only supports RADIUS, it is necessary to use the CAP as a proxy to connect to your AD server. This is because CAP can connect with the protection relay over RADIUS and connect with AD sever over LDAP.
- If your existing authentication server is RADIUS, the protection relay can be directly connected to the server
- We will use TekRADIUS as an example for connecting the protection relay and mapping the roles.

AD Server

If the existing authentication server is an AD server, it is recommended to use the CAP as a proxy to connect to the AD server. Using a CAP as a proxy can make firewall setup easier.

NOTE: The description of CAP in this document serves as a quick guide. For complete details on installing and using CAP, see the CAP documentation.

Figure 161 - Using the CAP as a proxy for connecting to the AD server

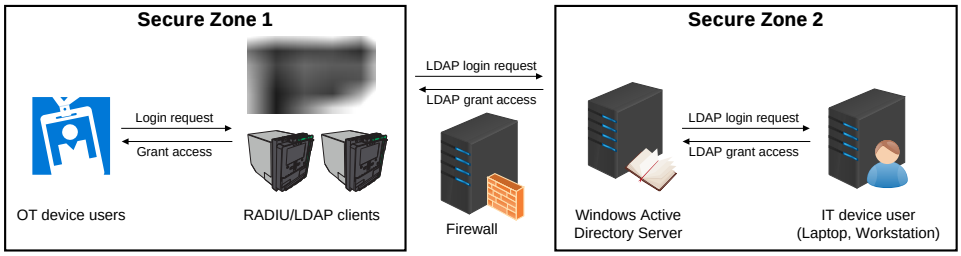


As shown above, the CAP server can be placed in Secure Zone 1 where PowerLogic P5 is located. Within the same zone there can be other devices such as RTUs, switches, and other protection relays. The firewall only needs to allow connection between the CAP server and the AD server, which makes the setup easier and more scalable.

NOTE: Secure Zone 1 is normally the most secure segment because it has OT devices which control the critical infrastructure devices such as circuit breakers and switches. Secure Zone 1 is more isolated than other network segments. Secure Zone 2 is the network used for information management services such as e-mail, file servers and Internet. Secure Zone 1 and 2 are isolated using firewalls and/or network diodes to ensure that the Secure Zone 1 is better secured.

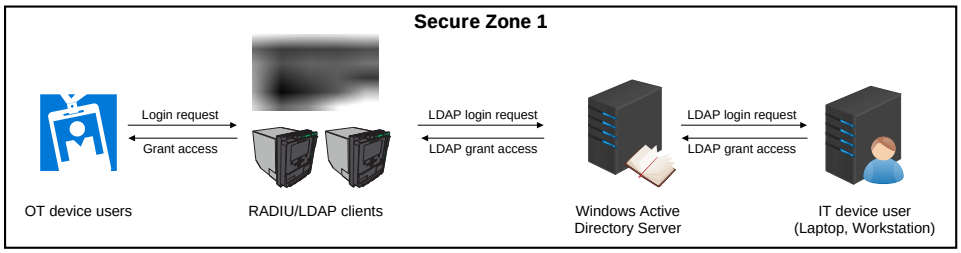
However, if using CAP is not wanted or possible, PowerLogic P5 can connect directly to the AD server with LDAP. In this case, the firewall needs to allow all PowerLogic P5 devices to connect to the AD server, as shown below.

Figure 162 - Direct connection between PowerLogic P5 and AD server, within two secure zones



Alternatively, if the AD server resides in the same Secure Zone with PowerLogic P5, there is no need to install the firewall, as shown below.

Figure 163 - Direct connection between PowerLogic P5 and AD server, within one secure zone



In the following sections, both connection methods between PowerLogic P5 and the AD server will be detailed, namely the indirect connection with CAP as the proxy, and the direct connection without CAP.

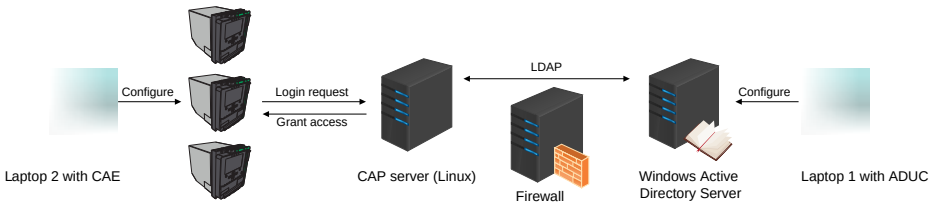
Again, it is recommended to use the CAP as the proxy if the AD server is not in the same Secure Zone as PowerLogic P5 as in Using the CAP as a proxy for connecting to the AD server, page 212.

The following items are required to carry out the configuration:

- A Microsoft Active Directory server. This is the central authentication server and the domain controller for your network. Windows Server 2019 was used when this document was written. Domain administrator privilege is required.
- A laptop with Active Directory Users and Computers (ADUC) installed. ADUC is the software to manage Active Directory objects, including users, computers, groups, organizational units (OU), and attributes. This laptop must be able to join the domain controlled by the above Windows server, for doing so the domain administrator privilege is required. This is “Laptop 1”.
- A laptop with CAE installed. With this laptop you can finish the PowerLogic P5 settings. Security Admin privilege to both the CAE project and to the PowerLogic P5 devices is required. There is no need for this laptop to join the above domain. This is “Laptop 2”. Note that you can also install CAE on your “Laptop 1” and to use only one laptop.
- A configured CAP server. For installation and configuration of the CAP server, see the CAP documentation. Administrative privilege to the CAP server is required.
- PowerLogic P5 devices in the Advanced CS mode.

When the above is all set as depicted in the following figure, the configuration can take place.

Figure 164 - Required devices and software for Indirect connection to AD server with CAP



The configuration consists of 2 or 3 steps, namely:

1. Configuration at the AD server end: this ensures that the user account is created and assigned to the user groups.
2. Configuration of the RADIUS server at the CAP end: it is only needed for older versions of PowerLogic P5. For newer versions it is not needed because LDAP can be used between PowerLogic P5 devices and the CAP.
3. Configuration at the PowerLogic P5 end: to map between user groups in the AD server and user roles in PowerLogic P5 devices.

We will use an example to walk you through.

In this example, a new user Alice WANG will be created in the AD sever. She belongs to the user group “Relay Engineer” in the domain controlled by that AD server. She should have the “ENGINEER” role privilege for the PowerLogic P5 devices.

Configuration at the AD server

In this step we will add a user and assign it to a user group in the AD server.

Use Laptop 1 to open the ADUC to connect to the AD server.

Create the user

Create a new user in the designated OU, here we use the OU “VALIDATION” as an example. The OU name “VALIDATION” and the domain “val.ctc.se.com” will be needed again in Assign user to group(s), page 215.

In ADUC (**Active Directory Users and Computers**), expand the domain *val.ctc.se.com*, right click on the OU *VALIDATION*, then click on **New/User** on the pop-up menu.

The new user is to be created with the detailed information as below:

- **First name**: Alice
- **Last name**: Wang
- **Full name**: AWang
- **User logon name**: Alice Wang
- **User logon name (pre-Windows 2000)**: Alice Wang

Note that the full name “AWang” is the username to be used for authentication at PowerLogic P5 end.

After the input of the above information, click on **Next >** button to next page.

> **NOTE:** If the user is newly created, do not check the *User must change password at next logon* option, as there is no mechanism at PowerLogic P5 to change the password. If it is required to force the user to change the initial password then they will need to log in with a PC and change the initial password before they can authenticate with PowerLogic P5.

Create the group

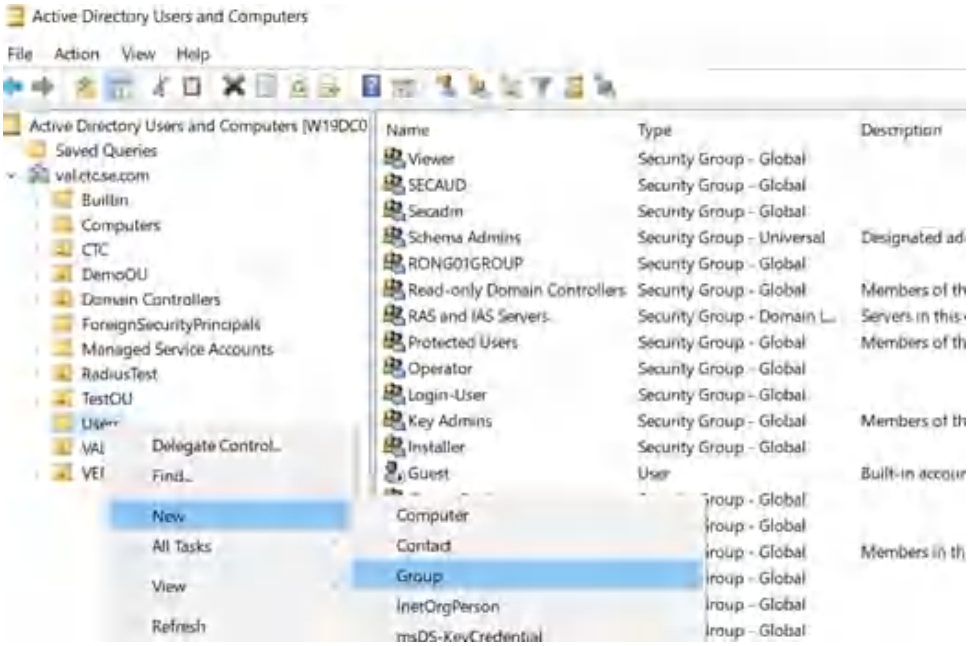
In ADUC, expand the domain *val.ctc.se.com*, right click on the Common Name (CN) *Users*, then click on **New/Group** on pop-up menu.

The new group is to be created with the detailed information as below:

- **Group name**: Relay Engineer
- **Group name (pre-Windows 2000)**: Relay Engineer
- **Group scope**: Global
- **Group type**: Security

Click **OK** button.

Figure 165 - Create the group in Users common name



Assign user to group(s)

Add the user “AWang” to the group “Relay Engineer” with the detailed information as below:

- **Select this object type**: Groups or Build-in security principals
- **From this location**: val.ctc.se.com
- **Enter the object names to select (examples)**: Relay Engineer

Click **OK** button.

If you want to assign the user to multiple groups, you can repeat the above step.

Configuration of the RADIUS server at CAP end

This step is only needed for older PowerLogic P5 versions which only have the RADIUS client. If your PowerLogic P5 version is V01.500.101 or later you can skip to the next section.

The setting at CAP end consists of two steps:

1. Mapping between AD groups and device roles
2. Setting the shared secret

Mapping between AD groups and device roles

Use the Laptop 1 to SSH into CAP with command:

ssh capuser@10.10.10.99 -p 4422

NOTE: capuser is the only username for managing CAP when the installation is completed. CAP will ask you the password for capuser.

After successful login, enter the following command to enter the CAP setting:

cap-config

When the CAP setting menu is displayed, navigate to the following item:

- **Configuration/Configure RADIUS/AD proxy/Edit user configuration file**

If you want to map the “ENGINEER” role in PowerLogic P5 to the “Relay Engineer” group in AD server, do the following:

- In the editor, for the user group “Relay Engineer” in common name “Users”, and domain “val.ctc.se.com”, add the following lines
  - DEFAULT Ldap-Group == “CN=Relay Engineer,CN=Users,DC=val,DC=ctc,DC=se,DC=com”

    Reply-Message = “ENGINEER”

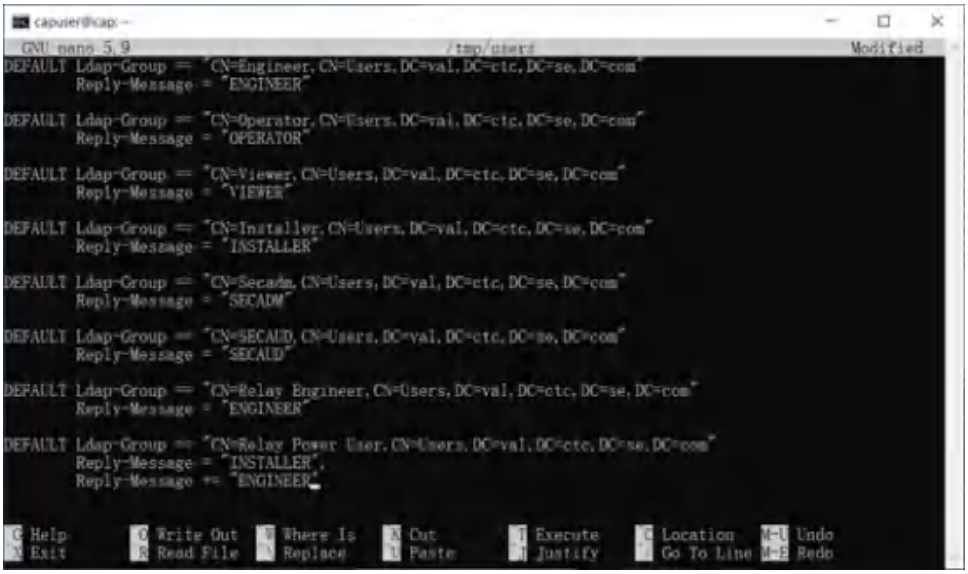
If you want to assign multiple roles in the PowerLogic P5 to one specific group in AD server, for example to map “INSTALLER” and “ENGINEER” roles to group “Relay Power User”, add the following lines:

- DEFAULT Ldap-Group == “CN=Relay Power User,CN=Users,DC=val,DC=ctc,DC=se,DC=com”

  Reply-Message = “INSTALLER”,

  Reply-Message += “ENGINEER”

Figure 166 - CAP server RADIUS configuration for mapping groups to roles



When the above modification is done, press **Ctrl + X**, then press **y** and **Enter** to confirm the modification and exit the nano editor with the changes saved.

The CAP will now restart the RADIUS service. To confirm the RADIUS service is successfully restarted, navigate to the following menu to check the logs:

- **Configuration/Configure RADIUS/AD proxy/Read logs**

The message “Ready to process requests” means that the RADIUS server has successfully restarted.

Setting the shared secret

The shared secret is a text string that serves as a password between the RADIUS client (PowerLogic P5) and the RADIUS server (CAP).

To set the shared secret, navigate to the following menu:

- **Configuration/Configure RADIUS/AD proxy/Edit clients configuration file**

Add the following lines to the file:

- client ctc-val-test {
  ipaddr = 10.10.10.0/24
  secret = Test*#12
  }

The client name can be any text as you want, as an example we have used “ctc-val-test” here.

The ipaddr shall be the network segment in which the PowerLogic P5 devices are located, with 24 being the length of the subnet mask, the specified network segment is 10.10.10.0 to 10.10.10.255 in this case.

Configuration at the PowerLogic P5 end

Open the CAE software installed on Laptop 2, go to the menu **SECURITY SETTINGS/Authentication Configuration**.

LDAP setting

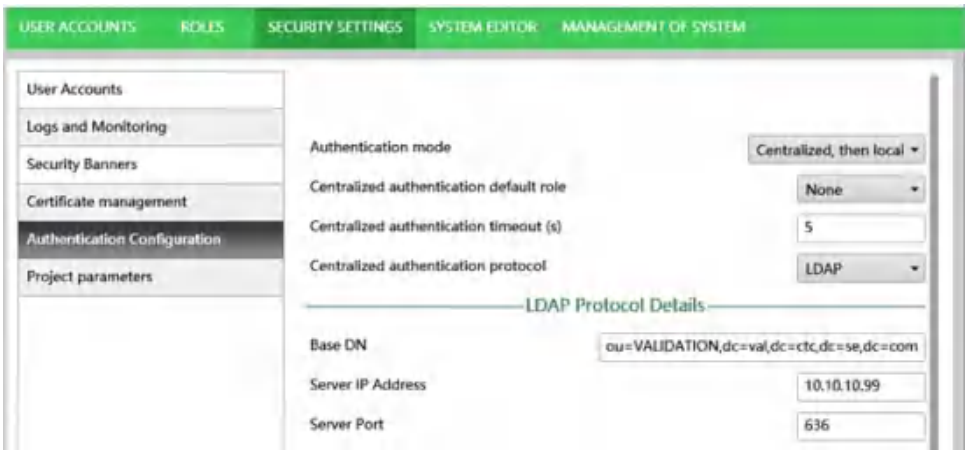
PowerLogic P5 versions later than V01.500.101 is equipped with an LDAP client thus it is recommended to use LDAP as it offers better security than RADIUS.

The LDAP protocol details for the setting are as following:

- In the section **LDAP Protocol Details**, for **Base DN**, for the OU *VALIDATION* and the domain *val.ctc.se.com* in this example, use value “ou=VALIDATION, dc=val,dc=ctc,dc=se,dc=com”.
- Value of input box **Server IP Address** and **Server Port**:
  - If you are using CAP as a proxy between PowerLogic P5 devices and the AD server, provide the proxy IP address and port number.
  - If PowerLogic P5 devices are connecting directly to the AD server, provide the AD server address and port number instead.

    NOTE: The port number depends on the type of protocol to be used. For detailed information about the port number and corresponding protocols please refer to the CAE and CAP documentation, and the setting of your AD server. PowerLogic P5 supports LDAP and LDAP + StartTLS protocols.

Figure 167 - LDAP setting in CAE



- To grant the ”ENGINEER” role privilege to the “Relay Engineer”, click **Add a new group** button, input name *Relay Engineer* in the text box above the button, and check *ENGINEER* in the list of **Role(s)**, then click **Add a new group** button again.

Figure 168 - Map one role to one group



- To grant the ”ENGINEER” and “INSTALLER” roles privilege to the “Relay Power User”, click **Add a new group** button, input name *Relay Power User* in the text box above the button, and check *ENGINEER* and *INSTALLER* roles in the list of **Role(s)**, then click **Add a new group** button again.

Figure 169 - Map multiple roles to one group



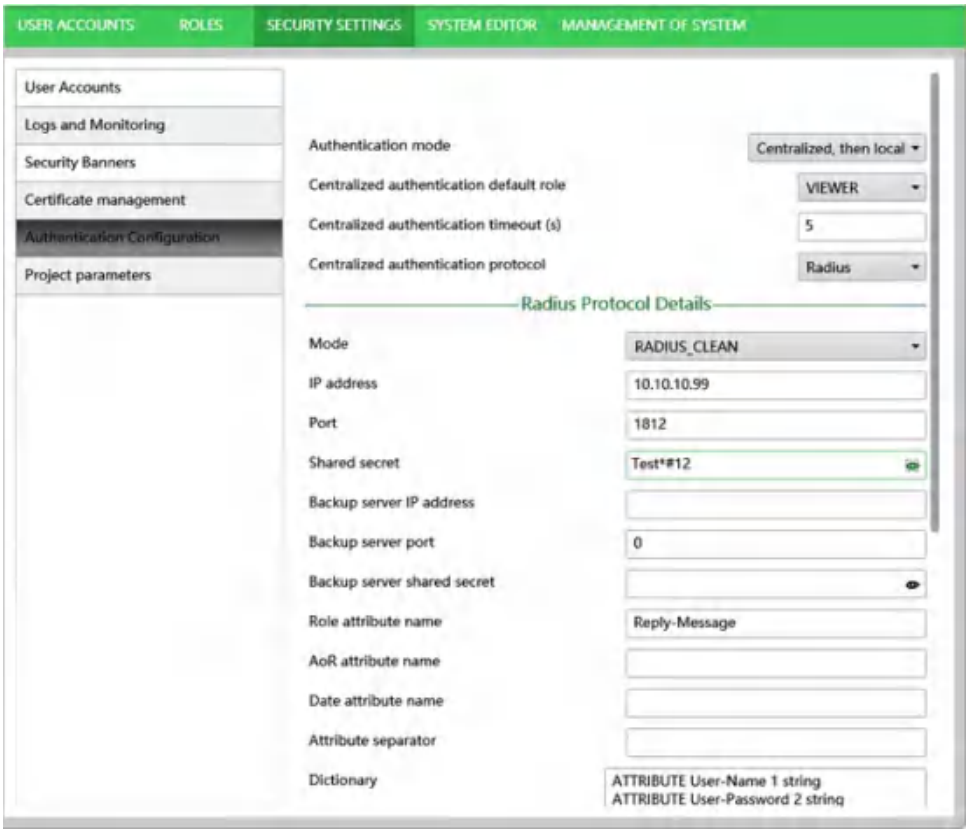
RADIUS setting

For older PowerLogic P5 versions, the only option is to connect to CAP over RADIUS.

Most of the settings can be left as defaults, except for the following in the section **LDAP Protocol Details**:

- **Shared secret**: it must be the same as set in the CAP server, which is “Test*#12” in this example.
- **Role attribute name**: it must be “Reply-Message”.
- **Mode** and **Port**: For details about the settings of Mode and Port, please refer to the CAE and CAP user documentation. PowerLogic P5 supports RADIUS_CLEAN and EAP_TTLS protocols.

Figure 170 - RADIUS setting in CAE for using CAP as proxy



Congratulations! After completing the above steps, user Alice WANG can use her credentials set by the AD server for PowerLogic P5 authentication and obtain the role privileges in device mapped to her user group in AD server accordingly.

RADIUS as existing authentication server

PowerLogic P5 can use a RADIUS server directly as the authentication server — no AD server or CAP server is required. The RADIUS server can be in the same secure zone with the PowerLogic P5 devices, as shown in RADIUS server in the same secure zone with PowerLogic P5, page 219. Or the RADIUS sever can be in another secure zone, and the firewall is set to allow the RADIUS protocol between the PowerLogic P5 devices and the RADIUS server, as shown in RADIUS server in a different secure zone with PowerLogic P5, page 220

Figure 171 - RADIUS server in the same secure zone with PowerLogic P5

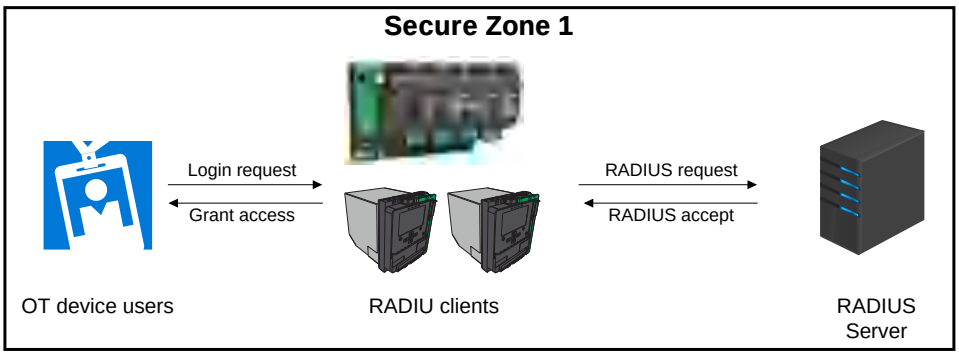
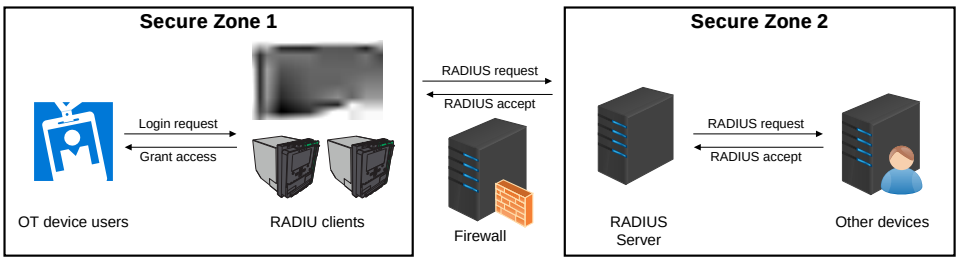


Figure 172 - RADIUS server in a different secure zone with PowerLogic P5



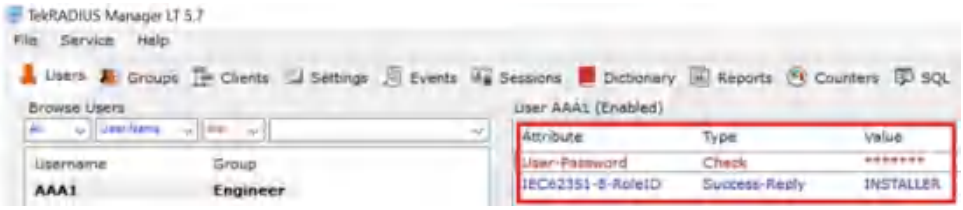
The configuration consists of 2 steps, namely:

1. Setting at the RADIUS server
2. Setting at the PowerLogic P5 end with CAE

Setting at the RADIUS sever

Using TekRADIUS as an example, the setting at the server end is as shown below.

Figure 173 - User role mapping in TekRADIUS server



On the left side you can find all the usernames and groups in the RADIUS server database. Note that the group “Engineer” here does not have any mapping relation with the roles in PowerLogic P5.

On the right side you can find the attributes for highlighted user. There are two attributes to be configured:

1. The first attribute specifies the password for user AAA1. The **Attribute** name shall be *User-Password*. The **Type** shall be *Check*. The **Value** contains the password.
2. To assign user AAA1 a role in PowerLogic P5, the 2nd attribute is needed. Its **Type** shall be *Success-Reply*. The **Attribute name** can be anything but must be the same as the Role attribute name setting in CAE. We use *IEC62351-8-RoleID* as an example. The role to be assigned to user AAA1 shall be entered in the Value field, which is *INSTALLER* in this example.

By providing the above two attributes, user AAA1 will get the INSTALLER role privilege in PowerLogic P5.

If you want to assign multiple roles to user AAA1, for example to assign “INSTALLER” and “ENGINEER” roles to AAA1, set the values of **Attribute** *IEC62351-8-RoleID* as *INSTALLER;ENGINEER* by repeating the sequence of operations above.

Figure 174 - Mapping multiple roles to TekRADIUS user

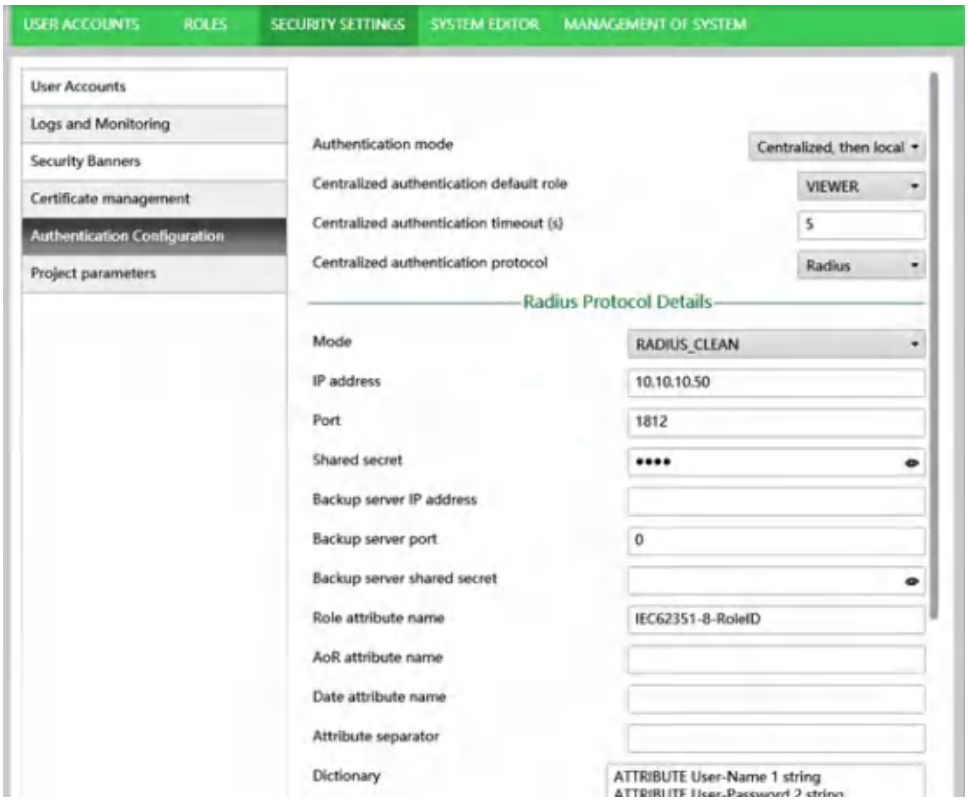


Setting at the PowerLogic P5 end with CAE

Open the CAE software, go to the menu **SECURITY SETTINGS/Authentication Configuration**. Choose *Radius* for **Centralized authentication protocol**. In the section of **Radius Protocol Details**, change the settings of the following items:

1. **Mode**, **IP address** and **Port number** of the TekRADIUS server: for details about the settings please refer to the CAE documentation and your RADIUS server setting. PowerLogic P5 supports RADIUS_CLEAN and EAP_TTLS
2. **Shared secret** needs to be the same as set in the TekRADIUS server.
3. **Role attribute name** must be the same as the TekRADIUS setting which is “IEC62351-8-RoleID” in this example

Figure 175 - CAE setting for RADIUS server



Now the user AAA1 can authenticate to PowerLogic P5 with the credential set in the TekRADIUS server and obtain accordingly the role privileges as specified in the TekRADIUS server.

Port hardening

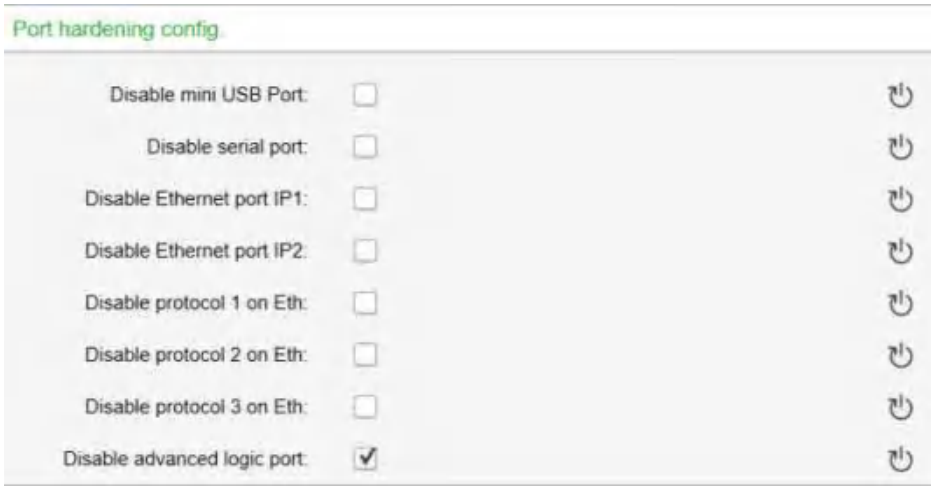
It is possible to disable PowerLogic P5 communication ports from the local panel, eSetup Easergy Pro, or web HMI with ENGINEER access right.

Physical ports which can be disabled:

- Front mini-USB port (for eSetup Easergy Pro connection)
- Rear serial port
- Rear Ethernet port

The figure below shows the Port Hardening Configuration settings in the Protocol Configuration view of the Communication menu in eSetup Easergy Pro:

Figure 176 - Port hardening configuration settings in eSetup Easergy Pro



The port hardening can also be set from the local panel through the **Port hardening** configuration view of the **General** menu.

When the ports or the protocols on the Ethernet module are disabled or enabled, reboot of the PowerLogic P5 protection relay is needed.

> **NOTE:** In addition to port hardening configuration, and in order to help prevent access to the communication ports on the local panel, it is possible to replace put with install physical seal (See Lock the shutter and handle, page 50).

It is possible to disable SSH protocol for the rear Ethernet ports. The setting can be made only from local panel via **General setting** / **Port hardening** / **Dis. Eth SSH**.

Security event logging

The function of security event log and back up remotely the logs to Syslog server is only available in Advanced CS level. The security logs are generated by PowerLogic P5 and saved locally with secured storage on FLASH memory. They are read-only and undeletable for any role. In the meantime the logs will be pushed to the Syslog server defined by CAE. Syslog server manages the logs according to customer security policy.

PowerLogic P5 does not enable by default any of logging standards listed in the table below . The logging standards can be selected in CAE according to requested logs.

Table 44 - Security logs list

Log ID	Description	BDEW	IEEE 1686–2013
CONNECTION_SUCCESS	Successful connection	■	■

Table 44 - Security logs list (Continued)

CONNECTION_FAILURE	Unsuccessful connection (wrong credentials)	■	■
CONNECTION_FAILURE_AND_BLOCK	Unsuccessful connection (wrong credentials) triggering the blocking of the account	■	■
CONNECTION_FAILURE_ALREADY_ BLOCKED	Unsuccessful authentication because the account is already blocked	■	■
DISCONNECTION	Disconnection triggered by user	■	■
DISCONNECTION_TIMEOUT	Disconnection triggered by timeout	■	■
FIRMWARE_UPDATE	Firmware update to IED	■	■
RBAC_UPDATE	Update of the RBAC setting in the IED		■
SEC_LOGS_RETRIEVAL	CAE extraction of security logs from IED		■
TIME_CHANGE	Time change from Easergy Pro, local HMI, Web HMI, protocol time synchronization		■
PORT_MANAGEMENT	Port hardening operations		■
SECURITY_UPDATE	Update of the Security policy database		■

Upgrades management

When the PowerLogic P5 protection relay firmware is upgraded – security configuration remains the same until changed, including usernames and passwords. It is recommended security configuration is reviewed after an upgrade to analyze rights for new or changed device features and revoke or apply them according to your company's policies and standards.

Security functionality verification

When the Cybersecurity functionalities have been configured, it is recommended to verify that the following functions are working as intended:

- RBAC function is making sure that user cannot perform actions for which he does not have privilege.
- Security event logs (CS Advanced only) are properly generated in PowerLogic P5 locally and the remote Syslog server (if configured) keeps record of them.
- Disabled logical and physical ports can no longer be accessed.

It is recommended to repeat the above tests after firmware update or security policy update.

Use

Introduction

The local panel can be used for both entering all the data required for operation of the PowerLogic P5 protection relay and accessing the data for equipment management.

The following tasks can be handled from the local panel:

- Controlling switchgear units:
  - View equipment status on an animated mimic diagram
  - Local opening and closing of up to 6 devices controlled by PowerLogic P5
- Read out the list of enabled protections
- Readout and modification of settings
- Readout of live operating data including waveforms
- Read out logic status signals
- Readout of operating data logs and of monitoring signal logs
- Readout of event logs after overload situations, ground faults, or short circuits in the power system
- Read out the PowerLogic P5 protection relay's module versions
- Device resetting and triggering of additional control functions used in testing and commissioning
- Test the protection relay with dedicated IED modes (contact outputs forced or not)
- Entering a password according to different access rights for settings and operations (see Cybersecurity, page 179)

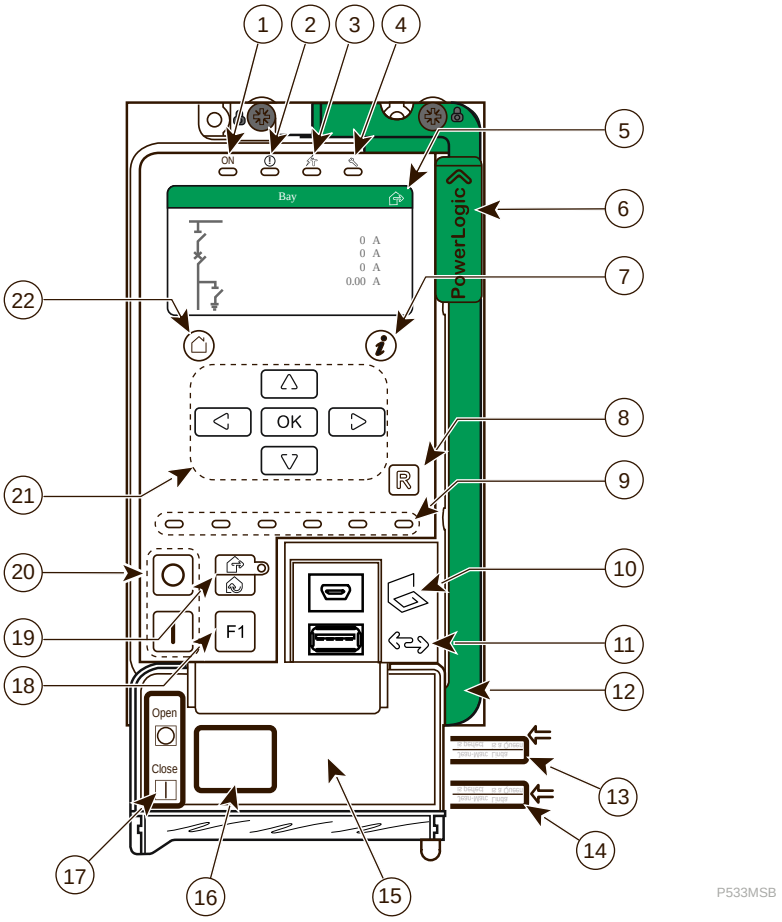
Control is also possible through the PC interface. This requires a suitable PC installed with a specific operating program called eSetup Easergy Pro (see eSetup Easergy Pro, page 243).

Local panel

Presentation

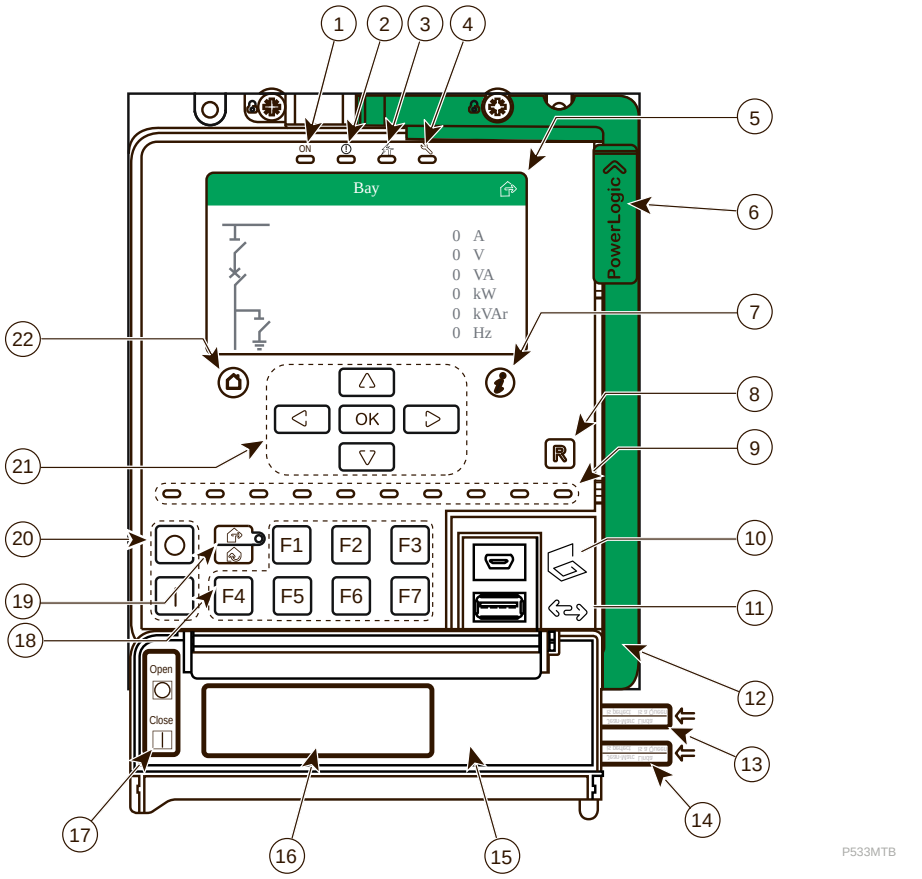
The PowerLogic P5 protection relay is equipped with a user friendly local panel.

Figure 177 - Local panel of PowerLogic P5x20



①	Power ON/OFF LED	⑫	Handle
②	Alarm LED	⑬	Label for protection relay name (inserted in the shutter)
③	Trip LED	⑭	LED identification label (inserted in the shutter)
④	Maintenance/Test LED	⑮	Shutter
⑤	Graphic 192 x 96 monochrome LCD screen	⑯	Label for programmable function key (stuck on the back of the shutter)
⑥	Handle lock (movable up and down)	⑰	Label for CB open and CB close keys (stuck on the back of the shutter)
⑦	Information key	⑱	F1 function key
⑧	Reset key	⑲	Remote Control/Local Control key
⑨	6 LEDs, user programmable	⑳	CB Open (upper) and CB Close (lower) keys
⑩	Mini-USB connector for connecting laptop (behind a plastic cover)	㉑	Navigation keypad and confirmation key
⑪	USB connector for data transfer (behind a plastic cover)	㉒	Home key

Figure 178 - Local panel of PowerLogic P5x30



①	Power ON/OFF LED	⑫	Handle
②	Alarm LED	⑬	Label for protection relay name (inserted in the shutter)
③	Trip LED	⑭	LED identification label (inserted in the shutter)
④	Maintenance/Test LED	⑮	Shutter
⑤	Graphic 480 x 272 color LCD screen	⑯	Label for programmable function key (stuck on the back of the shutter)
⑥	Handle lock (movable up and down)	⑰	Label for CB open and CB close keys (stuck on the back of the shutter)
⑦	Information key	⑱	F1 - F7 function keys
⑧	Reset key	⑲	Remote Control/Local Control key
⑨	10 LEDs, user programmable	⑳	CB Open (upper) and CB Close (lower) keys
⑩	Mini-USB connector for connecting laptop (behind a plastic cover)	㉑	Navigation keypad and confirmation key
⑪	USB connector for data transfer (behind a plastic cover)	㉒	Home key

Push buttons

Symbol	Function
	HOME/Cancel push-button for returning to the previous view. To return to the default screen of the LCD display, keep the button pressed for 3 seconds.
	INFO push-button for viewing additional information.
	Reset key to release latches and reset LED status.
	1 programmable function push-button for PowerLogic P5x20 (see Object control with function keys, page 504)
 to 	7 programmable function push-buttons for PowerLogic P5x30 (see Object control with function keys, page 504)
	ENTER push-button for activating or confirming a function.
	UP navigation push-button for moving up in the menu or increasing a numerical value.
	DOWN navigation push-button for moving down in the menu or decreasing a numerical value.
	LEFT navigation push-button for moving back across a menu or selecting a digit in a numerical value.
	RIGHT navigation push-button for moving forwards across a menu or selecting a digit in a numerical value.
	Circuit breaker ON push-button (see Object control with I and O buttons, page 505)
	Circuit breaker OFF push-button (see Object control with I and O buttons, page 505)
	This push button allows the user to set the PowerLogic P5 protection relay to remote control mode or local control mode.

NOTE: The programmable function push buttons, the Local/Remote control key and the control circuit breaker push buttons are protected by a shutter in normal operation. This shutter can be sealed (see Lock the shutter and handle, page 50).

LED indicators

Status indicators

This includes the 4 LEDs located on top of the LCD representing the different status of the PowerLogic P5 protection relay regarding power, alarm, trip, and operation mode (refer to item 1 to 4 in Local panel of PowerLogic P5x20, page 225 and Local panel of PowerLogic P5x30, page 226) and the LED associated with the "Local/Remote" push button (refer to item 19 in Local panel of PowerLogic P5x20, page 225 and Local panel of PowerLogic P5x30, page 226).

Table 45 - The states of the status indicators

Indicators	States		
	OFF	ON	Flash
ON	Power OFF	Power ON	-
	No alarm	Old alarm	New alarm
	No trip	Trip	-
	In service	Maintenance	Test/Test-block mode
	In local control mode	In remote control mode (steady green)	-

Configurable LEDs

These LEDs can be configured in three different colors: green, red and yellow, and be individually latched or unlatched (see LED matrix, page 496).

These LEDs are configured by default according to LED1 to LED6 on PowerLogic P5 x20, page 228 and LED1 to LED10 on PowerLogic P5 x30, page 228.

Table 46 - LED1 to LED6 on PowerLogic P5 x20

Color	LED 1	LED 2	LED 3	LED 4	LED 5	LED 6
PowerLogic P5U20						
Green	CB Open					
Yellow		TCS Alarm			Therm Alarm	
Red	CB Closed		I Trip	IN Trip		
PowerLogic P5V20						
Green	CB Open					
Yellow		TCS Alarm				
Red	CB Closed		V Trip	VN Trip	f Trip	

Table 47 - LED1 to LED10 on PowerLogic P5 x30

Color	LED 1	LED 2	LED 3	LED 4	LED 5	LED 6	LED 7	LED 8	LED 9	LED 10
Green	CB Open									
Yellow		TCS Alarm			Therm Alarm					
Red	CB Closed		I Trip	IN Trip			V Trip	VN Trip	f Trip	

Customising the local panel

The local panel of the PowerLogic P5 protection relay can be customised with four labels for:

- Configurable LEDs
- Configurable function keys
- Circuit breaker control push buttons

- Name of the protection relay or feeder

  NOTE: The PowerLogic P5 protection relay is delivered with:

  - A label of configurable LEDs with default configuration (English version; see LED1 to LED6 on PowerLogic P5 x20, page 228 and LED1 to LED10 on PowerLogic P5 x30, page 228)
  - A label in color for the circuit breaker control push buttons

The different labels can be defined with eSetup Easergy Pro (see LED documentation view in the Documentation menu).

When the labels are printed and adjusted:

- Insert the label for the configurable LEDs in the shutter (see 14 in Local panel of PowerLogic P5x20, page 225 and Local panel of PowerLogic P5x30, page 226)
- Stick the label for the programmable function push buttons on the back side of the shutter (see 16 in Local panel of PowerLogic P5x20, page 225 and Local panel of PowerLogic P5x30, page 226)
- Stick the label for the circuit breaker control push buttons on the back side of the shutter (see 17 in Local panel of PowerLogic P5x20, page 225 and Local panel of PowerLogic P5x30, page 226)
- Insert the label for the protection relay name in the shutter (see 13 in Local panel of PowerLogic P5x20, page 225 and Local panel of PowerLogic P5x30, page 226)

Introduction to the LCD display

PowerLogic P5 protection relay service cycle

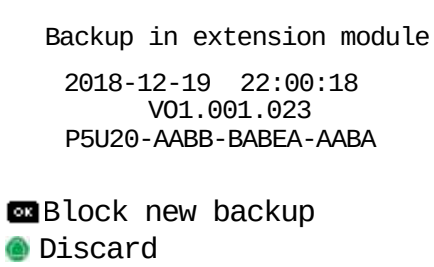
During the start-up of the PowerLogic P5 protection relay, a series of boot messages are displayed to guide the user through the whole process.

The start up process may be different dependent on whether the optional extension module is installed.

If there is no extension module installed, the protection relay enters into the operation mode and displays the default screen (e.g. the Mimic screen), which can be set through eSetup Easergy Pro in the **GENERAL** menu.

If the extension module is installed, the PowerLogic P5 protection relay checks whether the content of the extension module is a backup of its existing configuration and settings by comparing the version numbers.

Figure 179 - Message on handling the existing content in the extension module



If it is, the PowerLogic P5 protection relay proceeds to the default screen; If it isn't, a message is displayed, prompting the user to either keep or discard the content of the extension module. If the user selects the “Block new backup” option, the content is kept, the PowerLogic P5 protection relay will block the backup operation; If the user selects the “Discard” option, the protection relay directly reconfigures from the extension module.

When the PowerLogic P5 protection relay is in operation mode, it is possible to switch to the main menu screen by pressing key. Depending on the user role, the user can also change the device settings at any time.

If an event or alarm occurs during operation, a popup message is permanently displayed on the LCD screen until it is acknowledged using the key.

If a fault occurs during operation, a popup alarm message is permanently displayed on the LCD screen, press key to access the **Fault recorder** screen.

If there is an alarm message displayed and no action on the keypad for 5 minutes, the PowerLogic P5 protection relay will jump to the default screen and then display the alarm message again automatically.

If there is no alarm message displayed, the default screen is displayed automatically.

Menu structure

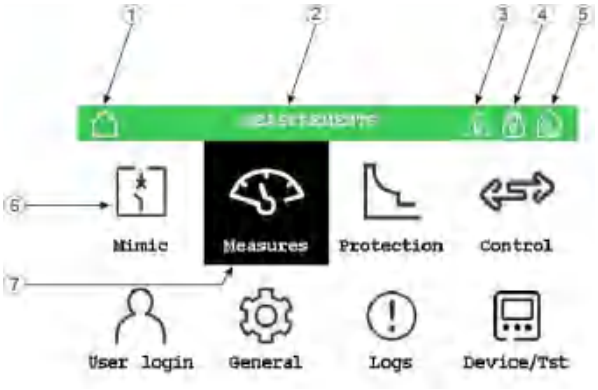
The PowerLogic P5 protection relay has two levels of menus: the main menu (home menu) and sub-menus.

> **NOTE:** The hierarchy and navigation of the menu structure are the same on PowerLogic P5x20 and PowerLogic P5x30, but due to a larger resolution, the PowerLogic P5x30 LCD color screens can display data and graphics in greater detail.

The PowerLogic P5 device is delivered with auto-login feature. It will be disabled when the passwords for all three levels are changed from the default ones. For the default passwords for all the levels, refer to Default settings, page 200.

Main menu (home menu)

Figure 180 - The main menu with menu item Measurement in focus



1	Home menu icon	5	Remote/Local control icon
2	Full name of the menu item in focus	6	Menu item not in focus
3	Cybersecurity level icon	7	Menu item in focus
4	Padlock icon		

The main menu screen has 2 widgets: the top title bar, and the main display area. The top title bar shows the following items:

- Menu name: full name of the menu item that is being selected (the names next to the menu icons use their short forms)
- Home icon: located on the left side of the top title bar, indicates that the current screen is the home screen of the LCD display

- Cybersecurity level icon: located on the right side of the top title bar. stands for the Basic Cybersecurity level, stands for the Advanced Cybersecurity level.
- Padlock icon ( ): located on the right side of the top title bar, indicating that no user has logged in to the device; the icon disappears when any user has logged in.
- Remote/Local control icon: located on the right end of the top title bar, indicates the protection relay's current control mode

Figure 181 - The remote/local control icons



P533RXA

Remote mode



P533MVB

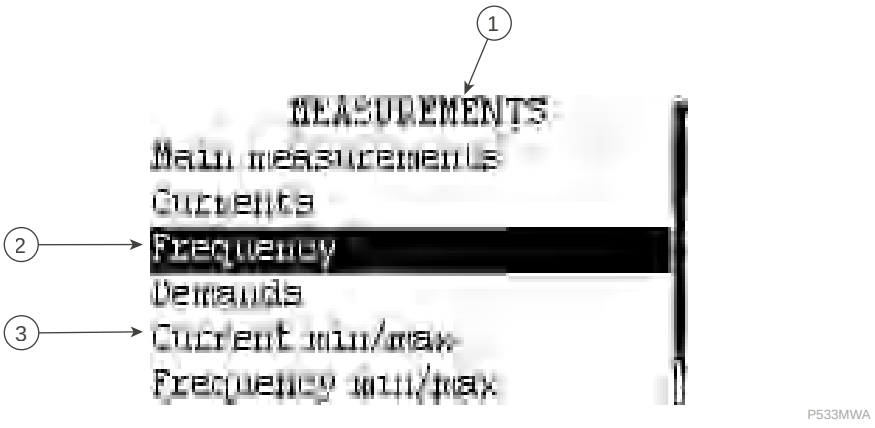
Local mode

The main display area lists all the menu items (sub-menus) of the PowerLogic P5 protection relay.

In the main menu, pressing the navigation keys on the local panel moves the focus onto a main menu item (sub-menu). The sub-menu title is displayed in the top title bar of the main menu screen. Pressing OK allows the user to enter the highlighted sub-menu.

Sub menus

Figure 182 - The Measurement sub-menu



P533MWA

1	Title of sub-menu	3	Menu item not in focus
2	Menu item in focus		

In the sub-menu, pressing ▲ or ▼ key moves the focus onto a sub-menu item and pressing OK selects the item and allows the user to enter the setting page of the item.

NOTE: There could be more menu items than is able to be displayed in the view. The user needs to scroll to these items using the ▼ key.

Data/setting page

Some sub-menu items may have more than one data/setting pages, which is indicated by an arrow on either the left or right end, or by arrows on both ends of the title bar:

- Arrow on the right end
  Press the ▷ key scrolls the screen to the next data/setting page.
- Arrow on the left end
  Press the ◁ key scrolls the screen to the previous data/setting page.
- Arrows on both the left and right ends
  Press the ◁ or ▷ key scrolls the screen to the previous or next data/setting page, respectively.

Upon seeing the desired data/setting page, press OK to allow the user to enter the data/setting page, then press the △ or ▽ key moves the focus onto each parameter field.

NOTE: There may be more parameters than the view can display. The user needs to scroll to these parameters using the ▽ key.

When an editable parameter is in focus, press OK to open the parameter setting view and enable the user to change the value or option by pressing the navigation arrow keys. When a non-editable parameter is in focus, press OK key to pop up a message indicating that the parameter is not editable. When the user is not fully authorised to edit the setting, press OK key to pop up a "Permission denied" message.

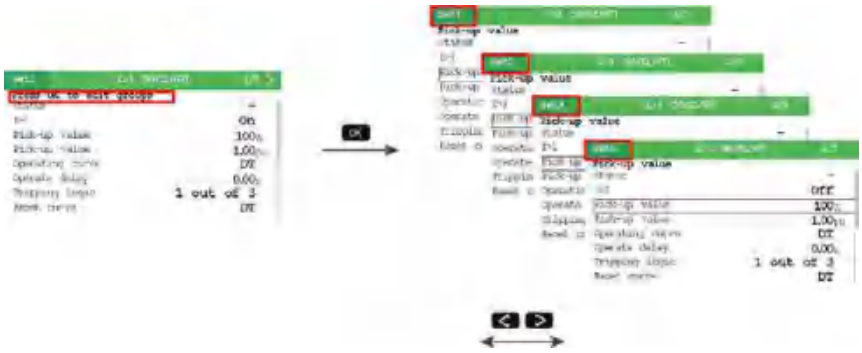
When changing the settings, use the navigation keys according to the following instructions to get the result quickly:

- For selecting options, use the △ and ▽ keys;
- For changing the value of integer numbers, use either the △ and ▽ keys, or the ◁ and ▷ keys;
- For changing the value of float numbers, first use the △ and ▽ keys to quickly approach the integer part of the number in steps of 1 and then use the ◁ and ▷ keys to adjust the decimal part in steps of 0.01.

In the protection menu, some protection stage items have a first setting page with more than one view. These views belong to different setting groups of the protection stage. In this case, upon selecting the menu item, an additional text line "Press OK to edit groups" is displayed at the top of the main display area to indicate that here the user can edit the settings of different setting groups.

Press the OK key to enter the group editing status. Press the ◁ and ▷ keys to scroll to the setting view for the desired setting group.

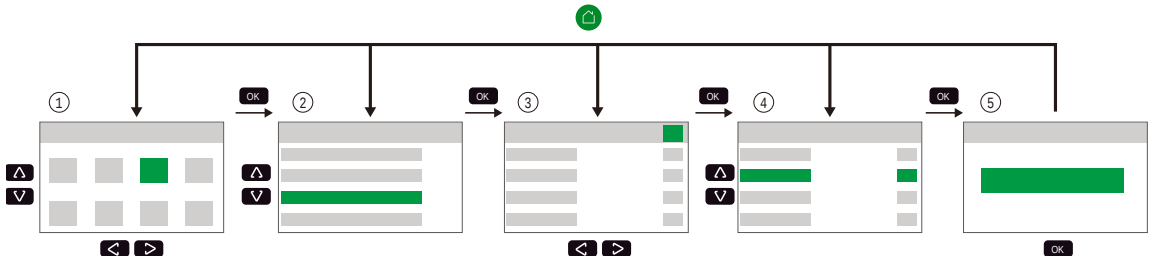
Figure 183 - Example of a data/setting page with 4 setting views



Moving in the menu structure

The following image describes the operation to navigate in the menu structure.

Figure 184 - Moving in the menu structure of the PowerLogic P5 protection relay



1	Main menu	4	Data/setting page (parameter selecting view)
2	Sub-menu	5	Parameter editing view
3	Data/setting page (page selecting view)		object in focus

Press ◁, ▷, △ and ▽ keys to move focus in menu.

Press OK key to enter the sub menu (2), the data/setting page selecting view (3), the parameter selecting view (4), or the parameter editing view (5), depending on where the user is situated in menu structure.

OK key is also used to confirm and finalise the editing in the parameter editing view.

Press ⌂ key once to return to previous view.

Keep pressing the ⌂ key for 3 seconds to display default screens.

Moving default screens and mimics

There are two ways to display default screens:

- keep pressing the ⌂ key for 3 seconds
- make no action on the keypad for 5 minutes.

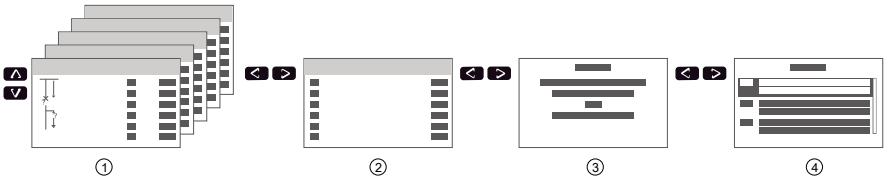
It is possible to scroll between visible mimics (per setting) and between default screens.

To scroll between mimics and other default screens, please press ◁ and ▷ keys to scroll between mimics and **Alarm list**.

In mimics of default screen, use △ and ▽ keys to scroll between **Mimic 1** and **Mimic 5**.

> **NOTE:** If **Mimic 2** to **Mimic 5** are set to invisible, press △ and ▽ keys will not scroll to other mimics from **Mimic 1**.

Regardless of which mimic is actually displayed, pressing ▷ key will scroll to **Main measurements** window. When pressing ◁ key in **Main measurements** window, **Mimic 1** will be displayed.



P533S4A

1	Mimics	2	Main measurements
3	Firmware version	4	Alarm list

Login and logout

NOTE: For more details about password management, see relevant sections in Cybersecurity, page 179.

Login

The user may need to log in before changing settings or accessing the data protected by password. The PowerLogic P5 device is delivered with auto-login feature. It will be disabled when the passwords for all three levels are changed from the default ones. For the default passwords for all three levels, refer to Default settings, page 200.

Except from the home screen or alarm popup screen, access the User Login screen by pressing the *i* key on the local panel and press the OK key. This feature allows you to access the User Login screen from anywhere in the menu structure instead of returning to the Home page.

The following login procedure starts from the main menu.

1. Press the navigation keys and the OK key to enter the User Login menu from the main menu screen.

   The screen displays the Login view with the focus on the "Name" field.
2. Press OK to show the user list, which displays the three default user levels provided by the PowerLogic P5: Engineer Level, Operator Level and Installer Level.
3. Press △ or ▽ key to select a user name from the user list and then press the OK key to confirm your choice.
4. Enter the password by first pressing ◁ or ▷ key to select the code position, and then press △ or ▽ key to select different letter or digits and press the OK key to confirm.

   NOTE: After a correct password is entered, the LCD display returns to the home screen and the padlock icon disappears from the screen title bar, indicating that the user is now able to view/edit the settings, depending on the access right level of the user type.

Logout

By default, the user is automatically logged out if there is no action on the keypad for 3 minutes.
The user can also logout manually by first going to the User Login screen from the local panel and then pressing the OK key.

NOTE: Except from the home screen or alarm popup screen, access the User Login screen by pressing the *i* key on the local panel and press the OK key. This feature allows you to access the User Login screen from anywhere in the menu structure instead of returning to the Home page.

Adjusting the LCD contrast (for PowerLogic P5x20)

The LCD contrast of the PowerLogic P5x20 protection relay can be adjusted according to the following steps:

1. On the local panel, select the **Device/Test** menu icon and then press the OK key to enter sub-menu.
2. Press ▽ key to select **Contrast of LCD**.
3. Press OK key twice to enter the setting page of LCD contrast.

4. The setting range of contrast is 1 to 15. To increase contrast, press △ or ▷, to decrease, press ▽ or ◁. After setting, press OK key to confirm. The contrast of LCD will be changed after confirmed.
5. Press ⌂ key to go back previous view, or keep press the key for 3 seconds to go back to default screen.

   NOTE: The LCD contrast can alternatively be adjusted by pressing the key and then pressing the △ and ▽ key. The contrast changes incrementally with every step but the screen does not display the values.

Changing language

The interface language can be changed on the local panel according to the following steps:

1. Press the navigation keys to select the **General settings** menu from the main menu screen, then press OK key to enter. The screen displays the **General settings** menu with the focus on the "Language" option.
2. Press the OK key to enter the Language setting page.
3. Press the OK key to focus on the setting item.
4. Press the OK key again to bring up the language list.
5. Press the △ or ▽ key to select the desired language and then press the OK key to confirm the selection.

   NOTE: The interface language can alternatively be changed through eSetup Easergy Pro in the **GENERAL** menu/**System info** sub-menu.

Changing the parameters

⚠WARNING

INOPERABLE PROTECTION RELAY

Make sure that the reboot of the protection relay has no impact on people and equipment.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

After changing some settings, the protection relay needs to reboot. During this time, the device is not operational.

Parameters can be changed on the setting pages of certain sub-menus:

1. In the main menu, enter the menu item that relates to the function you need to access.
   Refer to Main menu (home menu), page 230 for how to access the menu items.
2. In the sub-menu, select the sub-menu item that includes the parameter you want to change.
   Refer to Sub menus, page 231 for how to access the sub-menu items.
3. With the related sub-menu item selected, press ◁ or ▷ key to scroll to the specific setting page on which you can find the parameter and then press OK to enter the setting page.
4. Press the △ or ▽ key to move the focus onto the parameter field and then press the OK key to start editing the parameter.

5. Use the navigation keys to change the value of the parameter and then press the OK key to confirm your change.
   Refer to Data/setting page, page 232 for how to use the navigation keys tactically.
6. Press the ⌂ key once to go back to the previous view in the menu, or press it for 3 seconds to return to the default screen.

Manage the alarm messages

Handling the pop-up alarm message

When an alarm message box pops up on the LCD screen, the user can acknowledge the message and close the message box by pressing the R key. Alternatively, if there is more than one alarm, the user can press the key R for about 2 seconds to bring up a dialog box where the user can opt to delete all the alarm messages.

Changing the alarm settings and viewing the alarm list

Alarm settings and list can be accessed from the Logs function group in the main menu.

The following procedure describes how to change the alarm settings and view the alarm list:

1. From the main menu, use navigation keys to select **Logs & alarms** function group, click OK key to enter sub-menu. Refer to Main menu (home menu), page 230 for how to access the menu items.
2. In the **Logs & alarms** sub-menu, select the option **Alarm logs** to enter the **Alarms** setting page.

   Refer to Sub menus, page 231 for how to access the sub-menu items.
3. Press OK key to enable selection in setting page, use △ or ▽ key to move the focus onto the parameter field and then press OK to edit setting of parameters.

   The setting page includes the following parameters:
   - **Counter**: number of alarms (from 0 to 200)
   - **Order**: scroll order (Old - New or New - Old)
   - **Fault value**: fault value scaling (Primary or PU)
   - **Alarms**: enable alarm pop-up messages (On or Off)
   - **Event synchro.**: displaying event time not in sync (On or Off)
4. Press △ or ▽ key to change the settings of the parameters and then press OK to confirm change.
5. Press the ⌂ key once to go back to the previous view in the menu, or press it for about 3 seconds to return the default screen.

   NOTE: For viewing the alarm list, press ▷ key once to go to the **Alarm list** page after Step 2.

Matrix operations

The matrix mapping operation can be performed on the local panel of the PowerLogic P5 protection relay, in the eSetup Easergy Pro software tool, or through the web HMI.

The following procedure describes the mapping operation on the local panel of the PowerLogic P5 protection relay. The operation is much easier in eSetup Easergy Pro and the web HMI due to their intuitive interfaces.

1. Select the Control function from the main menu, press OK to enter the sub-menu.
2. Press △ or ▽ key to scroll to the menu item (e.g. DI) that needs matrix mapping operation.
3. Press ◁ or ▷ key to scroll to the matrix mapping page and start the mapping operation.

   NOTE: The local panel LCD screen only shows the first line of mapping relations already existing in the configuration. If no mapping relation is available for the first line of the matrix, the screen only shows the digital input or internal signal on the left side of the screen.
4. Press △ or ▽ key to scroll to the digital input or internal signal type and then press OK to confirm. The first crossing point on the matrix line starts to blink.
5. Press ◁ or ▷ key to scroll to the crossing point for which you want to set the mapping status.

   NOTE: Some crossing points may not be visible in the screen but the user can view all the crossing points by pressing ▷ key.
6. Press ◁ or ▷ key to select the mapping status (enabled or disabled; connected or unconnected; latched or unlatched, depending on which matrix mapping operation is being performed) and then press OK to confirm.

   The screen shows the current line of mapping relations, leaving the empty crossing points invisible on the screen.
7. Press ◁ key to leave the matrix setting page and then ⌂ key to return to the preview level in the menu structure.

Controlling objects

The local panel provides buttons for directly controlling objects like circuit breaker and earth/ground switch. The user do not need to go through the menu to find out the options for closing/opening the objects.

Controlling an object with Selective Control enabled

To enable the Selective control feature, navigate to the **Control** menu/**Control objects** sub-menu of the local HMI, or to the **GENERAL** menu/**Local panel conf** sub-menu of the eSetup Easergy Pro.

When Selective Control is enabled, the control operation will include a confirmation step (select before operate).

1. Press O on the local panel to open a circuit breaker or stop a motor, or press I on the local panel to close a circuit breaker or start a motor.
2. Press the same key (O or I) again to confirm your operation, or press ⌂ on the local panel to cancel the previous operation.

Controlling an object with Direct Control enabled

To enable the Direct control feature, navigate to the **Control** menu/**Control objects** sub-menu of the local HMI, or to the **GENERAL** menu/**Local panel conf** sub-menu of the eSetup Easergy Pro (refer to Controlling an object with Selective Control enabled, page 240 and Local panel configuration, page 501 respectively).

When Direct Control is enabled, the control operation is done without confirmation.

1. Press O on the local panel to open a circuit breaker or stop a motor, or press I on the local panel to close a circuit breaker or start a motor.
2. The object in control acts according to your control operation.

Specific language file change

The PowerLogic P5 protection relay can be ordered in English version only or in English with another local language (see Order information, page 589).

The selection of the language can be done with eSetup Easergy Pro or directly on the local panel of the PowerLogic P5 protection relay (see Changing language, page 236).

Other languages can be uploaded to the PowerLogic P5 protection relay through eSetup Easergy Pro, using the Update language option from the (Tools) drop down list in the tool bar.

NOTE: The language files use the .bin extension.

For detailed list of languages, contact Schneider Electric.

Transferring data to USB memory stick

The PowerLogic P5 protection relay supports data transfer to a USB memory stick plugged into the USB 3.0 type A port located under the flap of the local panel.

Files of the following formats in the protection relay can be transferred:

File format	Description
manifest.mnfs	IED information and integrated check data
/DR/*.dat, *.cfg	Disturbance records

The features of the USB data transfer function are as follows:

- Hot-plugging is supported and the USB key status is automatically detected by the device.
- Files are copied to folder “P5bak” in the USB key.

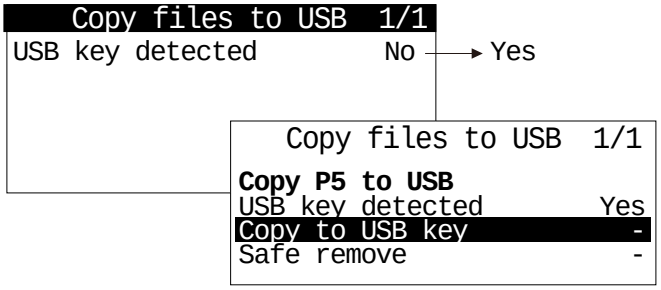
  The protection relay creates this folder automatically before transferring data. If a “P5bak” folder already exists, all the files in it will be over-written.
- Each file transferred is accompanied by a CRC32 check to help ensure the integrity.
- Software and hardware information is stored in the manifest file.
- Data transfer process takes about 2 to 10 minutes.
- The USB key used must be in FAT32 format and with write caching disabled.
- USB 3.0 or above is recommended for use on the device.

  NOTE: The USB data transfer function transfers only disturbance record files to USB key, the digital format setting file, event, alarm files can be transferred only by eSetup Easergy Pro tool.

The data is transferred to the USB key according to the following steps:

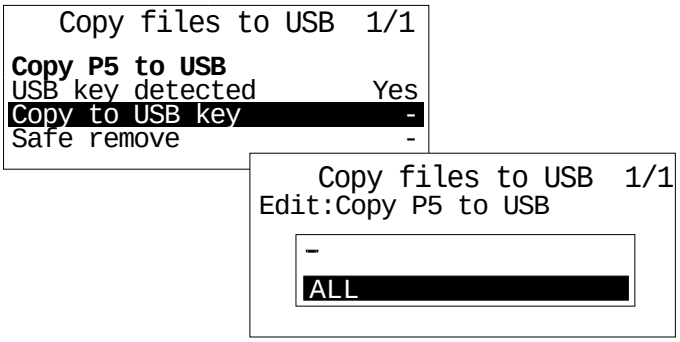
1. Use navigation keys to select and press OK key to enter **Device/Test** sub menu. Select **USB key** and press OK key to enter the view of **Copy files to USB**. Insert USB Key to the USB port in front of local panel.

   The **USB key detected** status will be changed from “No” to “Yes” automatically.



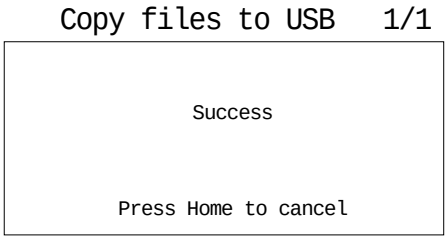
P533OKB

2. Press OK key to enable selection. Select **Copy to USB key** and then select **All** to copy all the files from the protection relay to USB key.



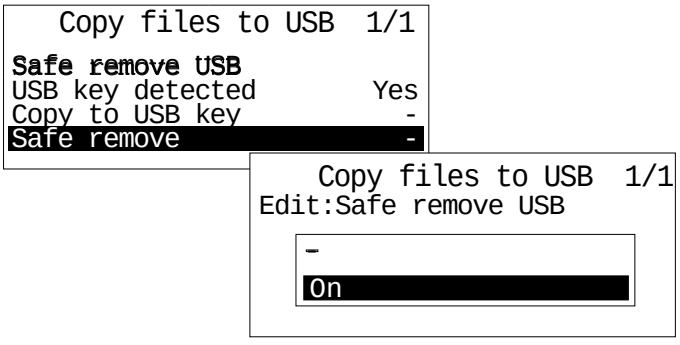
P533OJB

3. A progress bar will be displayed on the screen for a short while. After finished copy, a “Success” message will be displayed. Please press key to close this message.



P533O9B

4. To remove USB key, please select **Safe remove**, then select **On** and press OK key.



P533S0A

eSetup Easergy Pro

Overview

⚠WARNING

INOPERABLE PROTECTION RELAY

Make sure that the reboot of the protection relay has no impact on people and equipment.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

After changing some settings, the protection relay needs to reboot. During this time, the device is not operational.

eSetup Easergy Pro is a setting and operating software tool for configuring PowerLogic P5 devices, local operation and customisation functions.

The eSetup Easergy Pro software is supplied directly through the Schneider Electric website www.se.com, along with the eSetup Easergy Pro program for recovering disturbance recording files, and all the PowerLogic P5 documentation in PDF format.

Figure 185 - eSetup Easergy Pro menu bar and tool bar



The eSetup Easergy Pro software has a graphical interface where the protection relay settings and parameters are grouped under nine menu tabs:

- General
- Measurements
- Control
- Protection
- Matrix
- Logs
- Communication
- Device/Test
- Documentation

The contents of the tabs depend on the device type and the selected application mode. Refer to the User Manual of eSetup Easergy Pro for detailed information on the setting views of each menu.

The eSetup Easergy Pro stores the device configuration in a setting file. The configuration of one physical device is saved in one setting file. The configurations can be printed out and saved for later use.

When starting to work with eSetup Easergy Pro, there are three options:

- Create a new setting file without connecting to a protection relay
- Open an existing (previously saved) setting file without connecting to a protection relay
- Connect to a relay and read the settings from the protection relay .

eSetup Easergy Pro can be connected to a single relay via the mini-USB port in the protection relay's local panel or to a group of protection relays via Ethernet.

Operation modes

The eSetup Easergy Pro software can be used in three operation modes:

- Disconnected mode
- Single unit connecting mode
- Network connecting mode

Using eSetup Easergy Pro in disconnected mode

The disconnected mode allows you to prepare parameters and settings files for PowerLogic P5 prior to commissioning.

The parameter and protection setting files prepared in disconnected mode will be downloaded later to the PowerLogic P5 protection relays in connected mode.

In this mode, the user can create a setting file from scratch, or open a previously saved setting file as a basis for creating configuration for a protection relay of the same type. Refer to the User Manual of eSetup Easergy Pro for more information.

Using eSetup Easergy Pro connected to a single PowerLogic P5

The single connection mode is used during commissioning of a PowerLogic P5 protection relay:

- To upload, download and modify PowerLogic P5 parameters and settings.

  Refer to the User Manual of eSetup Easergy Pro for more information on uploading (writing)/downloading (reading) setting files to/from the connected protection relays.

NOTICE

UNINTENDED EQUIPMENT OPERATION AND NUISANCE TRIPPING

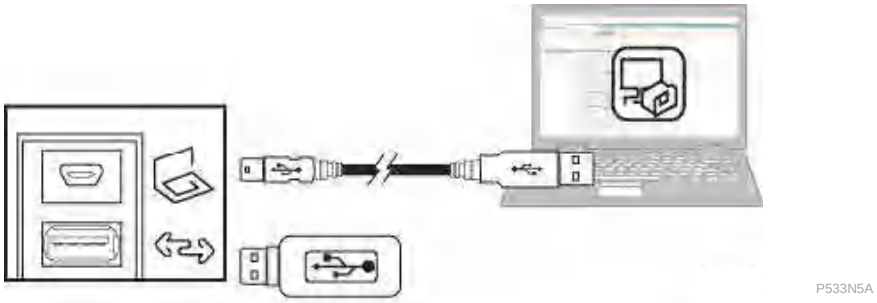
After writing new settings, configurations or firmware to a protection relay, perform a test to verify that the protection relay operates correctly with the new settings.

Failure to follow these instructions can result in unwanted shutdown of the electrical installation.

- To have all the measurements and supporting data available for commissioning.

The PC fitted with the eSetup Easergy Pro software is connected to the mini-USB port in the local panel of the PowerLogic P5 using a USB cord (reference 59700).

Figure 186 - Connecting a PC to the PowerLogic P5 using a USB cable



Using eSetup Easergy Pro connected to an PowerLogic P5 network

The network connection mode is used during operation:

- To manage the protection system.
- To check the status of the power supply.
- To diagnose any incident occurring on the power supply.

The PC fitted with the eSetup Easergy Pro software is connected to a group of PowerLogic P5 units via a communication network (connection via serial link or Ethernet).

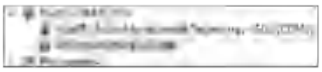
The connection window allows configuration of the PowerLogic P5 network, and provides access to the parameter and protection setting files of the PowerLogic P5 units on the network.

Setting up the connection

Installing the USB driver

If it is the first time you connect the PowerLogic P5 protection relay to a PC running eSetup Easergy Pro, you need to install the USB driver on the PC.

The steps for installing the driver are as follows:



1. Connect the USB cable (reference 59700) to the front port of the PowerLogic P5 protection relay and the PC (see Connecting a PC to the PowerLogic P5 using a USB cable, page 244), after that look for a new COM port under COM & LPT in the Device Manager window of the PC.

   If you are unsure which is the right port, detach the USB cable and insert it again when you are in this menu.



2. Right-click on the port and select Update Driver Software from the contextual menu.



3. Select the option Browse my computer for driver software and locate the driver in the P5 driver_files folder under the eSetup Easergy Pro directory.



4. Click the Install button in the prompt window to start installing the driver.



5. If the driver has been installed successfully, the connection now appears under Network adapters in the Device Manager window each time you connect the PC to a PowerLogic P5 protection relay.

Connecting to a single protection relay using USB cable

1. Install the USB driver from the eSetup Easergy Pro file package for the first time connecting the PowerLogic P5 protection relay to a PC running eSetup Easergy Pro (see Installing the USB driver, page 245).
2. Connect the USB cable (reference 59700) between the PC running eSetup Easergy Pro and the local port of the PowerLogic P5 protection relay, with the mini-USB type B connector of the cable plugged into the protection relay and the type A connector to the PC (see Connecting a PC to the PowerLogic P5 using a USB cable, page 244).
3. On the eSetup Easergy Pro toolbar, click the **ON** connection button. The Login pop-up window opens.
4. Select the right PowerLogic P5 USB serial port name.
5. Click **Connect**.
   A new window showing the relay information opens.
6. Enter the user name and password to login.
   eSetup Easergy Pro's main view opens.

   NOTE: If you connect for the first time to a device on which the default users and passwords are used, refer to Cybersecurity, page 179.

Connecting to protection relays via Ethernet

You can connect to a single protection relay or multiple protection relays via Ethernet.

1. On the eSetup Easergy Pro toolbar, click the **ON** connection button. The Login pop-up window opens.
2. Click **ETHERNET**.
3. Select the right IP address from the drop-down menu.
   - For the protection relay's IP address, see the protection relay local panel menu **BUS**/**ETHERNET PORT**.
   - To save the defined connection settings, click the disk icon.
4. Click **Connect**. A new window showing the protection relay information opens.
5. Enter the user name and password to login. eSetup Easergy Pro's main view opens.

Web HMI

Overview

The web HMI is used for operation and settings. It has the same functions as eSetup Easergy Pro except the logic and mimic customisation.

The web HMI can be accessed using the following browsers[363738]:

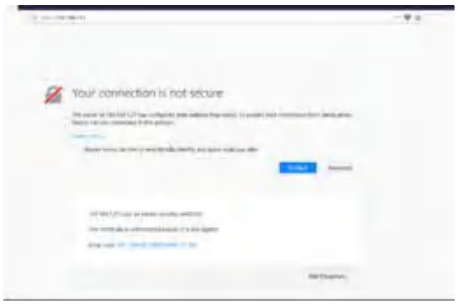
Operation system	Certificate state	Firefox®	Internet Explorer®	Edge®
Windows 7	without pre-installed certification	■	■	-
	pre-installed certification	■	■	-
Windows 10	without pre-installed certification	■	-	-
	pre-installed certification	■	■	■

Device reboot reminder

NOTE: Attention to the reminder message of device reboot.
Some setting changes require a reboot of the PowerLogic P5 protection relay. This is reminded by a message appearing on the HMI screen when you change such settings through the HMI.

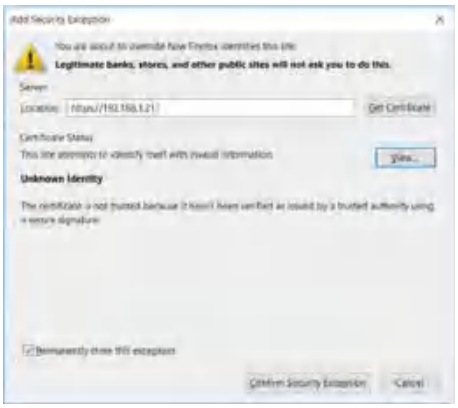
36. Chrome® is not supported.
37. Firefox is a registered trademark of the Mozilla Foundation.
38. Internet Explorer and Edge are registered trademarks of Microsoft Corporation.

Firefox



1. Enter "https://192.168.1.21" in the Firefox address bar, it will show the left message.

Click **Advanced** to show more information.



2. If a message regarding an invalid security certificate is displayed, click **Add Exception...**.

Left window will be displayed.



3. If needed, click the **View...** button to see the pop-up information of the certificate with the name "192.168.1.21.p12".



4. Close the certificate viewing window and then click the **Confirm Security Exception** button.

The login page will be opened.



5. Now the certificate file is already imported into Firefox and you find it in **Certificate Manager** of Firefox browser.

Internet Explorer in Windows 7



1. Enter "https://192.168.1.21" in the IE browser of Windows 7.

A warning messages window will pop-up.



2. Click **Continue to this website (not recommended)**.

Login page will be loaded with a "Certificate error" message displayed at the right end of address bar.



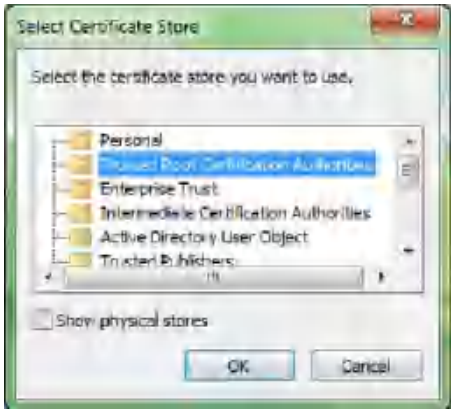
3. Click on **Certificate error** message, then click on **View certificates**.

There will be a pop-up window to show certificate information.



4. Click the **Install Certificate** button to install certificate.

The "Certificate Import Wizard" window will be shown.



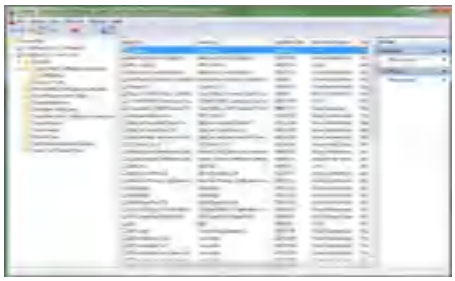
5. Click **Next**, on the **Certificate store** page, select the Certificate Store **Trusted Root Certification Authorities**.



6. Click **Finish** to import the certificate and close the Certificate Import Wizard window.



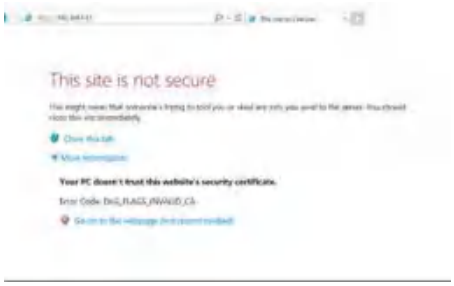
7. Click **Yes** on the pop-up Security Warning window to install the certificate.



8. The certificate is installed successfully and could be found under the Console Root/Certificates-Current User directory.

Edge in Windows 10

The following procedure for accessing the PowerLogic P5 web HMI uses the IE browser for illustration. The screen shots for the Edge browser are identical.



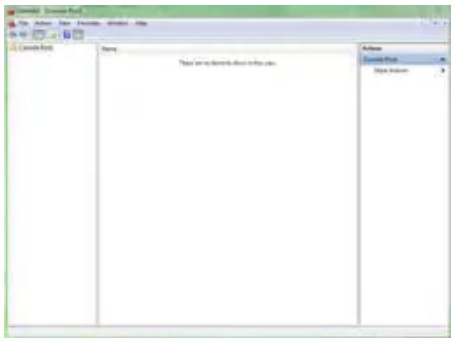
1. Enter "https://192.168.1.21" in the address bar of the Edge browser of Windows 10.

The left message will be displayed.



2. Click **Go on to the webpage (not recommended)**.

The left message displayed on the window, indicating that the right certificate needs to be installed in the computer first.



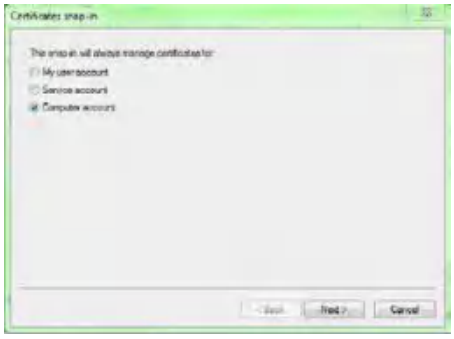
3. Click on **Start** button of desktop and then type in "mmc" in search bar.

The **Console** interface will be opened.



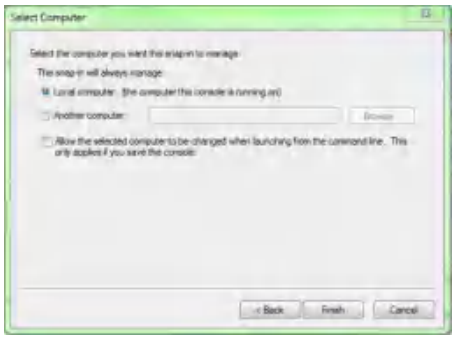
4. Click **File/Add/Remove Snap-in...**.

The **Add or Remove Snap-ins** window pops up.



5. Click **Certificates** in the left box and then click **Add** button.

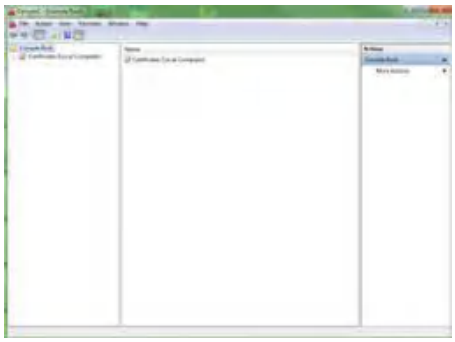
The **Certificates Snap-in** window appears.



6. Select **Computer account** and click **Next**.

The **Select Computer** window appears.

7. Select **Local computer** and click **Finish** to close **Select computer** window.



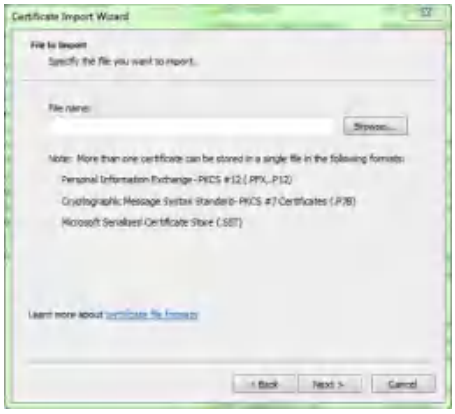
8. Click **Ok** to close **Add or Remove Snap-ins** window.

The “Console Root” folder in the **Console** interface is now populated with the "Certificates (local computer)" directory.



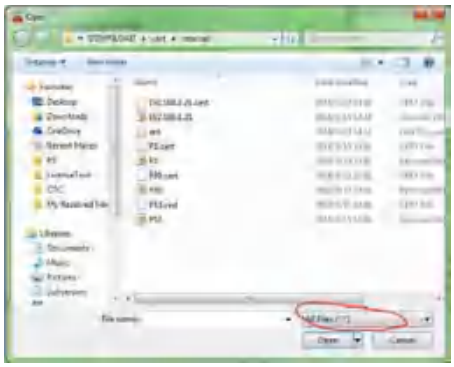
9. Select **Certificates (Local Computer)/Trusted Root Certification Authorities/Certificates** in the left box and then right click **Certificates** and select **All tasks/Import** in the context menu.

The "Certificate Import Wizard" window opens.



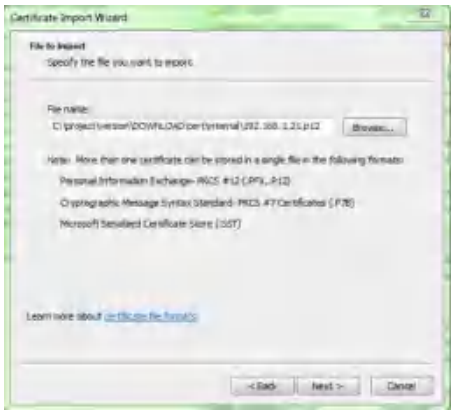
10. Click **Next**.

The "File to Import" window appears.

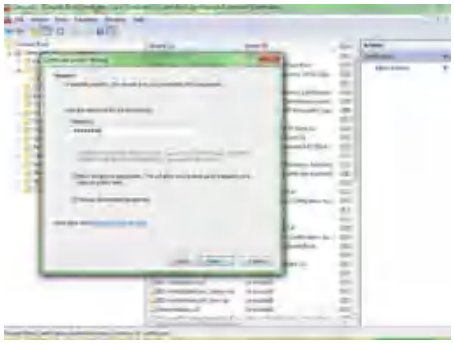


11. Click **Browse** and then, in the pop-up dialog box, select the path of the certificate followed by the certificate name "192.168.1.21.p12" (the suffix of the certificate is "p12").

Note that the file type should be **All Files**.

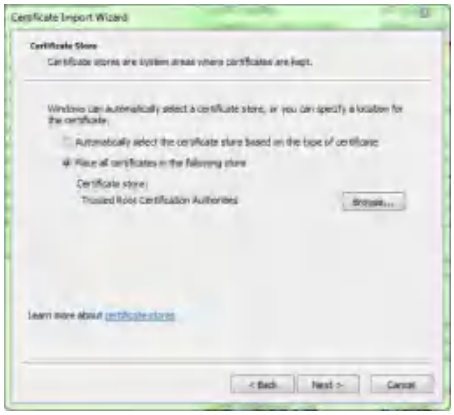


12. Click **Open** to finish locating the certificate file.



13. Click **Next** on the **File to Import** window.

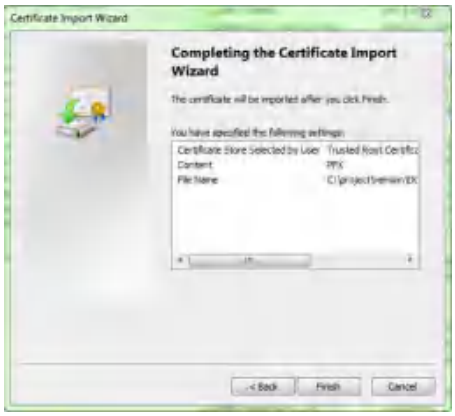
The "Password" window appears.



14. Type in the password "secbrick", check the **Mark this key as exportable...** option, and then click **Next**.

The "Certificate Store" window appears.

.



15. Check the **Place all certificates in the following store** option, browse to the certificate store folder "Trusted Root Certification Authorities", and then click **Next**.

The certificate import settings page appears.



16. Click **Finish**.

If the import was successful, a pop-up message with such content will appear on the screen.



17. After the certificate has been imported successfully, set up the Edge browser by checking the **Use TLS 1.0**, **Use TLS 1.1**, and **Use TLS 1.2** options under the **Advanced** tab of Internet options.



18. Enter "https://192.168.1.21" in the address bar of the Edge browser again.

Now we can access the Login page directly.

The EcoStruxure Power Device application

The EcoStruxure Power Device application is used to facilitate and simplify the operations and maintenance of the PowerLogic P5 protection relay, directly with a smart phone a few meters from the cubicle.

The EcoStruxure Power Device application can be connected to the PowerLogic P5 protection relay using a Wi-Fi router.

The EcoStruxure Power Device application provides easy access to device status, control and monitoring of the circuit breaker, measurements, settings, events and other functions through the mirror HMI or a simplified view.

- Mirror HMI:

  Duplicates the device display in the EcoStruxure Power Device application to perform actions more easily.

- Simplified view:

  The EcoStruxure Power Device application gives you an organised view of all the device's functionalities for easier access to data.

Connecting to protection relays via Ethernet

You can connect to a single protection relay or multiple protection relays via Ethernet.

Preparations before launching the EcoStruxure Power Device application

1. Equip the PowerLogic P5 protection relay with Ethernet modules (slot M or L).
2. Connect the PowerLogic P5 protection relay to a Wi-Fi router with RJ45 cable.
3. Configure the Wi-Fi network of the smart phone (IP address of the smart phone should be in the same network segment as the PowerLogic P5 protection relay).

Connecting to protection relays

1. Launch the EcoStruxure Power Device application.
2. Sign in with the account and password created at the Schneider Electric server.
3. Connect the new product via scanning QR code or selecting the PowerLogic P5 protection relay in the product list.
4. Enter the IP address of the PowerLogic P5 protection relay and click **Connect**.
5. Enter the username and password of the PowerLogic P5 protection relay.
6. A new window showing the PowerLogic P5 protection relay information opens.

Protection functions

General features of protection stages

Enable/disable protection functions

The different stages of the protection function can be enabled/disabled individually.

If a protection function stage is disabled, it is not shown in the **PROTECTION** menu in the local panel.

To enable or disable a protection function stage:

- With eSetup Easergy Pro or Web HMI, enter the **PROTECTION** menu/**Valid protection stages** sub-menu or directly go to each protection stage view in the same menu.
- With the local panel, enter the **Home** menu/**PROTECTION** sub-menu/**List of protection enabled** menu item/**Enabled Stages** menu item.

  The **Enabled Stages** menu item allows to enable or disable the protection stage(s) of a protection function. If a protection stage is enabled here, it appears in the **PROTECTION** menu as a menu option.

For the motor protection, there is a dedicated **Motor status** view (**PROTECTION** menu/**Motor status** sub-menu) where it is possible to enable or disable the following protection functions:

- Thermal overload protection for machine (ANSI code 49M)
- Motor start-up supervision (ANSI code 48)
- Motor restart inhibition (ANSI code 66)
- Locked rotor (ANSI code 51LR)
- Motor Anti-backspin (ABS) protection
- Motor speed detection
- Emergency restart

NOTE: The **Motor status** view is comprised of settings (e.g. nominal motor start current) common to these functions.

Setting groups

Setting groups are controlled by using controlling inputs like digital inputs, function keys, virtual inputs, HMI or custom logic.

When none of the assigned inputs are active, the active setting group is defined by parameter Setting group control in the **PROTECTION** menu/**Valid protection stages** sub-menu via eSetup Easergy Pro.

When one controlling input activates, the corresponding setting group is activated as well. If multiple inputs are active at the same time, the active setting group follows the definition by 'Setting group priority'.

By using virtual I/O the active setting group can be controlled using the local panel display, any communication protocol, or in-built programmable logic functions.

When a controlling input is configured, the **Setting group** parameter in the same menu is not operational.

Setting group changes are applied simultaneously to all protection functions.

Example of setting groups

Any digital input can be used to control setting groups but in this example DI1, DI2, DI3 and DI4 are chosen to control setting groups 1 to 4. This setting is done with the parameter 'Setting group x DI control' where x refers to the desired setting group.

'Setting group priority' is used to give a condition to a situation where two or more digital inputs, controlling setting groups, are active at the same time. 'Setting group priority' could have values: "1 to 4" or "4 to 1".

Assuming that DI2 and DI3 are active at the same time and 'Setting group priority' is set to "1 to 4" , setting group 2 becomes active. If 'Setting group priority' is reversed, that is, "4 to 1", the setting group 3 becomes active.

When a setting is selected by a digital input and this one is not activated, the 'Setting group' will not take effect.

Protection stage status

The status of a protection stage is one of the following:

- **Ok = '-'**

  The stage is idle and is measuring the analogue quantity for the protection. No power system fault detected.

- **Blocked**

  The stage is blocked for some reason (for example, through block matrix).

- **Start**

  The stage detected a fault (i.e. pick up value reached) and is counting the operation delay.

- **Trip**

  The stage has tripped and the fault is still on.

Directional operation

A global CT polarity setting is available in the **GENERAL** menu/**Scaling** submenu. These phase and neutral CT polarity settings affect:

- up to version v01.4xx.yyy only the ground differential protection function REF.

  NOTE: All other measurements and directional protection elements are not affected from this setting and still operate on measured current(s) and voltage(s) as per function description.

- from version v01.5xx.yyy additionally all measurements and directional protection elements (directional phase and neutral overcurrent, directional power, Wattmetric E/F, ...).

Mode of use for testing purposes

There is a **Mode of use** parameter which, when set to **Test** or **Test block** mode, allows forcing of the status of any protection stage to be **start** or **trip**. By using this forcing feature, current or voltage injection is not necessary to check the output matrix configuration, the wiring from the digital outputs to the circuit breaker and also to check that communication protocols are correctly transferring event information to a SCADA system.

The **Mode of use** can be configured in the **GENERAL** menu/**System info** sub-menu.

Start and trip signals

Every protection stage outputs two internal digital signals: start and trip. The start signal is issued when a fault has been detected. This start signal triggers the set operate timer. The trip signal is issued after the configured operate delay elapsed unless the fault disappears and starting resets before.

Global trip timer offers the possibility of assigning a dwell time delay (0.0...10.0 s) to the protection trip output. This **Minimum global trip cmd time** parameter can be configured in the **CONTROL** menu/**Global trip timer** sub-menu.

The hysteresis, as indicated in the protection stage's characteristics data, means that the signal is regarded as a fault until the signal drops below the start setting determined by the hysteresis value (see Hysteresis and reset ratio, page 261).

By using the output matrix, the user connects the internal start and trip signals to the digital outputs and indicators. See Output matrix, page 494.

Start and trip counters

Each protection function stage has a counter associated to the start and trip signals, they can be cleared individually.

Blocking

Any protection function, except arc-flash protection (see Arc-flash (ANSI 50ARC), page 373), can be blocked with internal and external signals through the block matrix. Internal signals are for example:

- logic outputs
- start signals from other stages
- trip signals from other stages

External signals are for example:

- digital inputs
- virtual inputs

Some protection stages are also inbuilt of blocking functions. For example, phase overcurrent protection with input of inrush detection.

Depending on the timing when the block input arrives at the protection function, the state of the protection will also be different:

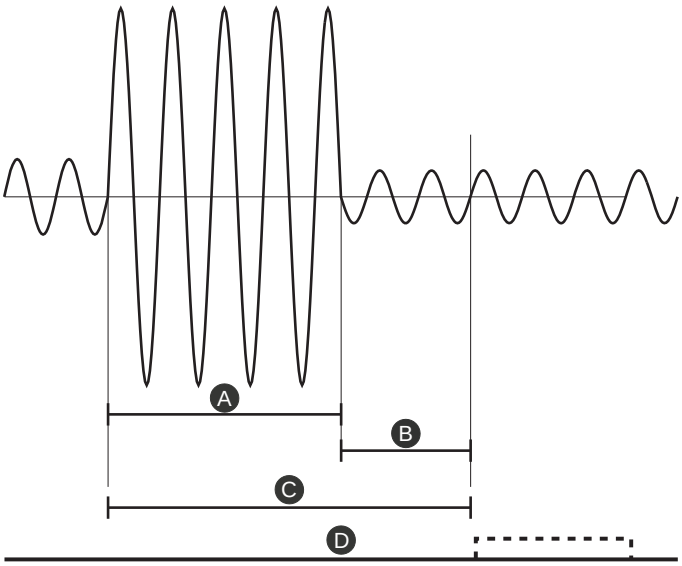
- If the protection is not started, the blocking input from block matrix will inhibit start, the protection will not trip in case of a fault condition.
- If the protection is started but not tripped, the blocking input from block matrix will frozen the delay counting until the blocking condition is off or the start resets, that is, the fault condition disappears.
- If the stage is already tripped, the blocking input from block matrix will reset both start and trip. The protection internal timer also resets to zero.

See Blocking matrix, page 494 for more information.

Overshoot time

Overshoot time is the time the protection relay needs to notice that a fault has been cleared during the operate time. This characteristic is important when grading the operate time settings between relays.

Figure 187 - Definition for overshoot time



A	Fault time	B	Overshoot time (≤ 50 ms)
C	Operate time configuration, have to be greater than the sum of fault time and overshoot time.	D	Trip contacts

For example, when there is a heavy fault in an outgoing feeder, it will start both the incoming and outgoing feeder relay. However, the fault must be cleared by the outgoing feeder protection relay and the incoming feeder relay must not trip. Although the operating delay setting of the incoming feeder is more than that of the outgoing feeder, the incoming feeder might still trip if the operate time difference is not big enough. The difference must be more than the overshoot time of the incoming feeder relay plus the operate time of the outgoing feeder circuit breaker.

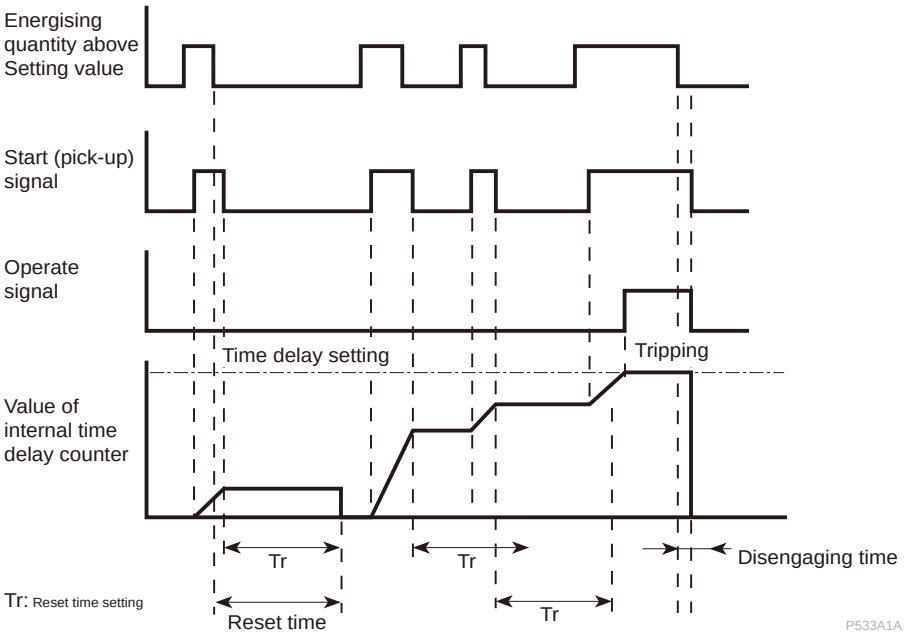
Definition for overshoot time, page 260 shows an overvoltage fault seen by the incoming feeder when the outgoing feeder clears the fault. If the operation delay setting would be slightly shorter or if the fault duration would be slightly longer than in the figure, an unselective trip might happen (the dashed pulse in the figure). In devices, the overshoot time is less than 50 ms.

Disengaging time and reset time

The disengaging time is the time between the moment when the fault conditions disappear and the moment the tripping contact relay opens. It is an instantaneous time.

Disengaging time and adjustable reset time according to IEC 60255-151 standard, page 261 shows an example of reset time, that is, release delay when the PowerLogic P5 protection relay is clearing an overcurrent fault. When the PowerLogic P5 protection relay's trip contacts are closed, the circuit breaker (CB) starts to open. After the CB contacts are open, the fault current still flows through an arc between the opened contacts. The current is finally cut off when the arc extinguishes at the next zero crossing of the current. This is the start moment of the reset delay. After the reset time delay the trip contact and start contact are opened unless latching is configured. The precise reset time depends on the fault size; after a significant fault, the reset time is longer. The reset time also depends on the specific protection stage. The maximum reset time for each stage is specified under the characteristics of every protection function.

Figure 188 - Disengaging time and adjustable reset time according to IEC 60255-151 standard



The adjustable reset time is a definite or inverse time hold used mainly to detect restriking faults (DT) or allow coordination with electromechanical protection relays (Inverse). It can be used also for coordination with electromechanical relays.

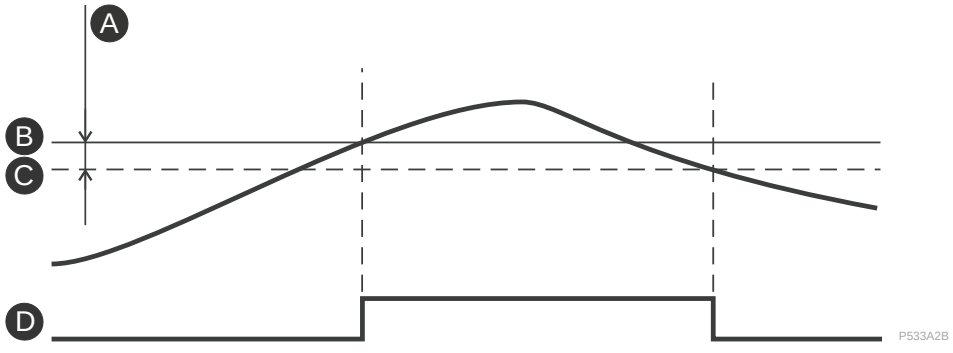
It is implemented in the following protection functions:

- Non-directional/directional phase overcurrent protection (ANSI 50/51/67)
- Non-directional/directional earth/ground fault overcurrent protection (ANSI 50N/51N/67N)
- Negative sequence overcurrent (ANSI 46)

Hysteresis and reset ratio

When comparing a measured value against a start value, some amount of hysteresis is needed to avoid oscillation near equilibrium situation. With zero hysteresis, any noise in the measured signal or any noise in the measurement itself would cause unwanted oscillation between fault-on and fault-off situations.

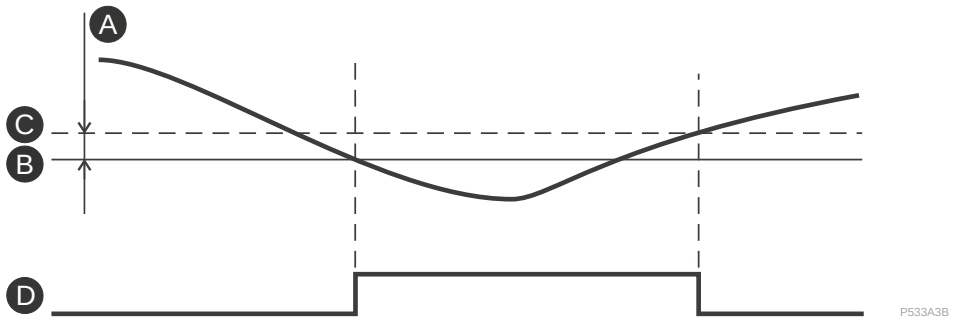
Figure 189 - Example of behaviour of an over-protection with hysteresis



A	Hysteresis	B	Start level
C	Reset level	D	Start

The reset ratio is the ratio between the reset level and the start level. To avoid any chattering of the protection for low settings of thresholds, a reset ratio can be claimed with a minimum value of hysteresis. For example: <93% with a minimum of hysteresis of 0.005 Inom.

Figure 190 - Example of behaviour of an under-protection with hysteresis



A	Hysteresis	B	Start level
C	Reset level	D	Start

Time grading for logic selectivity

When a fault occurs, the protection scheme only needs to trip circuit breakers whose operation is required to isolate the fault.

This selective tripping is also called discrimination or protection coordination and is typically achieved by time grading. Protection systems in successive zones are arranged to operate in times that are graded through the sequence of equipment so that upon the occurrence of a fault, although there are a number of protections that devices respond to, only those relevant to the faulty zone complete the tripping function.

The different operation time characteristics of control outputs have to be considered:

- the signaling of the raising edge (“make”) with high speed output is at least 5 ms faster than with conventional hinged-armature relay output;
- the signaling of the falling edge (“break”) with high speed output is at maximum 15 ms slower than with conventional hinged-armature relay output.

The recommended discrimination time between two PowerLogic P5 protection relays in an MV network is 200 ms considering a CB opening time of 60 ms.

Accuracy claims

All accuracy claims on operation and reset thresholds and times are based on tests performed according to related functional standard of the IEC 60255-1xx series.

Unless explicitly stated (or required per standard) the tests were executed under reference conditions:

- quasi-stationary semisolid signals at nominal frequency fnom (frequency protection excepted)
- total harmonic distortion ≤ 2 %
- ambient temperature 20°C (68°F)
- nominal auxiliary voltage VA.nom

Deviations are claimed relative to the setting under such reference conditions, where required also with an additional absolute value (usually relevant at very small/ low set thresholds only).

Recorded values on the last eight faults

There are detailed information available on the last eight faults for each of the protection stages. The recorded values are specific for protection stages and could contain information like time stamp, fault value, elapsed delay, fault current, fault voltage, phase angle and setting group.

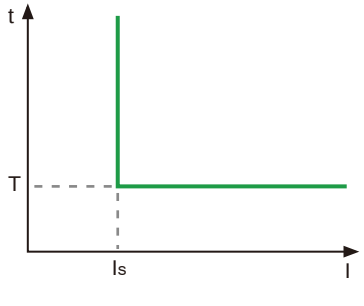
Dependent time and definite time operation

Description

Definite time protection

The tripping time is constant. The operation time is started when the set point is overrun.

Figure 191 - Definite time protection



Dependent time operation

The dependent time operation is the Inverse Definite Minimum Time (IDMT) type of operation in accordance with standards IEC 60255-151, BS 142 and IEEE C-37.112. The dependent time operation is available for several protection functions:

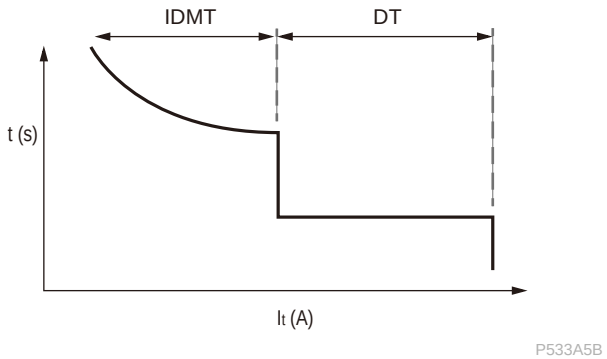
- Overcurrent protection (directional or not),
- Earth/ground fault protection (directional or not),
- Over/under voltage protection

The operate time in the dependent time mode (IDMT) is dependent on the magnitude of the fault. The bigger the fault, the faster the stage issues a trip signal and vice versa. The trip time calculation resets if the injected quantity drops below the start level.

The operate time in Definite Time (DT) mode is defined regardless of the fault signal. It is activated as soon as the pickup value is reached.

The operate time in the definite time mode is fixed by the operate delay setting. The timer starts when the protection stage starts and counts until the set time has elapsed. After that, the stage issues a trip command. If the fault is cleared before the definite time has elapsed, then the protection stage resets.

Figure 192 - Dependent time and definite time operation curves



Stage-specific dependent delay

Some protection functions have their own specific type of dependent delay. Details of these dedicated dependent delays are described with the appropriate protection function.

Operation modes

There are two operation modes to use the dependent time characteristics:

- Standard delays

  Using standard delay characteristics by selecting the **Operating curve** parameter in dedicated protection function. See Standard dependent operation delay, page 266.

- Fully programmable dependent delay characteristics

  Building the characteristics by setting 16 [current, time] points. The relay interpolates the values between given points with second degree polynomials. This mode is activated by the setting curve family to "PrgN", where N = 1, 2, 3, corresponding to the three different programmable curves available. Each programmed curve can be used independently by any number of protection stages. See Programmable dependent time curves, page 268.

Local panel graph

PowerLogic P5 protection relay shows a graph of the currently used dependent delay on the local panel display. The up and down keys can be used for zooming. Also the delays at 20 x I_{set}, 4 x I_{set}, 2 x I_{set} and 1.05 x I_{set} are shown.

Limitations

The minimum definite operation time starts when the measured value exceed the G_D[39] value, which is varied for different curves.

Curve	G_D (x G_S)
IEC SI	30
IEC VI	30
IEC EI	20
IEC LTI	30
UK RECT	15
RI	36
IEEE MI	76
IEEE VI	76
IEEE EI	76
NI CO8	76
STI CO2	76
LTI CO5	76
MI CO7	76
VI CO9	76
EI CO11	76
IEC UTI	76
FR STI	76

39. Threshold of independent time operation

BPN	76
ANSI NI	76
ANSI STI	76
ANSI LTI	76

Standard dependent operation delay

The standard dependent operation delay curves follow the equation below:

$$t(s) = TMS \times \left[\frac{k}{\left(\frac{G}{G_S} \right)^{\alpha} - p} + c \right]$$

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where:

- t(s) is the operate time in seconds.
- G is the measured value.
- G_S is the start value.
- TMS is Time Multiplier Setting.

Table 48 - IDMT operating characteristics

Description **according to IEC60255-151 standard**	**k**	**c**	**α**	**p**	
Data attribute **according to IEC 61850-7-3 standard**	**setParA**	**setParB**	**setParC**	**setParD**	**SetCharact**
IEC Standard Inverse (IEC/A)	0.14	0	0.02	1	9
IEC Very Inverse (IEC/B)	13.5	0	1	1	10
IEC Extremely Inverse (IEC/C)	80	0	2	1	12
IEC Long Time Inverse	120	0	1	1	14
IEC Ultra Time Inverse	315.2	0	2.1	1	17
Rectifier Inverse	45900	0	5.6	1	18
RI	-4.2373	0	-1	1.43644	19
FR Short Time Inverse	0.05	0	0.04	1	20
BPN (EDF)	1000	0.655	2	1	21
IEEE Moderately Inverse (IEC/D)	0.0515	0.114	0.02	1	4
IEEE Very Inverse (IEC/E)	19.61	0.491	2	1	2
IEEE Extremely Inverse (IEC/F)	28.2	0.1217	2	1	1
Short-Time Inverse (CO2)	0.1052	0.0262	0.8	1	22

Table 48 - IDMT operating characteristics (Continued)

Description according to IEC60255-151 standard	k	c	α	p	
Data attribute according to IEC 61850-7-3 standard	setParA	setParB	setParC	setParD	SetCharact
Long-Time Inverse (CO5)	4.842	1.967	1.1	1	23
Moderately Inverse (CO7)	0.0094	0.0366	0.02	1	24
Inverse (CO8)	5.95	0.18	2	1	25
Very Inverse (CO9)	4.12	0.0958	2	1	26
Extremely Inverse (CO11)	5.57	0.028	2	1	27
ANSI Normally Inverse	8.9341	0.17966	2.0938	1	29
ANSI Short Time Inverse	0.2663	0.03393	1.2969	1	30
ANSI Long Time Inverse	5.6143	2.18592	1	1	31

NOTE:

- SetCharact is for DT curve: 5.
- The effective operate value G_T defined in IEC 60255-151 is equal to 1.05 x G_S.

Standard dependent reset delay

After the IDMT time elapses, the operation timer is reset when the start signal goes low, according to the following equation:

$$t_{reset}(I) = TMS \times \left[\frac{tr}{1 - \left(\frac{G}{G_s} \right)^p} \right]$$

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The reset time characteristic is defined by a setting in the protection stage. The allowed settings are dependent on the operate curve as shown in the table.

Table 49 - IDMT reset time

Operating curve	Reset curve		
	IDMT		DT
	tr(s)	P	
DT	-	-	Yes
IEC Standard Inverse (IEC/A)	8.2	6.45	Yes
IEC Very Inverse (IEC/B)	50.92	2.4	Yes
IEC Extremely Inverse (IEC/C)	44.1	3.03	Yes
IEC Long Time Inverse)	40.62	0.4	Yes
IEC Ultra Time Inverse	-	-	Yes

Table 49 - IDMT reset time (Continued)

Operating curve	Reset curve		
	IDMT		DT
	tr(s)	P	
Rectifier Inverse	-	-	Yes
RI	-	-	Yes
FR Short Time Inverse	-	-	Yes
BPN (EDF)	-	-	Yes
IEEE Moderately Inverse (IEC/D)	4.85	2	Yes
IEEE Very Inverse (IEC/E)	21.6	2	Yes
IEEE Extremely Inverse (IEC/F)	29.1	2	Yes
Short-Time Inverse (CO2)	0.1052	2	Yes
Long-Time Inverse (CO5)	4.842	2	Yes
Moderately Inverse (CO7)	0.0094	2	Yes
Inverse (CO8)	5.95	2	Yes
Very Inverse (CO9)	4.12	2	Yes
Extremely Inverse (CO11)	5.57	2	Yes
ANSI Normally Inverse	9	2	Yes
ANSI Short Time Inverse	0.5	2	Yes
ANSI Long Time Inverse	15.75	2	Yes

The TMS (inverse time coefficient) of the IDMT reset curve is the one defined for the operating curve.

For all operating curves not listed in the table above, the reset curve is of DT type.

Programmable dependent time curves

Programming dependent time curves requires eSetup Easergy Pro setting tool and rebooting the unit.

The [current, time] curve points are programmed using eSetup Easergy Pro PC program. There are some rules for defining the curve points:

- the configuration must begin from the top line
- the line order must be as follows: the smallest current (longest operate time) on the top and the largest current (shortest operate time) on the bottom
- all unused lines (on the bottom) should be filled with I/I_{start} = 1 and operate time = 0.00 s

Here is an example configuration of curve points:

Table 50 - Example configuration of curve points

Point	Current I/I_{start}	Operate delay
1	1.00	10.00 s
2	2.00	6.50 s
3	5.00	4.00 s
4	10.00	3.00 s
5	20.00	2.00 s
6	40.00	1.00 s
7	1.00	0.00 s

Table 50 - Example configuration of curve points (Continued)

Point	Current I/I_{start}	Operate delay
8	1.00	0.00 s
9	1.00	0.00 s
10	1.00	0.00 s
11	1.00	0.00 s
12	1.00	0.00 s
13	1.00	0.00 s
14	1.00	0.00 s
15	1.00	0.00 s
16	1.00	0.00 s

Cold load pick-up

Description

Cold load pick-up

The cold load pickup function detects that a cold load condition exists and provides an information to optionally change the selected current protection settings for defined duration of time after energisation of the load.

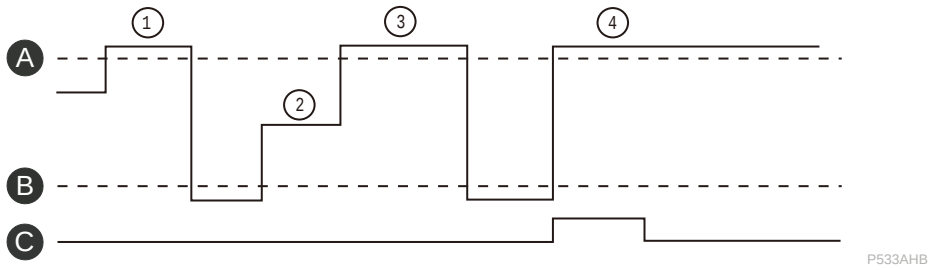
A situation is regarded as cold load when all the three phase currents have been below a given idle value for longer than the cold time setting and then at least one of the currents exceeds a given pick-up level within 80 ms. In such a case, the cold load detection signal is activated and will keep active for "CLPU time delay" for a given time. This signal is available for the output matrix and blocking matrix.

Application for cold load detection

Right after closing a circuit breaker, a given amount of overload can be allowed for a given limited time to take care of situations where a load has been de-energised for an extended period of time and is then re-energised. This applies particularly to applications such as motor loads (e.g., compressor motor inside air conditioning loads) or thermostatically controlled heating of water where the load current is much greater for a cold load than when it is operating normally. So, the cold load pickup function can improve the profiling of overcurrent protection settings to dynamic load situations caused by load de-energisation.

Example

Figure 193 - Functionality of cold load current feature



A	Pick-up value	B	Idle state
C	Cold load		

1. No activation because the current has not been under the set Idle current.
2. Current dropped under the Idle current level but now it stays between the Idle current and the pick-up current for over 80 ms.
3. No activation because the phase two lasted longer than 80 ms.
4. Now we have a cold load activation which lasts as long as the “CLPU time delay” was set or as long as the current stays above the pick-up setting.

Characteristics

Table 51 - Settings and characteristics of cold load pick-up function

Settings/characteristics (description/label)	Value
Idle current/Idle current	
Range	0.01...0.50 pu[40]
Resolution	0.01 pu[40]
Pickup current/Pickup	
Range	0.30...10.00 pu[40]
Resolution	0.01 pu[40]
CLPU dead time/Dead time	
Setting range	0.10...14400.00 s
Resolution	0.01 s
CLPU time delay/Max time	
Setting range	0.01...300.00 s
Resolution	0.01 s
Accuracy	1% or ±20 ms

40. Nominal CT Rating

Selective Overcurrent Logic (SOL)

Description

The Selective Overcurrent Logic (SOL) function, can considerably reduce the tripping time of the circuit breakers closest to the source, compared to a pure time discrimination, and may be used for logic discrimination in closed ring networks also using directional protection.

SOL function is applied to the non-directional/directional phase overcurrent protection (ANSI 50/51/67), non-directional/directional earth/ground fault overcurrent protection (ANSI 50N/51N/50G/51G/67N), definite time and IDMT.

With PowerLogic P5 protection relays, the discrimination can be done in two different ways:

- Logic overcurrent stages protection functions that send SOL signals (downstream protection) and that may be prevented from tripping by the reception of SOL signals (upstream protection).
- Time-based overcurrent stages: protection stages that may delayed by SOL signals (upstream protection). They are used as backup for the logic overcurrent stages.

When a fault occurs:

- Any downstream protection can activate the SOL function through the output matrix, so that the SOL function can send a SOL signal to the upstream protections.
- At the reception of the SOL signal by the upstream protection, the latter changes its operating delay from operate delay to SOL operate delay. When the upstream protection is using IDMT delay, SOL will also have impact on the curve settings.

Operation

To implement the SOL function, downstream and upstream protection should be set as follows:

Set the downstream protection to send the SOL1 trip signal to upstream relay:

1. Check the **Enable for SOL** box in the **Selective overcurrent logic** view of **PROTECTION** Menu in Easergy Pro.
2. Select from the drop-down list of **SOL signal number**.
3. Set the value of **CB trip clearing time**.
4. Switch to **MATRIX** menu/**Output matrix** submenu, configure the PowerLogic P5 output matrix:

   Connect the start signals of the different protections involved in the logic discrimination to the SOLxStart (x = 1 or 2) signal, then connect the SOLx trip (x = 1 or 2) signal to a dedicated contact relay or GOOSE output.

Set the upstream protection to receive the SOLx trip signal:

1. Configure the PowerLogic P5 output matrix:

   Connect the dedicated logic input (DI or GOOSE input signal), linked with the downstream SOLx trip signal, to the SOL Inputx signal.
2. Switch to **PROTECTION** menu, select specific protection function in the left column, set the SOL status to the value "SOLx"
3. Set the **SOL operate delay** to a value higher than the value of the setting **Operate delay**.

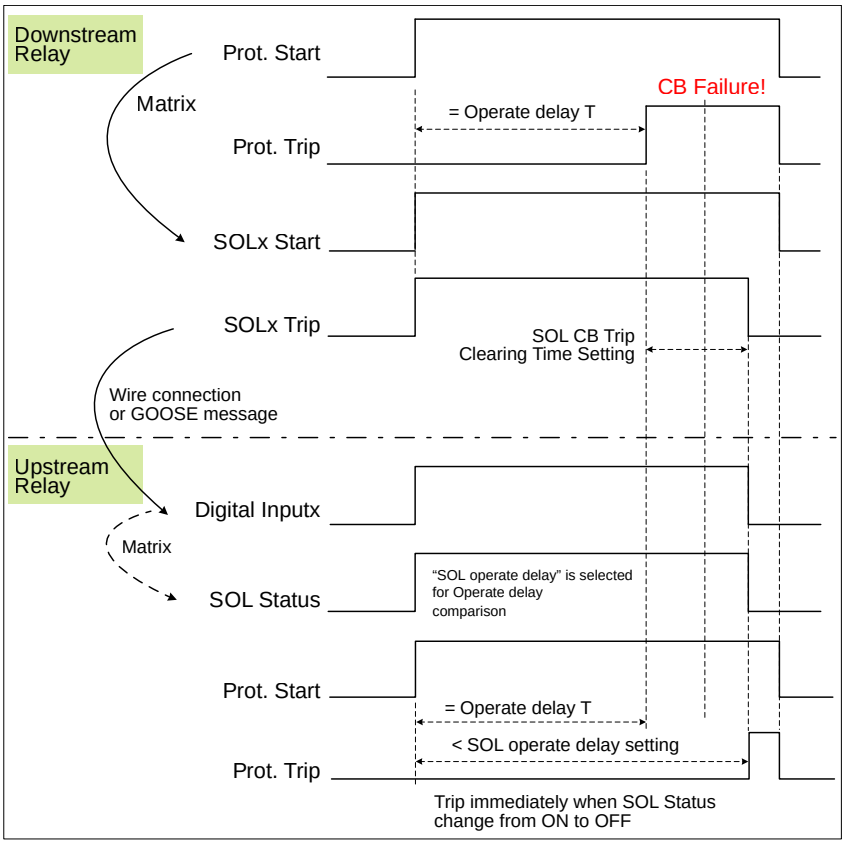
Up to two output signals can be provided by the SOL function.

The value of the setting **SOL operate delay** should be greater than the value of the setting **Operate delay** in the overcurrent protection plus the value of the setting **CB trip clearing time** in the SOL function. The setting **SOL operate delay**

can make sure the downstream protection tripping with selectivity. The setting **CB trip clearing time** is used to set the release time of the SOL trip signal for the downstream protection.

If a fault occurs at downstream, the downstream protection issues a trip command to isolate the fault according to the value of the setting **Operate delay**. Then a global trip signal is activated by the trip signal. At the same time, a timer with the value of the setting **CB trip clearing time** is triggered by the global trip signal and starts timing. If the downstream protection successfully isolates the fault, the SOL signal is released and all the P5 relays of the upstream protection will be reset. If the downstream protection cannot clear the fault due to a CB fail, when the tripping duration time of the downstream protection exceeds the value of the setting **CB trip clearing time**, consequently upstream protection nearest to the downstream protection will switch the value of the setting **SOL operate delay** to the value of the setting **Operate delay** due to no reception of the SOL signal. Then the protection will trip immediately.

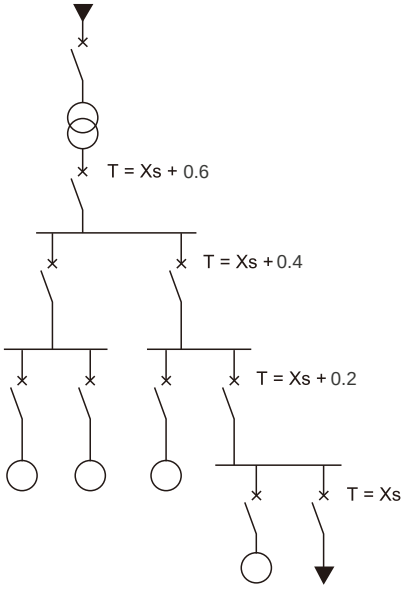
The SOL operate delay of the upstream protection usually takes into account the breaking device operating time and the protection reset time.



NOTE: Normally Prot.Start/Prot.Trip means the start/trip signal of over current protection or earth/ground fault protection (50/51/67/50N/51N/50G/51G/67N). SOL operation delay setting should be greater than "Operation delay T + SOL CB Trip Clearing Time Setting".

Example 1

Figure 194 - Example 1: Radial distribution with use of time-based discrimination

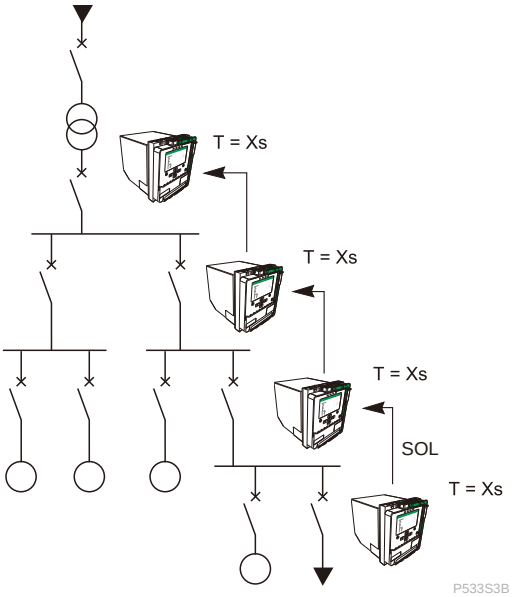


T: operate delay setting in protection function

The upstream protection units are typically delayed by 0.2 s to give the downstream protection units time to trip. When there are many levels of discrimination, the protection tripping time at the source is long. In this example, if the protection tripping time for the protection unit furthest downstream is Xs = 0.2 s, the protection tripping time at the source is T = Xs + 0.6 s = 0.8 s.

Example 2

Figure 195 - Example 2: Radial distribution with use of logic discrimination

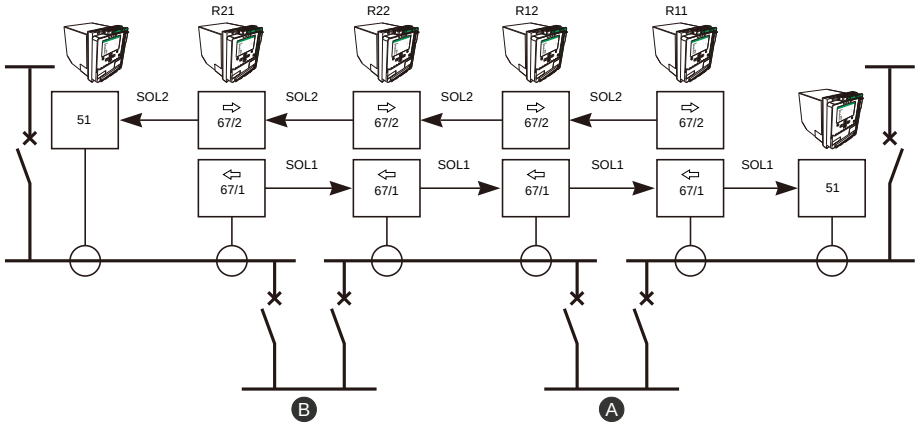


T: operate delay setting in protection function

When a fault appears, the protection units that detect it inhibit the upstream protection units by switching to the SOL operate delay setting. 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.

Closed ring network application

The SOL function can support the closed ring network which includes two substations application, each of which comprises two PowerLogic P5 relays, marked R11, R12 and R21, R22. Each of the PowerLogic P5 relay configures different directional overcurrent units (stages).



A Substation 1 B Substation 2

Starting at one end of the ring, the detection direction of PowerLogic P5 unit 1 and 2 of the directional protection functions should be alternated between line and busbars.

Characteristics

Settings and characteristics	Values
Enable for SOL/SOL	
Options[41]	Disabled; Enabled
SOL1Start	
Options[41]	-; Trip
SOL2Start	
Options[41]	-; Trip
SOL signal number/SOL op number	
Range	1, 2
CB trip clearing time/CB trip time	
Setting range	0.00...1.00 s
Resolution	0.01 s

41. Configured via Output Matrix

Incomer fault locator (ANSI 21FL)

Description

The PowerLogic P5 protection relay can locate a short-circuit in a radial operated network.

The fault location is given in reactance (ohms) and kilometers or miles. The fault value can then be exported, for example, with an event to a Distribution Management System (DMS). The system can then localise the fault. If a DMS is not available, the distance to the fault is displayed as kilometers, and as a reactance value. However, the distance value is valid only if the line reactance is set correctly. Furthermore, the line should be homogenous, that is, the wire type of the line should be the same for the whole length. If there are several wire types on the same line, an average line reactance value can be used to get an approximate distance value to the fault. Names and reactance values for widely used overhead wires are:

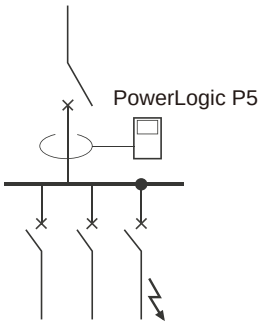
- Sparrow: 0.408 ohms/km or 0.656 ohms/mile
- Raven: 0.378 ohms/km or 0.608 ohms/mile

NOTE: The fault locator is normally used in the incoming bay of the substation. Therefore, the fault location is obtained for the whole network with just one PowerLogic P5 protection relay, by compensating the effect of the healthy feeders.

The incomer short circuit fault locator operates if:

- The PowerLogic P5 protection relay is located in the incoming feeder.
- The CTs and VTs are connected such that the fault is seen in the forwards direction. Any fault seen in the reverse direction will not produce a fault location result.

Figure 196 - Example of fault on feeder detected by the incomer fault detector



The algorithm functions in the following order:

1. The needed measurements (phase currents and phase to phase voltages) are continuously available.
2. The fault distance calculation can be triggered in two ways:
   - By opening a feeder circuit breaker due to a fault and sudden increase in phase currents (Enable incomer fault locator + Triggering digital input).
   - Another option is to use only the sudden increase in the phase currents (Enable incomer fault locator).
3. Phase currents and voltages are registered in three stages: before the fault, during the fault and after the faulty feeder circuit breaker was opened.
4. The fault distance quantities are calculated.
5. Two phases with the biggest fault current are selected.
6. The load currents are compensated.
7. The faulty line length reactance is calculated.

$$Z_{AB} = \frac{\vec{V}_A - \vec{V}_B}{\vec{I}_A - \vec{I}_B - \vec{I}_{pre\text{-}fault}}$$

P533AKB

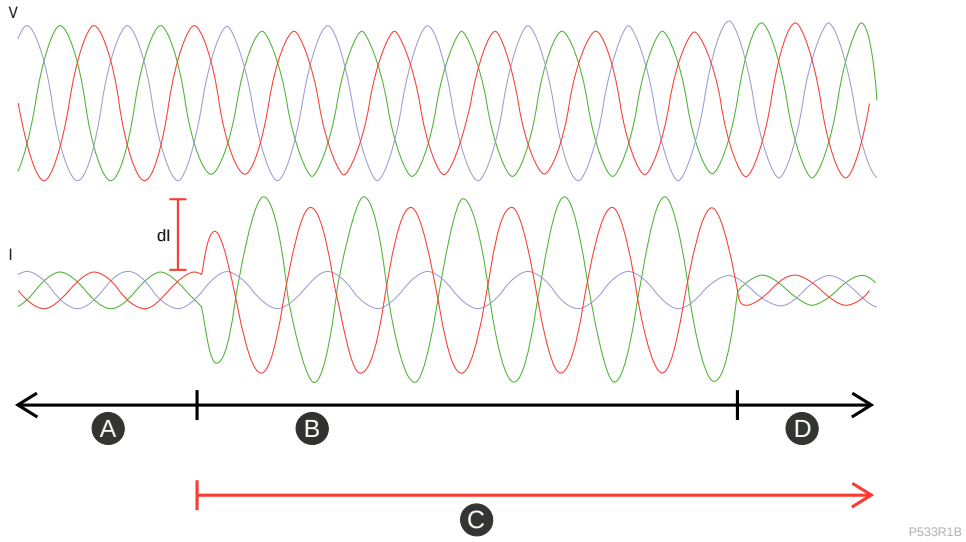
VA	Phase A to ground voltage
VB	Phase B to ground voltage
IA	Phase A current
IB	Phase B current
$I_{pre\text{-}fault}$	Pre-fault load current

The reference current setting is used to start the calculation of the fault locator based on the pre-fault current magnitude. The calculation can be triggered by a digital or logic input.

Example

An application example where the fault location algorithm is used at the incomer side is presented below. The settings of the Incomer fault locator function is configured in the **PROTECTION** menu/**Incomer fault locator** sub-menu.

Figure 197 - Illustration of the fault location algorithm used at the incomer side



P533R1B

A	Pre-fault time more than 2 s	B	In order to calculate the fault location, the fault current must be present for at least 0.08 s and last no longer than 1 s
C	When the digital input is used together with the current change, the input signal has to be activated at least 0.5 s after the fault occurs	D	Post-fault only few cycles

Characteristics

Table 52 - Setting parameters of incomer fault locator

Parameter	Value	Unit	Default	Description
Triggering digital input (Trig DI)	Selection of one digital input (DI), one virtual input (VI), one virtual output (VO), or one function key (Fx)	-	-	Trigger mode (= triggering based on sudden increase of phase current, otherwise sudden increase of phase current + DIx/VIx)
Line reactance/ unit (Xline)	0.010...10.000	Ohm	0.389	Per unit (positive-sequence) reactance of the line. This value is only used to convert the fault reactance to the distance per set unit (kilometers or miles).
Current change to trig (dI)	0.10...8.00	pu	0.5	Trig current (sudden increase of phase current)
Blocked before next trig	10...600	s	70	Blocks function for this time after trigger. This is used for blocking calculation during auto-reclosing sequences.
Xmax limit	0.5...500.0	Ohm	500.0	Limit for maximum reactance. If the reactance value is above the set limit, the calculation result is not shown.
Unit	Editable for user	-	km	-
Event	Disabled; Enabled	-	Enabled	Event mask
Accept zero pre-fault current	Disabled; Enabled	-	Disabled	-

Table 53 - Measured and recorded values of incomer short circuit fault locator

	Parameter	Unit	Description
Measured values/ recorded values	Distance fault	km	Distance to fault
	XFlt	Ohm	Fault reactance
	Date	-	Fault date
	Time	hh:mm:ss:mss	Fault time
	Cntr	-	Number of faults
	Pre	A	Current before fault (= load current)
	Fault	A	Fault current
	Post	A	Current after fault
	V drop	%	Voltage drop during the fault
	Duration	s	Fault duration
	Type	-	Fault type (1-2, 2-3, 1-3, 1-2-3)

Feeder fault locator (ANSI 21FL)

Description

The PowerLogic P5 protection relay can locate a short-circuit fault and an earth/ground fault on the feeder itself in a radially operated network. The fault location function (ANSI code 21FL) is given as a reactance (ohms) and converted to kilometers or miles. The fault value can then be exported, for example, with an event to a Distribution Management System (DMS). The system can then localise the fault. If a DMS is not available, the distance to the fault is displayed as kilometers/miles and as a reactance value.

However, the distance value is valid only if the line reactance is set correctly.

Furthermore, the line should be homogenous, that is, the wire type of the line should be the same for the whole length. If there are several wire types on the same line, an average line reactance value can be used to get an approximate distance value to the fault. Names and reactance values for widely used overhead wires are:

- Sparrow: 0.408 ohms/km or 0.656 ohms/mile
- Raven: 0.378 ohms/km or 0.608 ohms/mile

When the feeder fault locator is calculating short-circuit impedance, the following formula is used:

$$\vec{Z}_{AB} = \frac{\vec{V}_A - \vec{V}_B}{\vec{I}_A - \vec{I}_B}$$

P533ANB

VA	Phase A to ground voltage
VB	Phase B to ground voltage
IA	Phase A current
IB	Phase B current

When the feeder fault locator is calculating ground fault impedance, the following is used (e.g. for phase A):

$$\vec{Z}_A = \frac{\vec{V}_A}{\vec{I}_A + k \times \vec{I}_N}$$

P533APB

VA	Phase A to ground voltage
IA	Phase A current
k	Earth/ground factor k, needs to be set by user
IN	Earth/ground fault overcurrent, calculated from phase currents (IN.calc)

$$\overrightarrow{IN}_{.calc} = \vec{I}_A + \vec{I}_B + \vec{I}_C$$

P533ARB

The earth/ground factor k is calculated with the following formula:

$k = (Z_{0L} - Z_{1L}) / (3 \times Z_{1L})$

where:

Z_{0L} = Zero sequence line impedance

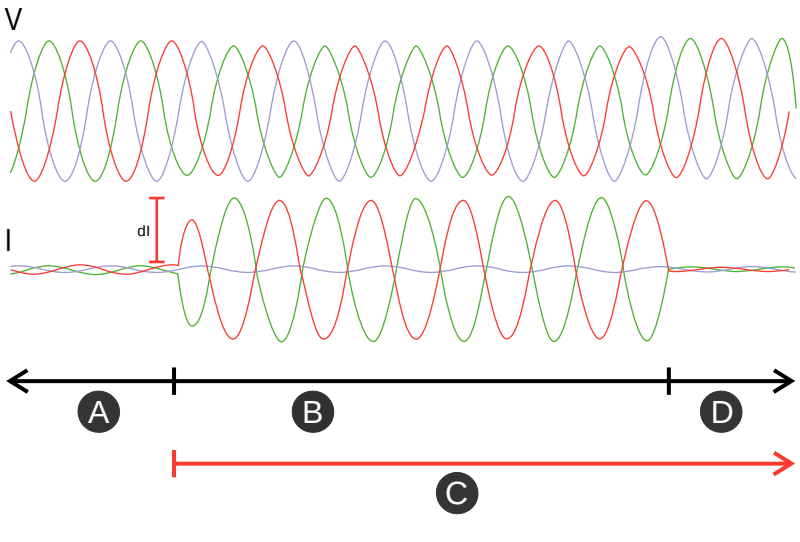
Z_{1L} = Positive sequence line impedance

Fault reactance calculation is triggered if the start value is exceeded or both “Start setting” and “Triggering digital input” terms are fulfilled. When used, “Triggering digital input” can be either digital or virtual input.

Example

An application example where the fault location algorithm is used at the feeder side is presented below. The settings of the feeder fault locator function is configured in the **PROTECTION** menu/**Feeder fault locator** sub-menu.

Figure 198 - Illustration of the fault location algorithm used at the feeder side



A	Pre-fault time more than 2 s	B	In order to calculate the fault location the fault current must be present for at least 0.08 s and last no longer than 1 s
C	When the digital input is used together with the current change, the input signal has to be activated at least 0.5 s after the fault occurs	D	Post-fault only few cycles

Characteristics

Table 54 - Settings and characteristics of the feeder fault locator function (ANSI 21FL)

Parameter	Value	Unit	Default	Description
Pick-up value	0.10...5.00	pu[42]	1.2	Current limit for triggering.
Triggering digital input	Selection of one digital input (DI), one virtual input (VI), one virtual output (VO), or one function key (Fx)	-	-	Trigger mode (= triggering based on sudden increase of phase current, otherwise sudden increase of phase current + DIx/VIx/VOx/Fx)
Line reactance/ unit (Xline)	0.010...10.000	Ohm	0.491	Per unit positive-sequence reactance of the line. This value is only used to convert the fault reactance to the distance per set unit (kilometers or miles).
Earth factor	0.000...10.000	-	0.678	Calculated earth factor from line specifications.
Earth factor angle	-60... +60	°	10	Angle of calculated earth factor from line specifications.
Unit	km	-	km	Unit of distance
Event enabling	Off; On	-	On	Event mask

42. Inom = phase CT primary nominal

Table 55 - Measured and recorded values of feeder fault locator

	Parameter	Unit	Description
Measured values/ recorded values	Distance	km	Distance to the fault
	Xfault	Ohm	Fault reactance
	Cntr	-	Number of faults
	Type	-	Fault type: IA-N, IB-N, IC-N; IA, IB-N; IB, IC-N; IA, IC-N; IA-IB; IB-IC; IA-IC IA-B-C; IA, B, C-N

Neutral admittance (ANSI 21YN)

Description

The neutral admittance protection function can be applied in high resistance earthed/grounded, unearthed/ungrounded or compensated power system to detect earth/ground fault with increased sensitivity. Two stages of the neutral admittance protection are available in the PowerLogic P5 protection relay, each stage has three elements: over-admittance (YN>1 or YN>2), over-conductance (GN > 1 or GN > 2) and over- susceptance (BN > 1 or BN > 2).

The neutral admittance Y_n is calculated based on the neutral current IN and the neutral voltage VN:

$Y_n = G_n + jB_n = IN / -VN = 3IN / -3VN$

The source of the neutral current is settable from the sensitive E/F CT, CSH core balance CT, standard E/F CT, or the sum of three phase currents.

The neutral admittance protection is blocked if the following conditions are met:

- The neutral current is based on the sum of three phase currents
- The CTS supervision function detects a CT failure
- The CTS output signal is configured to block neutral admittance protection through the blocking matrix

The source of the neutral voltage is from the direct measurement when the Voltage mode is “+VN”, otherwise the source of the neutral voltage is from the sum of three phase voltages. The neutral admittance protection is only active when the neutral voltage VN is above the setting threshold.

The neutral admittance protection is also blocked if the following conditions are met:

- The neutral voltage is based on the sum of three phase voltages
- The VTS supervision function detects a VT failure
- The VTS output signal is configured to block neutral admittance protection through the blocking matrix

The settings of the admittance protection are based on the percentage of the rated neutral admittance. The formula for calculating the rated neutral admittance are listed in the table below.

Table 56 - Calculation of the rated neutral admittance

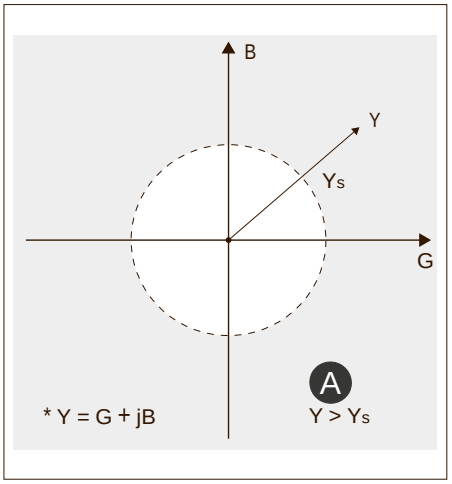
IN source	VN source	Rated neutral admittance (Y_n)
Sensitive E/F CT	VN	Sensitive IN CT primary / (√3*VN primary)
Sensitive E/F CT	(VA + VB + VC)	Sensitive IN CT primary / (√3*VT primary)
CSH core balance CT	VN	Nominal IN.CSH / (√3*VN primary)
CSH core balance CT	(VA + VB + VC)	Nominal IN.CSH / (√3*VT primary)
Standard E/F CT	VN	EF CT primary / (√3*VN primary)
Standard E/F CT	(VA + VB + VC)	EF CT primary / (√3*VT primary)
(IA + IB + IC)	VN	CT primary / (√3*VN primary)
(IA + IB + IC)	(VA + VB + VC)	CT primary / (√3*VT primary)

Operation

Operation of admittance protection

The admittance protection is non-directional. Hence, provided the magnitude of admittance exceeds the set value YN>1, the protection relay will operate.

Figure 199 - Admittance protection operation with non-directional characteristic

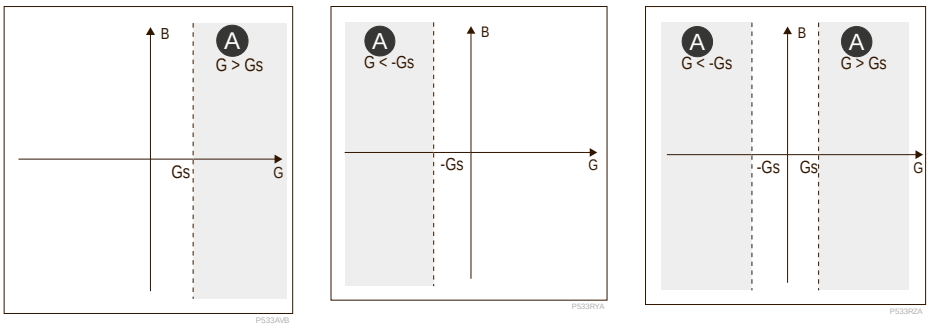


A Operate zone

Operation of conductance protection

The conductance protection may be set to non-directional, forward or reverse. Hence, provided the magnitude and the directional criteria are met for conductance, the PowerLogic P5 protection relay will operate. The correction angle causes rotation of the directional boundary for conductance through the set correction angle.

Figure 200 - Conductance protection operation characteristic



Conductance: Forward Conductance: Reverse Conductance: Non-directional

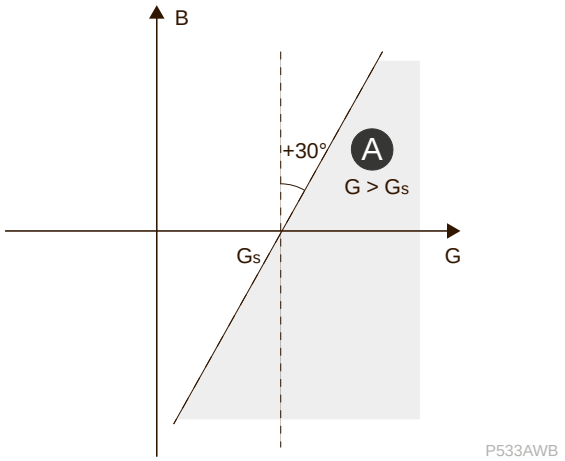
A Operate zone

NOTE:

Center of the characteristic area for forward direction occurs when IN is in phase with -VN.

Assuming that the direction of the G axis is 0°. If the correction angle is set to +30°, this rotates the boundary from 90°...270° to 60°...240°.

Figure 201 - Conductance protection operation characteristic with +30° correction angle

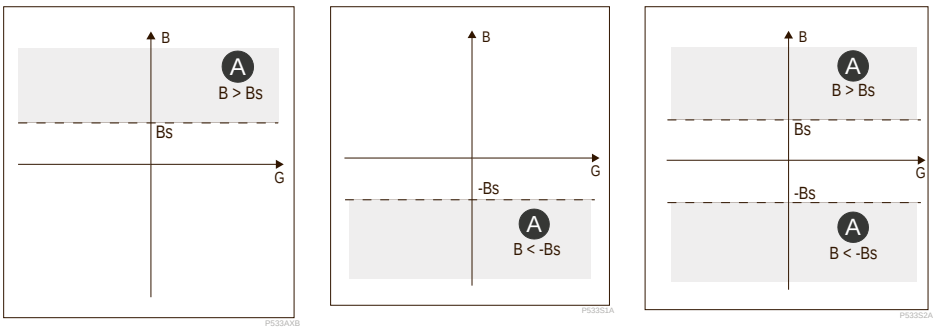


A Operate zone

Operation of susceptance protection

The susceptance protection may be set to non-directional, forward or reverse. Hence, provided the magnitude and the directional criteria are met for susceptance, the PowerLogic P5 protection relay will operate. The correction angle causes rotation of the directional boundary for susceptance through the set correction angle.

Figure 202 - Susceptance protection operation characteristic



Susceptance: Forward Susceptance: Reverse Susceptance: Non-directional

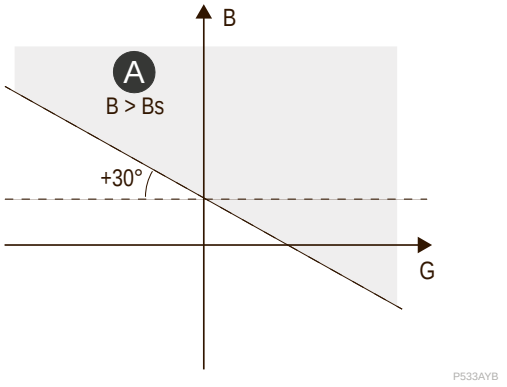
A Operate zone

NOTE:

Center of characteristic area for forward direction occurs when IN leads -VN by 90°.

Assuming that the direction of the G axis indicates 0°. If the correction angle is set to +30°, this rotates the boundary from 0°...180° to 330°...150°.

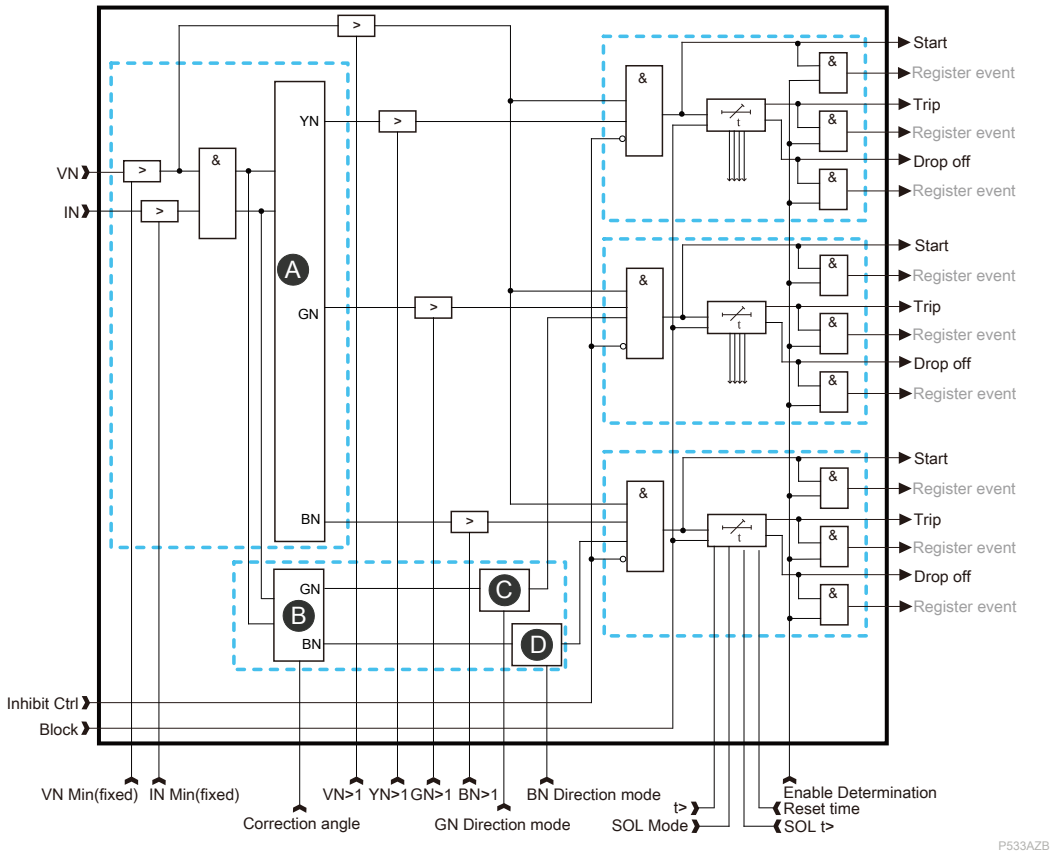
Figure 203 - Susceptance protection operation characteristic with +30° correction angle



A	Operate zone

Block diagram

Figure 204 - Block diagram of the neutral admittance protection



A	Admittance Calculation	B	Direction Determination
C	GN Mode = Non dir or GN Mode = GN dir	D	BN Mode = Non dir or BN Mode = BN dir

Characteristics

Table 57 - Settings and characteristics of the neutral admittance protection

Settings/ characteristics (description/label)	Values
Enable All YN>/All YN>[43]	
Options	Off/On
VN pick-up value/VN>	
Setting range	0.005...0.800 pu[44] for measured values 0.020...0.800 pu[44] for calculated values
Resolution	0.001
Accuracy	±5%
Reset ratio	95% ± 2%
VN minimum	
Value	0.004 pu[44] (fixed) for measured values 0.019 pu[44] (fixed) for calculated values
IN minimum	
Value	0.1 A primary (fixed), for current measured by CSH core balance CT (2A) 1 A primary (fixed), for current measured by CSH core balance CT (20A) 0.005 pu[45] (fixed) for current measured by sensitive EF CT 0.02 pu[45] (fixed) for current measured by standard EF CT 0.005 pu[45] (fixed) for current measured by standard EF CT (for CSH30 use) 0.05 pu[45] (fixed) for calculated EF current value
Enable YN>1/GN>1/BN>1[46]	
Options	Off/On
Pick-up value/YN>1	
Setting range	(1%...200%) IN/VN[47] for current measured by sensitive earth/ground fault CTs (5%...1000%) IN/VN[47] for current measured by standard earth/ground fault CTs (5%...1000%) IN/VN[47] for current measured by standard earth/ground fault CTs (for CSH30 use) (25%...5000%) IN/VN[47] for current measured by 2A CSH, 20A CSH, and for current value that is calculated
Resolution	1% IN/VN[47] for current measured by sensitive earth/ground fault CTs 5% IN/VN[47] for current measured by standard earth/ground fault CTs 25% IN/VN[47] for current measured by 2A CSH, 20A CSH, and for current value that is calculated
Accuracy	±5%
Reset ratio	90% ± 5%
Pick-up value/GN>1	
Setting range	(1%...100%) IN/VN[47] for current measured by sensitive earth/ground fault CTs (5%...500%) IN/VN[47] for current measured by standard earth/ground fault CTs (5%...500%) IN/VN[47] for current measured by standard earth/ground fault CTs (for CSH30 use) (25%...2500%) IN/VN[47] for current measured by 2A CSH, 20A CSH, and for current value that is calculated
Resolution	1% IN/VN[47] for current measured by sensitive earth/ground fault CTs 5% IN/VN[47] for current measured by standard earth/ground fault CTs 25% IN/VN[47] for current measured by 2A CSH, 20A CSH, and for current value that is calculated

43. General protection stage on/off control
44. Vnom = VT primary nominal (PP)
45. Inom
46. This setting does not take effect if the general protection stage control is set to Off. See the previous footnote.
47. YN.nom

Table 57 - Settings and characteristics of the neutral admittance protection (Continued)

Settings/ characteristics (description/label)	Values
Accuracy	±5%
Reset ratio	90% ± 5%
Pick-up value/BN>1	
Setting range	(1%...100%) IN/VN[48] for current measured by sensitive earth/ground fault CTs (5%...500%) IN/VN[48] for current measured by standard earth/ground fault CTs (5%...500%) IN/VN[48] for current measured by standard earth/ground fault CTs (for CSH30 use) (25%...2500%) IN/VN[48] for current measured by 2A CSH, 20A CSH, and for current value that is calculated
Resolution	1% IN/VN[48] for current measured by sensitive earth/ground fault CTs 5% IN/VN[48] for current measured by standard earth/ground fault CTs 25% IN/VN[48] for current measured by 2A CSH, 20A CSH, and for current value that is calculated
Accuracy	±5%
Reset ratio	90% ± 5%
Direction mode/Direction mode	
Options	Non-dir; Forward; Reverse
Operate delay/Operate delay	
Setting range	0.00...300.00 s
Resolution	0.01 s
Accuracy	±5% or ±50 ms
SOL1/SOL1	
Options	Disable/Enable
SOL operate delay/SOL operate delay	
Setting range	0.00...300.00 s
Resolution	0.01 s
Accuracy	±5% or ±20 ms
Reset delay/Reset delay	
Setting range	0.00...100.00 s
Resolution	0.01 s
Accuracy	±5% or ±20 ms
Input for inhibit control/Inhibit control	
Options	Digital inputs and virtual inputs for selection
Characteristic time	
Start time	≤ 65 ms at 2 YN>1 100 ms at maximum
Overshoot time	≤ 40 ms at 2 YN>1
Setting group/SetGrp	
Number	4

48. YN.nom

Transformer Overfluxing Protection (ANSI 24)

Description

Overview

This Transformer Overfluxing Protection (ANSI 24) function is applied for P5T30.

The transformer overfluxing protection detects an inadmissibly high induction in the iron core of transformers which may have been caused by a voltage increase and/or a frequency decrease.

Flux density of transformer $B = K \times U / f$

Where: K is a coefficient depending on iron core material and dimensions.

The degree of overexcitation can be expressed by the overexcitation multiple (the ratio based on nominal excitation Bn):

$$n = \frac{B}{B_n} = \frac{V/f}{V_n/f_n}$$ P533TJA

Where:

- n: the overexcitation ratio.
- B, B_n: actual and nominal values of flux density of transformer cores.
- V, V_n: actual and nominal voltage of transformer windings, phase to phase voltage.
- f, f_n: actual and nominal frequency.

According to the overexcitation ratio, one three-stage overfluxing (V/f) element protects the transformer against overexcitation:

- One alarm stage with DT delay (V/f Alarm)
- One trip stage with DT or IDMT delay (V/f>1)
- One trip stage with DT delay (V/f>2)

The element measures the ratio of voltage to frequency and operates when this ratio exceeds the setting. When the flux level drops below the reset value (set pickup value minus hysteresis), the reset timer starts.

Conditions

The element is valid only when the VT measures VP or VPP. Otherwise, the element is invisible on the HMI screen and in Easergy Pro.

Whether the VT measures VP or VPP, the voltage used in overfluxing element is VPP.

The element is operational only when the measured frequency is 45Hz to 55Hz for fnom = 50 Hz; 54Hz to 66Hz for fnom = 60 Hz.

The overfluxing element is equipped with a definite-time reset time for inverse-time trip characteristic.

Function decomposition

V/f Alarm stage (DT)

The definite-time alarm stage is used to indicate unhealthy conditions before damage of the transformer. The “V/f Alarm” signal is issued when the

overexcitation multiple is greater than the setting of pick-up value of the operate delay.

The “V/f Alarm” signal can be issued only when “Enable for V/f Alarm” is on.

V/f>1 Trip stage (DT/IDMT)

V/f>1 trip stage can be set to operate with a definite time (DT) or inverse time delay (IDMT), as per set “Operating curve”. This stage can be used to provide the protection trip output.

The “V/f>1 Start” and “V/f>1 Trip” signals can be issued only when “Enable for V/f>1” is on.

Definite-time delay

When the overexcitation multiple is greater than the setting of pick-up value, “V/f>1 Start” signal will be issued. The “V/f>1 Trip” signal will be issued in case of the “V/f>1 Start” signal is active for the operate delay.

Inverse-time delay

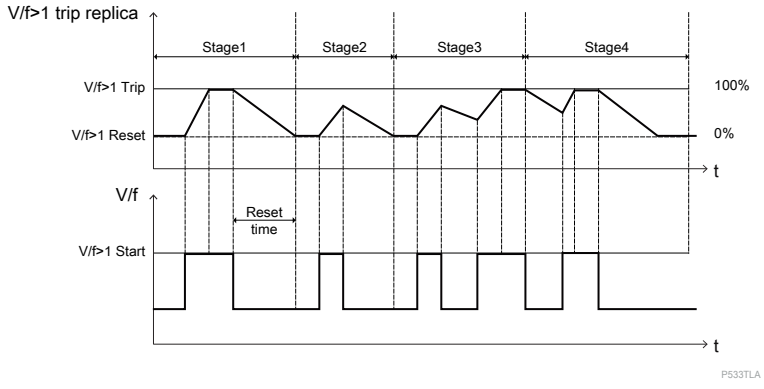
When the overexcitation multiple is greater than the setting of pick-up value, “V/f>1 Start” signal will be issued. There are three delay curves for selection of inverse time delay (IDMT) setting: Prg1, Prg2, Prg3. Each curve is composed by 16 operation values and delays. For overfluxing, the value of “Gs” is always 1.00. The “V/f>1 Trip” signal will be issued according to the operation values of selected curve.

Definite-time reset delay

Overfluxing is a thermal heating based function, therefore the reset timer starts whenever the flux level drops below reset value (= pick-up – hysteresis). The accumulated heat is linearly decreased from the present value down to zero over the course of the reset time. It will restart from half the previously accumulated level, if that level was 100%.

The following figure explains the reset characteristic. It will take the set reset time for the replica to reset completely to zero after the thermal replica reached 100% of V/f>1 Trip level. If the thermal replica has not reached 100% of V/f>1 Trip, the reset time will be reduced proportionally. For example, if the reset time setting is 100 s and the thermal replica reached only 50% of V/f>1 Trip level when V/Hz resets, the reset time will be 50 s, as shown in Stage 2. If another V/Hz excursion appears before replica reaches 0, the V/Hz time delay takes the remaining time left into consideration, as shown in Stage 3.

Figure 205 - Example of Reset characteristic



This implies that the V/f>1 trip replica is limited to 100% and kept at 100%, even if the V/f>1 Start condition persists (for example, broken trip circuit). Likewise, the V/f>1 trip replica never can drop below 0% level.

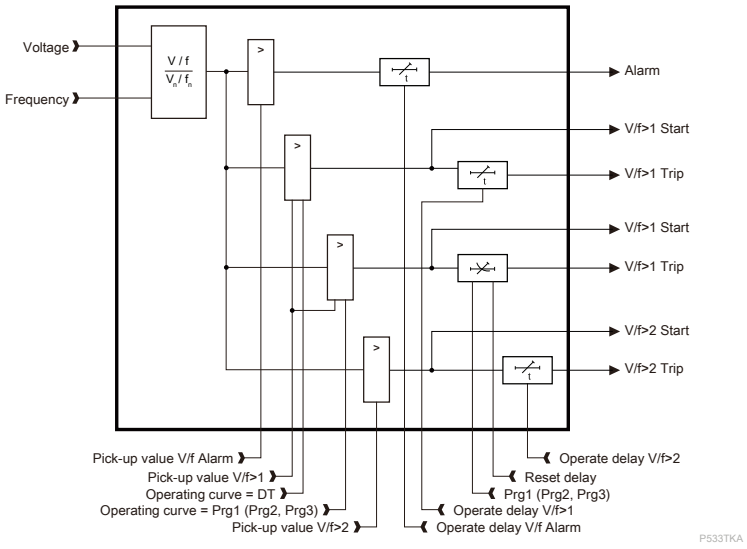
V/f>2 Trip Stage(DT)

The V/f>2 is a definite-time trip stage. The “V/f>2 Start” signal will be issued when the overexcitation multiple is greater than the setting of pick-up value. The “V/f>2 Trip” signal will be issued when the “V/f>2 Start” signal is active for the operate delay.

The “V/f>2 Start” and “V/f>2 Trip” signals can be issued only when “Enable for V/f>1” is on.

Block diagram

Figure 206 - Block diagram of the Transformer Overfluxing Protection (ANSI 24)



Characteristics

Table 58 - Settings and characteristics of the transformer overfluxing protection

Settings/characteristics (description/label)	Value
V/f>1 alarm stage	
Pick-up value	1.00...1.60
Accuracy of pick-up value	±2%
Operate delay	0...10000 s
V/f>1 trip stage	
Enable	On/Off
Pick-up value	1.05...1.60
Accuracy of pick-up value	±2%
Operate curve	DT, Prg1, Prg2, Prg3

Table 58 - Settings and characteristics of the transformer overfluxing protection (Continued)

Settings/characteristics (description/label)	Value
Definite-time delay	
Operate delay[49]	0...10000 s
Accuracy of definite-time delay	±1% or ±100 ms
Inverse-time delay	
Reset delay[50]	0...10000 s
Accuracy of inverse-time delay	±5% or ±100 ms
Accuracy of reset-time delay	±1% or ±100 ms
V/f>2 trip stage	
Enable	On/Off
Pick-up value	1.05...1.60
Accuracy of pick-up value	±2%
Operate delay	0...10000 s
Characteristics	
Starting resetting ratio	95% ±2%

49. Setting for the operate delay of the definite-time trip stage.
50. Setting for the reset time defines the decreasing rate at the inverse-time characteristic.

Synchro-check (ANSI 25)

Description

The synchro-check function (ANSI code 25) checks the synchronisation of the electrical networks on either side of a circuit breaker to avoid closing a breaker when phases are not aligned. This helps ensure that circuit breaker contacts have the minimum wear when closing and avoids excessive disturbance on the network.

The PowerLogic P5 protection relay includes a function that checks synchronism when the circuit breaker is open. The function monitors voltage amplitude, frequency and phase angle difference between two voltages.

The synchro-check function operates in different conditions according to three synchronisation modes: Sync, Async and Off.

In case that the synchro-check function is set to Sync mode, the conditions to operate are defined as below:

- The phase angle difference is less than 2°;
- The frequency difference is less than the frequency difference setting;
- The magnitude difference is less than the voltage difference setting.

In case that the synchro-check function is set to Async mode, the conditions to operate are defined as when the phase angle difference, the frequency difference, and the magnitude difference are respectively below their setting values.

- The phase angle difference is less than the phase angle difference setting;
- The frequency difference is less than the frequency difference setting;
- The magnitude difference is less than the voltage difference setting.

In case that the synchro-check function is set to Off, the circuit breaker cannot be closed when the voltage is present on both sides.

The synchro-check function is available when one of the following analogue measurement modules and a suitable measuring mode is in use:

- VPP/VPPy
- 3VP/VPPy
- 3VP/VPy
- 2VPP+VN+VPPy

  NOTE: The voltage used for synchro-check is the phase to phase voltage. Where only phase to neutral is available the equivalent phase to phase voltage will be calculated.

The synchro-check function operates for a power system frequency between 46 Hz and 64 Hz.

The following signals of the stage are available in the output matrix and in the logic editor:

- “Request” signal

  This signal is active when a request has been received but the breaker is not yet closed.

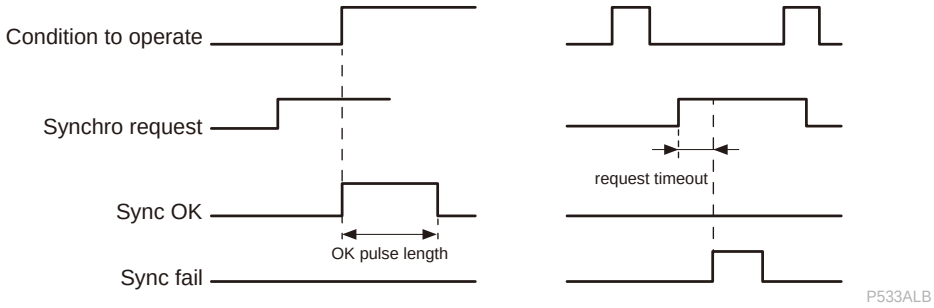
- “OK” signal

  This signal is active when the synchronising conditions are met, or the voltage check criterion is met. See section "Voltage checking" below.

- “Fail” signal

  This signal is activated, if the function fails to close the breaker within the request timeout setting. See The principle of the synchro-check function, page 293.

Figure 207 - The principle of the synchro-check function



NOTE: The CB close time setting can be used to anticipate the closing of the CB and meet all the conditions to operate.

Voltage checking

When one of the two voltage is absent, coupling may be authorised according to one of the seven checking modes.

- VAB and VABy absent (DD)
- VAB absent and VABy present (DL)
- VAB present and VABy absent (LD)
- VAB absent regardless of VABy state (present or absent) (DD/DL)
- VABy absent regardless of VAB state (present or absent) (DD/LD)
- One voltage is present while the other one is absent (DL/LD)
- At least one voltage is absent (DD/DL/LD)

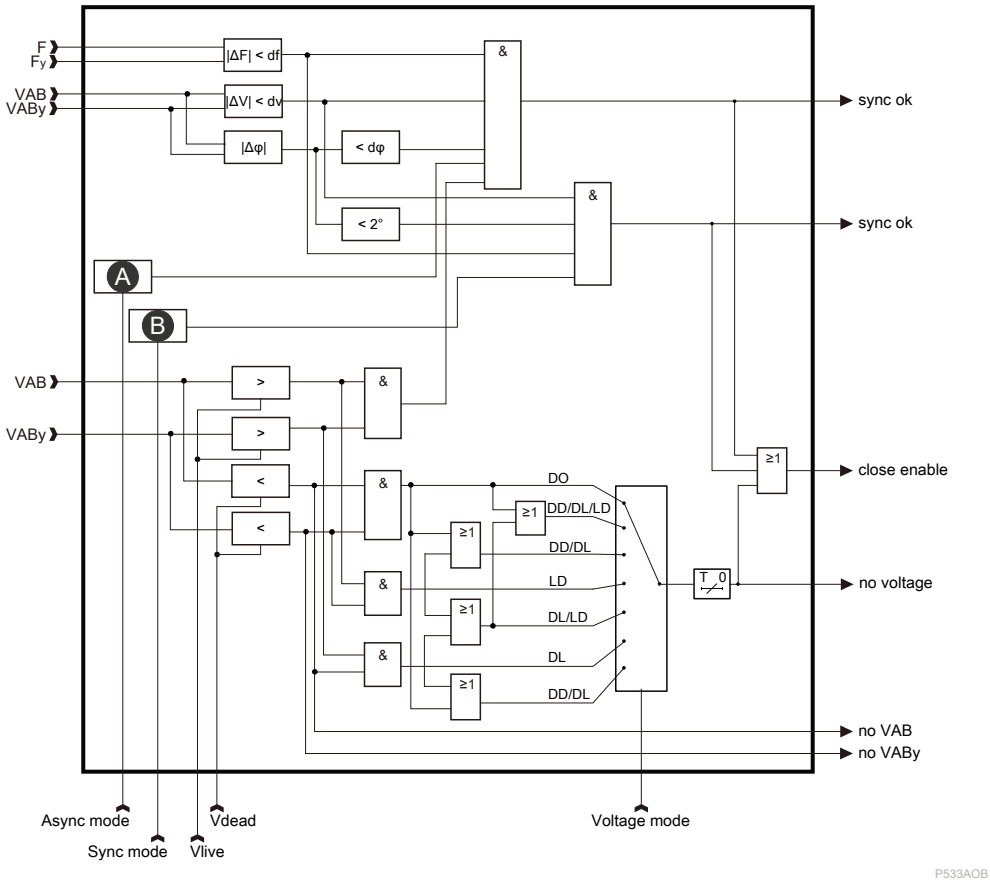
The presence of each voltage is detected by comparing the voltage to the Vlive limit setting. The absence of each voltage is detected by comparing the voltage to Vdead limit setting.

Synchro-check enable and bypass

In the application when circuit breaker closing should be guaranteed by synchro-check result, a parameter to define the circuit breaker should be configured, otherwise synchro-check result will not impact on the close operation, this parameter can be found under **Protection** menu/**Sync-check** sub-menu/**CB object 1**. Sometimes there are also the request to bypass sync-check result, this is also available in PowerLogic P5, which can be realised via the "Bypass" parameter under Protection menu/Sync-check sub-menu.

Block diagram

Figure 208 - Block diagram of the synchro-check protection function (ANSI 25)



A	Async	B	Sync

Characteristics

Table 59 - Setting and characteristics of the synchro-check function (ANSI 25)

Settings/characteristics (description/label)	Values
Synchronisation mode/Synchro mode	
Options	Off; Async; Sync
Voltage check mode/Voltage mode	
Options	DD; DL; LD; DD/DL; DD/LD; DL/LD; DD/DL/LD
CB close time/CB close time	
Setting range	0.04...0.60 s
Resolution	0.01 s
Vdead limit setting/Vdead	
Setting range	0.01...1.20 pu[51]
Resolution	0.01 pu[51]

51. VT Primary nominal

Table 59 - Setting and characteristics of the synchro-check function (ANSI 25) (Continued)

Settings/characteristics (description/label)	Values
Accuracy	±0.03 pu[52] or 3% of the setting
Vlive limit setting/Vlive	
Setting range	0.10...1.30 pu[52]
Resolution	0.01 pu[52]
Accuracy	0.03 pu[52]
Frequency difference/Frequency diff	
Setting range	0.01...1.00 Hz
Resolution	0.01 Hz
Accuracy	±20 mHz
Hysteresis	< 10 mHz
Voltage difference/Voltage diff	
Setting range	0.01...0.60 pu[53]
Resolution	0.01 pu[53]
Accuracy	±0.03 pu[53]
Reset ratio	97% ± 2%
Phase angle difference/Angle diff	
Setting range	2°...90°
Resolution	1°
Accuracy	±2° when Δf < 0.2 Hz; else ±5°
Request timeout/Request time	
Setting range	0.1...600.0 s
Resolution	0.1 s
Accuracy	±1% or ±20 ms
Stage operation range	
Frequency range	46...64 Hz
Setting groups/SetGrp	
Number	4

52. VT Primary nominal
53. Vnom

Undervoltage (ANSI 27)

Description

The Undervoltage protection function (ANSI code 27) is used to detect voltage dips or sense abnormally low voltages to trip or trig load shedding or load transfer. The function provides the selection of three phase to phase voltages or three phase to ground voltages for comparison with the voltage threshold. Each phase can start or trip independently. If the fault situation remains on longer than the operate time setting, a trip signal is issued.

This function operates with either the definite time delay or inverse time delay or programmable curves. These 3 options could be set in Operating curve parameter by eSetup Easergy Pro. The inverse time delay characteristic follows the equation below:

$$t(G) = \frac{T}{1-(\frac{G}{G_S})}$$ P533ORB

where:

- t(G) is the theoretical operate time in seconds with constant value of G.
- T is the time delay setting (theoretical operate time for G = 0).
- G is the measured value of the characteristic quantity.
- G_S is the setting value.

The [voltage, time] curve points are programmed using eSetup Easergy Pro. There are some rules for defining the curve points:

- the configuration must begin from the top line
- the line order must be as follows: the smallest voltage (shortest operate time) on the top and the largest voltage (longest operate time) on the bottom
- all unused lines (on the bottom) should be filled with G/G_S= 1.00 and operate time = 0.00 s

Here is an example configuration of curve points:

Table 60 - Example configuration of curve points

Point	Voltage (pu)	Operate delay(s)
1	0.10	0.00 s
2	0.10	0.10 s
3	0.70	0.10 s
4	0.70	0.50 s
5	0.90	1.00 s
6	1.00	0.00 s
7	1.00	0.00 s
8	1.00	0.00 s
9	1.00	0.00 s
10	1.00	0.00 s
11	1.00	0.00 s
12	1.00	0.00 s
13	1.00	0.00 s
14	1.00	0.00 s
15	1.00	0.00 s
16	1.00	0.00 s

Reset delay

The V< stage has a settable reset delay that enables the detection of intermittent faults. This means that the time counter of the protection function does not reset immediately after the fault is cleared, but resets after the release delay has elapsed. If the fault appears again before the release delay time has elapsed, the delay counter continues from the previous value. This means that the function eventually trips if faults are occurring often enough.

Blocking during voltage transformer fuse failure

At all the protection stages, the undervoltage function can be blocked with any internal or external signal using the block matrix. The blocking signal can also be a signal from the custom logic (refer to Logic functions, page 507).

The VTS fast alarm output can be used to block undervoltage protection function as internal signals. Refer to Voltage transformer supervision (ANSI 60), page 556.

This function can also be blocked when circuit breaker is opened and the setting “CB open blocking” is ON.

Operate mode

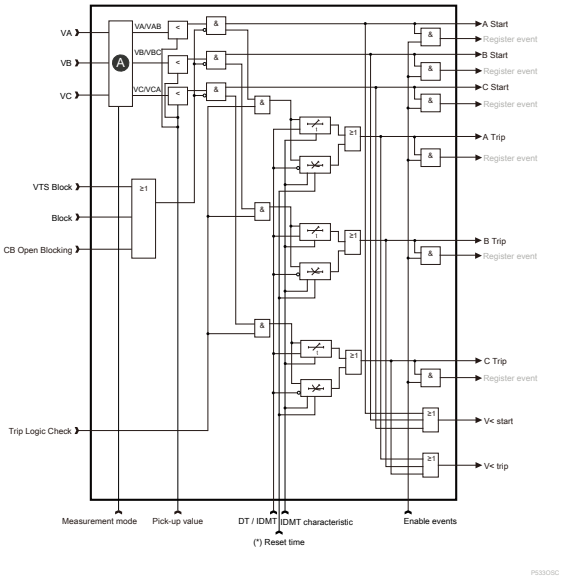
The setting "Tripping logic" is available to configure the operate mode. When "Tripping logic" is "Any phase", the general trip signal "V< trip" is raised when any phase operates. When "Tripping logic" is "Three phases", the signal "V< trip" is raised only when all three phases operate.

Three independent stages

There are three separately adjustable stages: V<1, V<2 and V<3. All these stages have the same settings and performance.

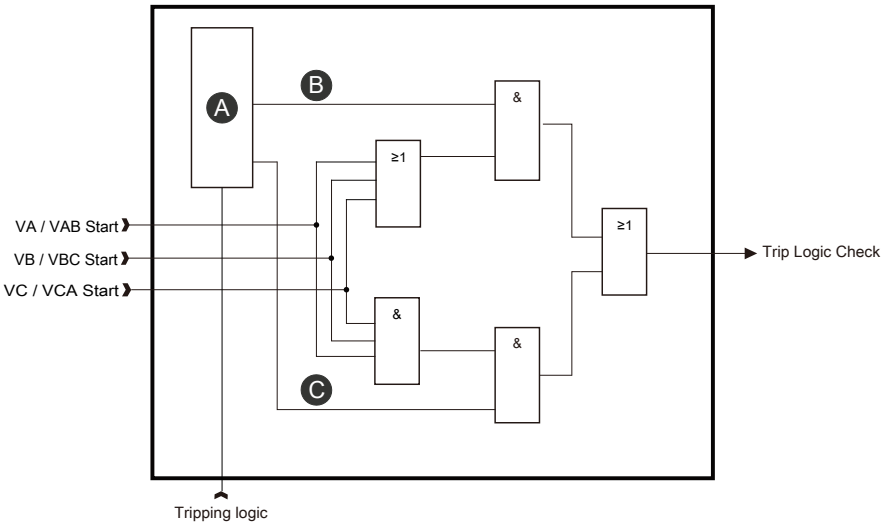
Block diagram

Figure 209 - Block diagram of the Undervoltage protection function (ANSI 27)



A	Select setting

Figure 210 - Block diagram of the Tripping Logic



A	Select setting	B	“Any ph”
C	“Three ph”		

Once Trip logic check passed, which means general trip happens, the general trip resets only if all three phase are reset, no matter which trip logic is selected.

Characteristics

Table 61 - Settings and characteristics of the Undervoltage protection (ANSI 27)

Settings/characteristics (description/label)	Values
Enable V</V<	
Options	Off/On
Pick-up value/Pick-up value	
Setting range	0.02...1.20 pu[54]
Resolution	0.01 pu[54]
Accuracy	±2% or ±0.0005 pu[54]
CB open blocking/CB open blocking	
Options	Off/On
Measurement mode/Meas mode	
Options	Phase-phase; Phase-ground
Operating curve/Operating curve	
Options	DT; IDMT; Prg1-3
Tripping logic/Tripping logic	
Options	Any phase; Three phases
Operate delay/Operate delay	
Setting range	0.00...600.00 s
Resolution	0.01 s
Accuracy	DT: ±1% or ±10 ms
	IDMT: ±5% or ±20 ms
Reset delay/Reset delay	
Setting range	0.00...100.00 s
Resolution	0.01 s
Accuracy	±5% or ±30 ms
Hysteresis/Hysteresis	
Setting range	1.0%...5.0%
Resolution	1.0%
Accuracy	±2%
Characteristic times	
Start time	< 40 ms (35 ms with high speed)
Disengaging time	< 60 ms (75 ms with high speed)
Overshoot time	< 30 ms
Setting group/SetGrp	
Number	4

54. Vnom = VT primary nominal (PP) or Vnom/√3 = VT primary nominal (PN) depending on measurement mode parameter setting.

Positive sequence undervoltage (ANSI 27P)

Description

This is a protection function (ANSI code 27P) for motors against faulty operations due to insufficient or unbalanced power system voltage. There are special self-blocking features for starting up and shutting down a motor.

This undervoltage protection function calculates the positive sequence of the fundamental frequency component V1.

By using the positive sequence, all three phases are supervised, with one value, and if the motor looses the connection to the network (loss of mains), the undervoltage situation is detected even if the frequency decreases significantly from nominal frequency.

Whenever the positive sequence voltage V1 drops below the start setting of a particular stage, this stage activates and a start signal is issued. If the fault situation remains on longer than the time defined in the operate time setting, a trip signal is issued.

Blocking during VT fuse failure

Like all the protection stages, the positive sequence undervoltage function can be blocked with any internal or external signal using the block matrix, for example, if the secondary voltage of one of the measuring transformers disappears because of a fuse failure. The blocking signal can also be a signal from the user's logic.

Self-blocking at low voltage

The protection is blocked when the biggest of the three phase to phase voltages is below the low voltage block limit setting (refer to Positive sequence undervoltage state and block limit, page 301).

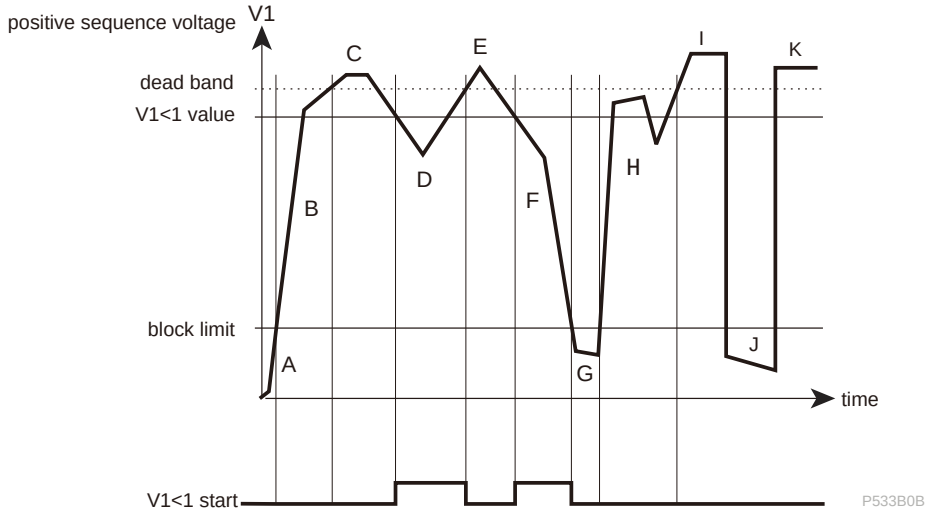
Block according to circuit breaker position

The positive sequence undervoltage protection is blocked when the circuit breaker is open or in undefined status.

Two independent stages

There are two separately adjustable stages: V1<1 and V1<2. Both stages can be configured for definite time (DT) operate characteristic.

Figure 211 - Positive sequence undervoltage state and block limit



A The maximum phase to phase voltage is below the block limit. This is not regarded as an undervoltage situation.

B The maximum phase to phase voltage is above the block limit but below the start level. However, this is not regarded as an undervoltage situation because the voltage has never been above the start level since being below the block limit.

C The voltage is OK because it is above the pick-up value.

D This is an undervoltage situation.

E The voltage is OK.

F This is an undervoltage situation.

G The maximum phase to phase voltage is below the block limit and this is not regarded as an undervoltage situation.

H Same as B.

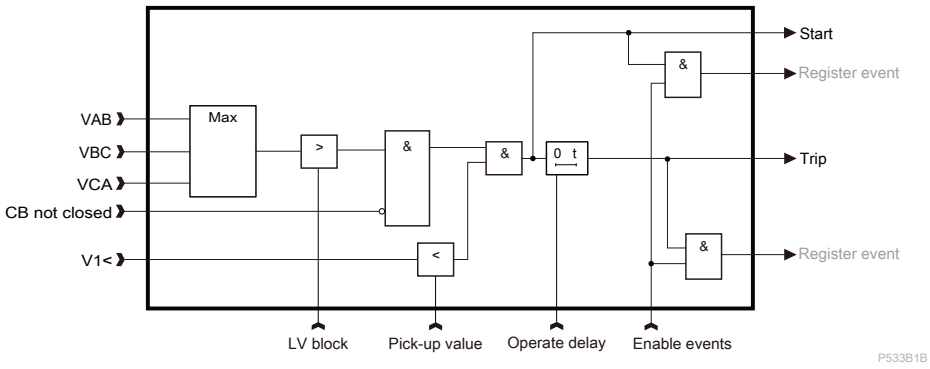
I The voltage is OK.

J Same as G.

K The voltage is OK.

Block diagram

Figure 212 - Block diagram for the positive sequence undervoltage protection



Characteristic

Table 62 - Settings and characteristics of the positive sequence undervoltage protection stages V1<1 and V1<2

Settings/characteristics (description/label)	Value
Pick-up value/Pick-up value	
Setting range	0.20...1.20 pu[55]
Resolution	0.01 pu[55]
Accuracy	±1%
Reset ratio	105%
Operate delay/Operate delay	
Setting range	0.00...300.00 s
Resolution	0.01 s
Accuracy	±1% or ±30 ms
Under voltage blocking/LV block[56]	
Setting range	0.02...1.00 pu[55]
Reset value	1.05 pick-up value
Resolution	0.01 pu[55]
Accuracy	±2%
Characteristic times	
Start time	< 70 ms (65 ms with high speed)
Disengaging time	< 85 ms (100 ms with high speed)
Overshoot time	< 50 ms
Setting group/SetGrp	
Number	4

55. Vnom/√3
56. Common settings for setting group 1, 2, 3, 4.

Directional power (ANSI 32)

Description

Directional power protection function (ANSI code 32) can be used, for example, to disconnect a motor in case the supply voltage is lost and thus help prevent power generation by the motor. It can also be used to detect loss of load of a motor.

Directional power protection function is sensitive to active power. If the fault situation stays on longer than the delay setting, a trip signal is issued.

Figure 213 - Example of loss of load

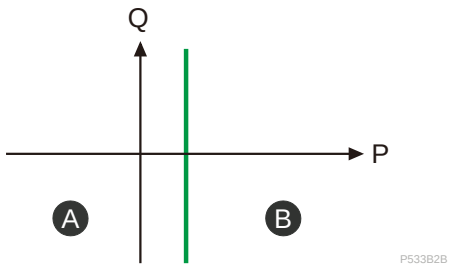
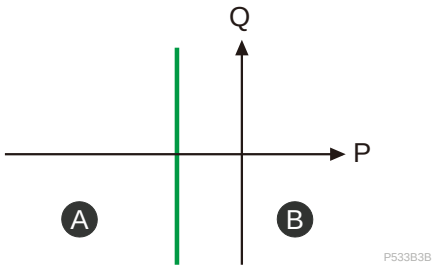


Figure 214 - Example of a motor working as a generator



A	Reverse zone	B	Forward zone

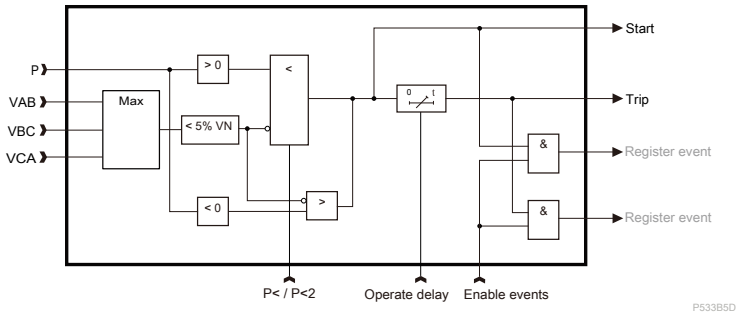
The start setting range is from -200% to +200% of the nominal apparent power S_n. The nominal apparent power is determined by the configured voltage and current transformer values according to equation below.

$$S_n = \sqrt{3}\, V_{nom} \times I_{nom}$$ P533B4B

There are two identical stages available with independent setting parameters. Each stage is deactivated if the maximum voltage of all phases drops below 5% of the nominal voltage value.

Block diagram

Figure 215 - Block diagram of the directional power protection



Characteristics

Table 63 - Settings and characteristics of the directional power protection

Settings/characteristics (description/label)	Value
Pick-up value/Pick-up value	
Setting range	-200.0%...+200.0% Sn[57]
Resolution	0.5%
Accuracy	±3% or ±0.5% Sn
Reset ratio	105% ± 3% if P > 0; 95% ± 3% if P < 0
Hysteresis minimum	2.5 W secondary
Operate delay/Operate delay	
Setting range	0.00...300.00 s
Resolution	0.1 s
Accuracy	±1% or ± 150 ms
Characteristic times	
Start time	< 250 ms
Disengaging time	< 500 ms
Setting group/SetGrp	
Number	4

57. Snom = √3 x Vnom x Inom

Wattmetric earth/ground fault (32N)

Description

The wattmetric earth/ground fault protection function (ANSI code 32N) is a directional earth/ground fault protection adapted for compensated neutral power systems (i.e. Petersen-coil earthed/grounded) in which the resistive part of the earth/ground fault current is large enough (typically greater than 5 A).

The settings of the wattmetric earth/ground fault protection are based on the fundamental component of the neutral current and of the neutral voltage. The protection operates with a detection of restriking faults.

The protection calculates the active and reactive neutral powers as follows:

$PN = IN \times VN \times \cos\varphi_N$

$QN = IN \times VN \times \sin\varphi_N$

where

$$IN = \vec{I}_A + \vec{I}_B + \vec{I}_C$$ P533B6B

$$VN = \vec{V}_A + \vec{V}_B + \vec{V}_C$$ P533B7B

The Pick-up value setting of neutral power setting in percentage of PN.

NOTE: Connect the VN signal according to the connection diagram to achieve correct polarisation.

The wattmetric earth/ground fault protection provides 2 operating zones, separated by a non-detection zone:

- Forward fault zone

  The forward zone is intended to issue a signal or trip command during a fault at the downstream side of the protection.

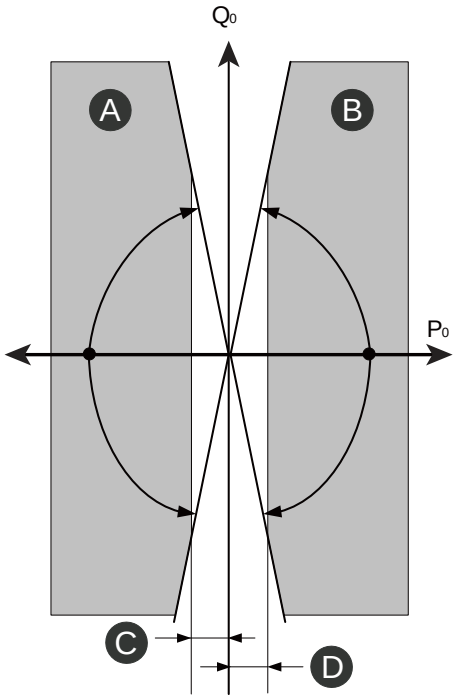
- Backward fault zone

  The backward zone is intended to issue a signal during a fault at the upstream side of the protection.

The two zone area are defined by a pickup sector setting.

If the direction mode is set to Reverse, the wattmetric earth/ground fault protection operates in upstream fault zone.

Figure 216 - Operating zones of the wattmetric earth/ground fault protection



A	Forward zone	B	Reverse zone
C	Pick-up value	D	Pick-up value

The protection is deactivated if the neutral voltage is lower than VN pick-up value setting.

Four memory modes

The detection of current faults is controlled by a memory hold time that extends the transient pick-up information enabling the operation of the definite time delay even if the faults are rapidly extinguished (< 1.5 ms) and restrike rapidly and periodically.

The wattmetric protection can be used in different modes:

- Fault memory based on voltage

  The detection of current faults is controlled by the presence of neutral voltage that extends the transient pick-up information enabling the operation of the definite time delay even if the faults are rapidly extinguished and restrike rapidly and periodically. The level of the neutral voltage is settable.

- Fault memory based on the time memory

  The detection of current faults is controlled by a memory hold time that extends the transient pick-up information enabling the operation of the definite time delay even if the faults are rapidly extinguished and restrike rapidly and periodically. The memory time is settable (Memory time).

- Both criteria

  The protection operates with both, memory time and memory neutral voltage.

- Without memory criteria

  When the fault is detected, the start signal is raised after confirmation. Neither memory time nor neutral voltage memory is taken into account.

Operation

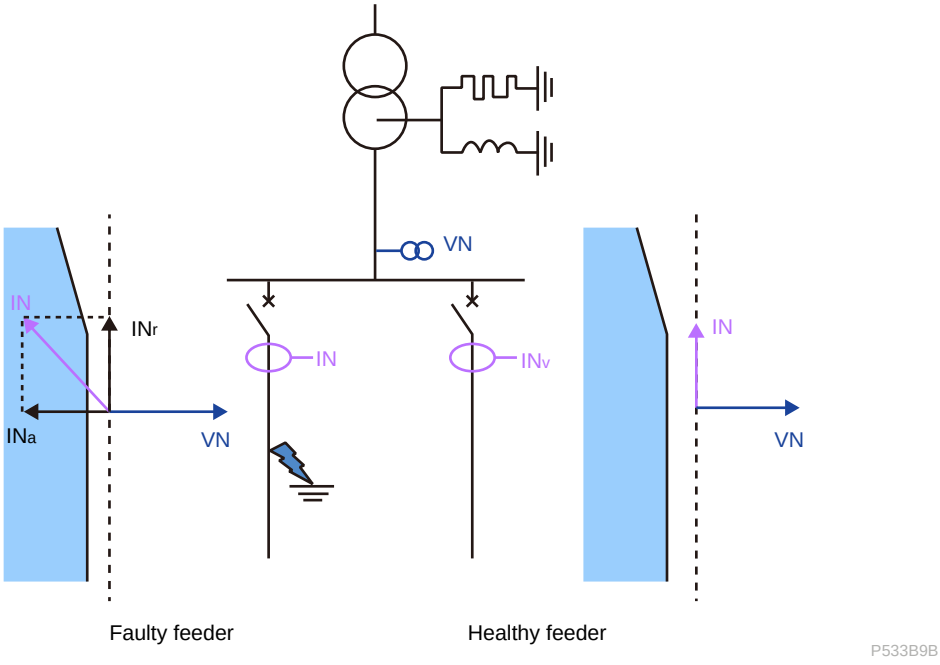
With a Petersen coil system, the current in a faulty feeder is usually inductive and in a healthy feeder, capacitive.

For the forward output, a confirmation is applied on the start signal, because the wattmetric is based on active power and when a restriking fault occurs with a Petersen coil system, the following phenomenon needs to be considered:

For the backward output, the wattmetric protection is able to detect the capacitive current circulation in healthy feeders, to see that the fault is on upstream side:

- In steady state, this capacitive current has a phase-shift of 90° with the neutral voltage. So this capacitive current is not detected because it is outside the backward characteristic, symmetrical to forward area.
- During the transient, the capacitive current goes first in the backward area, before to go outside with at the end a phase-shift of 90°. This transient signal is not used to detect a backward fault with capacitive current, but mainly to block other protection functions of healthy feeders. This can be the case when a HV/MV transformer supplies two incomers at the same time (see Faulty feeder vs. healthy feeder, page 307).

Figure 217 - Faulty feeder vs. healthy feeder

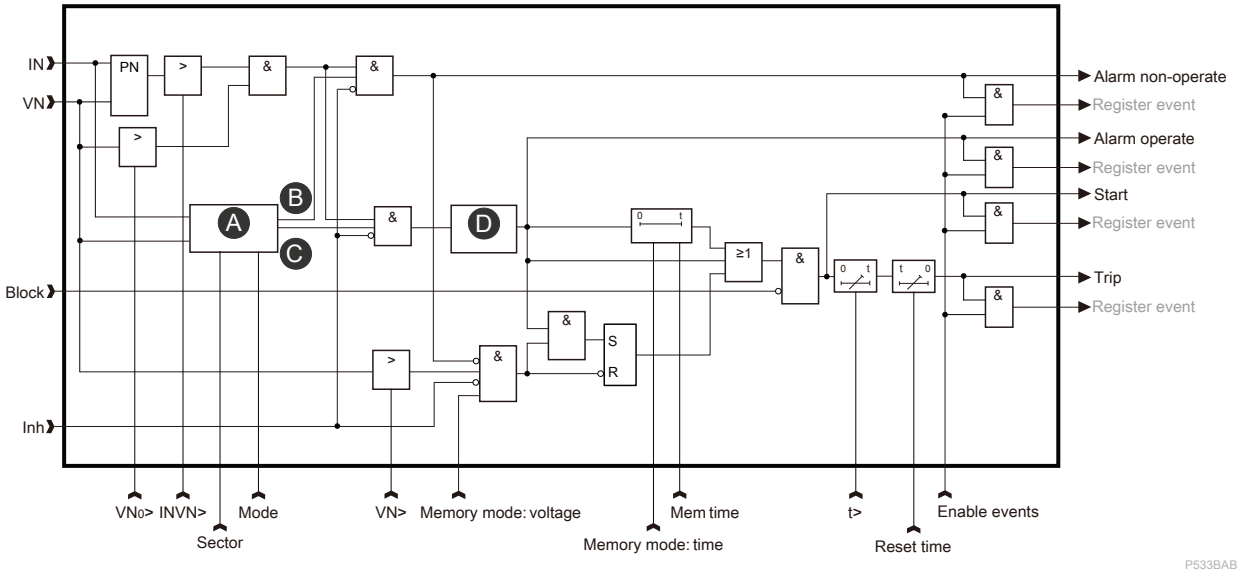


Tripping direction

The normal operate area, in PowerLogic P5 protection relay could be set to forward or reverse area, because sometimes it is not possible to modify CT or VT connections when there is a mistake in the wirings. In that case, to avoid a modification of wirings, you can set the operate area to forward (default setting) or reverse. So if you change the operate area, the confirmation must be applied to the operate area (which could be forward or reverse).

Block diagram

Figure 218 - Block diagram of the wattmetric earth/ground fault protection function (ANSI 32N)



A	-Sector < φ0 < +Sector 180 - Sector < φ0 < 180 + Sector	B	Backward
C	Forward	D	Confirmation

Characteristics

Table 64 - Settings and characteristics of the wattmetric earth/ground fault protection

Settings/characteristics (description/label)	Value
IN input/IN input	
Options	IN.meas, IN.calc, IN.sens for model with EF CT (1/5A CT, 1A CT and CSH30) IN.calc, IN.CSH for model with CSH
Direction mode/Direction mode	
Options	Forward; Reverse
Inhibit control/Inhibit control	
Options	Selection of one digital input (DI) or one virtual input (VI)
Timer instant delay ctrl./Timer Inst control	
Options	Selection of one digital input (DI) or one virtual input (VI)
Pick-up value/Pick-up value	
Setting range	0.001...0.2 Pn_0[58] if IN calculated or measured with standard EF CT (1A/5A CT or CSH30) 0.001...2 Pn_0[58] if IN measured with sensitive EF CT 0.1...20 Pn_0[58] if IN measured with CSH 2A 0.01...2 Pn_0[58] if IN measured with CSH 20A
Resolution	0.1%

58. PN.nom = IN x VN x cosφN

Table 64 - Settings and characteristics of the wattmetric earth/ground fault protection (Continued)

Settings/characteristics (description/label)	Value
Accuracy	±10%
Reset ratio	90% ± 3%
VN pick-up value/VN>	
Setting range	0.020...0.800 pu[59]
Resolution	0.001 pu[59]
Accuracy	±0.050 pu[59]
Reset ratio	95% ± 3%
Pick-up sector size/Sector	
Setting range	0°...90°
Resolution	1°
Accuracy	±1° with IN and VN measured ±3° with IN and VN calculated
Hysteresis	1° with IN measured 3° with IN calculated
Operate delay/Operate delay	
Setting range	0.00...300.00 s
Resolution	0.01 s
Accuracy	±1% or ±20 ms
SOL status/SOL status	
Options	Off, SOL1, SOL2
SOL operate delay/SOL operate delay	
Setting range	0.00...300.00 s
Resolution	0.01 s
Accuracy	±1% or ±20 ms
Memory mode/Memory mode	
Options	None; Voltage; Time; Both
Memory time/Memory time	
Setting range	0.05...10.00 s
Resolution	0.01 s
Accuracy	±1% or ±20 ms
Reset delay/Reset delay	
Setting range	0.00...100.00 s
Resolution	0.01 s
Accuracy	±1% or ±20 ms
Characteristic times	
Start time	< 50 ms (45 ms with high speed) for power at 2 IN pick-up value × VN pick-up value < 55 ms (50 ms with high speed) for power at 1.2 IN pick-up value × VN pick-up value < 60 ms (55 ms with high speed) for power at 1.05 IN pick-up value × VN pick-up value
Overshoot time	< 40 ms for power at 2 IN pick-up value × VN pick-up value

59. Vnom = VT primary nominal (PP)

Table 64 - Settings and characteristics of the wattmetric earth/ground fault protection (Continued)

Settings/characteristics (description/label)	Value
Disengaging time	< 60 ms (75 ms with high speed)
Setting group/SetGrp	
Number	4

Phase undercurrent (ANSI 37)

Description

The phase undercurrent protection (ANSI code 37) measures fundamental component of phase currents. By detecting motor loss of load, it's typically used to protect pumps against loss of prime. This protection protects rather the devices driven by motor than the motor itself, for example a submersible pump (where the flowing liquid inherently cools the pump) or conveyor belt.

Phase undercurrent protection can be configured for definite time characteristic only.

To differentiate normal operation of circuit breaker and undercurrent conditions, a low current setting is available to block this protection function.

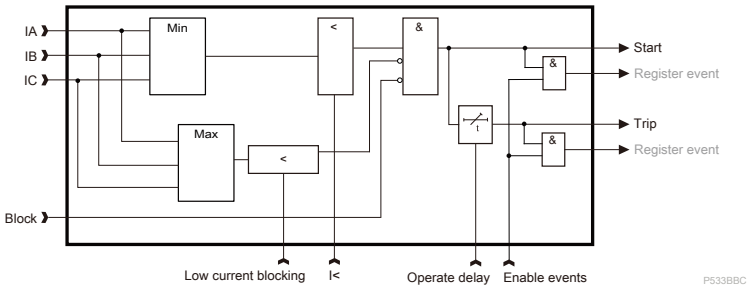
Low-current self-blocking

The value of low-current self-blocking could be different in each setting groups. To avoid unwanted tripping, phase undercurrent protection shall be blocked when maximum of phase currents drops under the setting.

Phase undercurrent protection will automatically become inactivated if its pickup threshold is set equal to or lower than this undercurrent blocking limit.

Block diagram

Figure 219 - Block diagram of the phase undercurrent protection function (ANSI 37)



Characteristics

Table 65 - Settings and characteristics of the phase undercurrent protection function (ANSI 37)

Settings/characteristics (description/label)	Value
Pick-up value/Pick-up value	
Setting range	0.05...1.00 pu[60]
Resolution	0.01 pu[60]
Accuracy	±2% or ±0.005 Inom
Reset ratio	105% ± 2%
I< block limit/I< block limit	
Value	0.02...0.50 pu[60]
Operate delay/Operate delay	
Setting range	0.0...300.0 s
Resolution	0.1 s
Accuracy	±1% or ±20 ms
Characteristic times	
Start time	< 60 ms (55 ms with high speed)
Disengaging time	< 65 ms (80 ms with high speed)
Setting group/SetGrp	
Number	4

60. Inom

Temperature monitoring (ANSI 38)

Description

The temperature monitoring function (ANSI code 38) is used to detect abnormal heat rise by measuring the temperature inside equipment fitted with sensors:

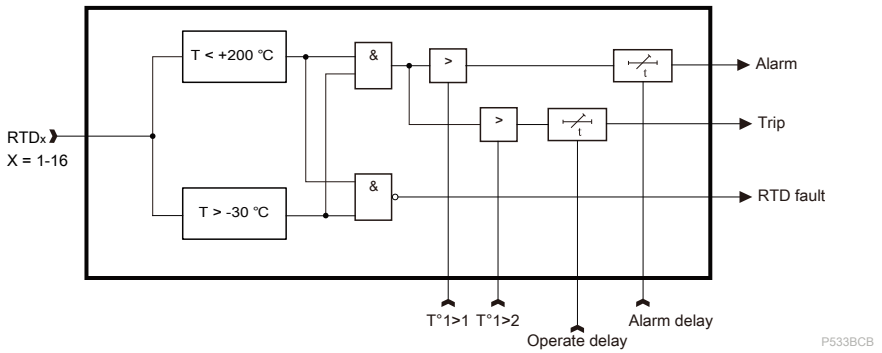
- transformer: protection of primary and secondary windings
- motor and generator: protection of stator windings and bearings. This protection function is associated with an RTD of the Pt100 platinum (100 Ω at 0°C or 32°F) or nickel (Ni100 or Ni120) type, in accordance with the IEC 60751 and DIN 43760 standards.
- it picks up when the monitored temperature is greater than the set point (Ts)
- it has two independent set points:
  - alarm set point
  - tripping set point, the trip signal of temperature monitoring is not a part of the global trip.
- 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 -30°C or -22°F (measurement displayed as "——")
  - RTD disconnection is detected if the measured temperature is greater than +200°C or +392°F (measurement displayed as "–//–").

  If an RTD fault is detected, the associated threshold is inhibited and the start and trip signals are forced to reset state.

  The "RTD fault" item is also made available in the control matrix and an alarm message is generated specifying the number of the MET148-2 module for the faulty RTD.

Block diagram

Figure 220 - Block diagram of the temperature monitoring function (ANSI 38)



Characteristics

Table 66 - Setting and characteristics of the temperature monitoring function (ANSI 38)

Settings/characteristics (description/label)	Value
Alarm and trip set points/T°1>1, T°1>2	
Setting range	0°C...180°C (32°F...356°F)
Unit	°C
Accuracy	±1°C (±1.8°F)
Resolution	1°C (1.8°F)
Pick up/drop out	3°C (37.4°F)
Alarm delay/AlmDly	
Setting range	0.00...600.00 s
Accuracy	1% ± 20 ms
Operate delay/OperDly	
Setting range	0.00...600.00 s
Accuracy	1% ± 20 ms
Characteristic times	
Start time	< 3 s
Setting group/SetGrp	
Number	1

Negative sequence overcurrent (ANSI 46)

Description

The negative sequence overcurrent protection function (ANSI code 46) gives greater sensitivity to detect phase to phase faults at the end of long lines, where phase overcurrent elements may not operate.

For rotating machines, the negative sequence overcurrent protection provides protection against a temperature rise caused by an unbalanced power supply, phase inversion, loss of phase, and unbalanced phase current.

The negative sequence current is calculated from the measured phase currents according to the following formula (for standard phase rotation A - B - C):

$$\vec{I_2} = \frac{1}{3}\left(\vec{I_A} + a^2\vec{I_B} + a\vec{I_C}\right)$$

P533BDB

with

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

P533BEB

The negative sequence overcurrent protection function operates with inverse or definite tripping time characteristic.

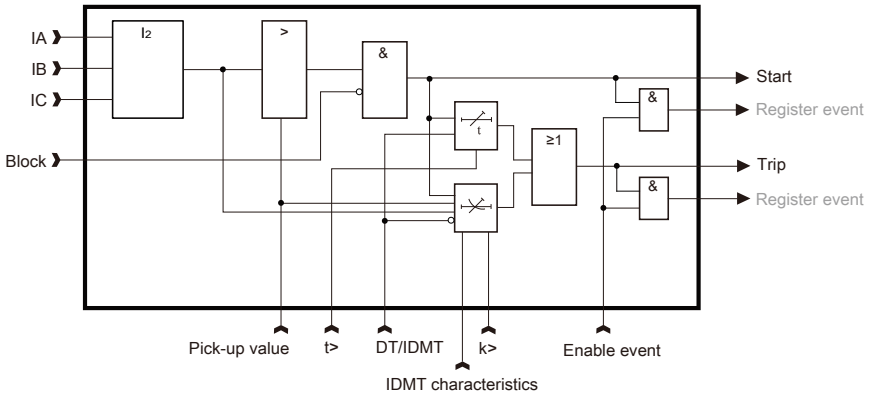
There are two separately adjustable stages available in PowerLogic P5, both providing the same settings and performance.

With transformer differential protection P5T30 each stage can be individually linked to the measured phase currents of one end.

If phase swapping feature is used, then this is considered in the calculation of the negative sequence current.

Block diagram

Figure 221 - Block diagram of the negative sequence overcurrent protection function (ANSI 46)



P533BFC

Characteristics

Table 67 - Settings and characteristics of the negative sequence overcurrent protection

Settings/characteristics (description/label)	Value
Pick-up value/Pick-up value	
Setting range	0.02...5.00 pu[61]
Resolution	0.01 pu[61]
Accuracy	±3% or ±0.005 pu[61]
Reset ratio	95% ± 2%
CT input selection[62]	
Setting range	CT-1, CT-2
Operate delay/Operate delay	
Setting range	0.00...300.00 s
Accuracy	±1% or ±20 ms
Operating curve/Operating curve	
Option	DT; IEC: SI, VI, EI, LTI, UTI; IEEE: MI, VI, EI ANSI: NI, STI, LTI Others: UK_Rectifier, FR_STI, RI, STI_CO2, LTI_CO5, MI_CO7, NI_CO8, VI_CO9, EI_CO11, BPN Prg1-3
Accuracy	±5% or ±30 ms
TMS/TMS	
Setting range	0.020...20.000
Resolution	0.001
DT adder/DT adder	
Setting range	0.00...1.00 s
Resolution	0.01 s
Minimum operate delay/Min operate delay	
Setting range	0.00...10.00 s
Resolution	0.01 s
Reset curve/Reset curve	
Options	DT; IDMT; Prg1-3
Reset delay/Reset delay	
Setting range	0.03...100.00 s
Resolution	0.01 s
Accuracy	±1% or ±20 ms
Characteristic times	
Start time	< 50 ms (45 ms with high speed) for currents at 2 x Pick-up value < 55 ms (50 ms with high speed) for P5T30, for currents at 2 x Pick-up value < 60 ms (55 ms with high speed) for currents at 1.2 x Pick-up value

61. I_{nom}
62. Available for P5T30 only.

Table 67 - Settings and characteristics of the negative sequence overcurrent protection (Continued)

Settings/characteristics (description/label)	Value
	< 65 ms (60 ms with high speed) for currents at 1.05 x Pick-up value
Disengaging time	< 75 ms (90 ms with high speed)
Setting group/SetGrp	
Number	4

Unbalance overcurrent, broken conductor (ANSI 46BC)

Description

The purpose of the unbalance overcurrent, broken conductor protection function (ANSI code 46BC) is to detect unbalanced load conditions, for example a broken conductor of a loaded overhead line in a medium voltage radial network.

Different fault conditions may apply:

- Broken conductor in contact with the earth/ground at the source side
- Broken conductor in contact with the earth/ground at the load side
- Open circuit (conductor not in contact with the earth/ground) caused by broken conductor, blown fuse, circuit breaker pole failure, etc.

This function can also be used for motor protection in order to detect blown fuse or phase reverse connection.

The PowerLogic P5 provides two stages of unbalance overcurrent, broken conductor protection. Each stage can be enabled or disabled independently.

The function is inactive if only 2 phase current sensors are connected (2 CT mode with setting **Number of connected phase CT** = *A/C* in the **GENERAL** menu/ **Scaling** sub-menu).

The operation of the unbalanced load function is based on the negative phase sequence component I_2 related to the positive phase sequence component I_1. These are calculated from the phase currents using the method of symmetrical components. The function requires that the measuring inputs are connected correctly. The unbalance protection has definite time operation characteristic.

The positive and negative sequence currents I_1 and I_2 are defined as follows (for standard phase rotation A - B - C):

$$\vec{I_1} = \frac{1}{3}(\vec{I_A} + a\vec{I_B} + a^2\vec{I_C})$$

P533BGB

$$\vec{I_2} = \frac{1}{3}(\vec{I_A} + a^2\vec{I_B} + a\vec{I_C})$$

P533BHB

with phasor rotating constant:

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

P533BEB

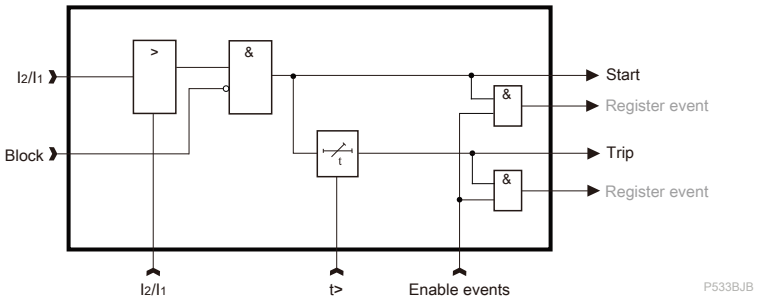
NOTE: The broken conductor function is inhibited if the positive sequence current I_1 is less than 5% of the nominal current.

With transformer differential protection P5T30 each stage can be individually linked to the measured phase currents of one end.

If phase swapping feature is used, then this is considered in the calculation of the sequence currents.

Block diagram

Figure 222 - Block diagram of the unbalance overcurrent broken conductor protection function (ANSI 46BC)



Characteristics

Table 68 - Settings and characteristics of the unbalance overcurrent broken conductor protection

Settings/characteristics	Value
Pick-up value/Pick-up value	
Setting range	2%...70%
Resolution	1%
Accuracy	±3%
CT input selection[63]	
Setting range	CT-1, CT-2
Reset ratio	
Value	95%
Accuracy	±2% or ±2 mA secondary
Operate delay/Operate delay	
Setting range	0.00...300.0 s
Resolution	0.01 s
Accuracy	±1% or ±20 ms
Characteristic times	
Start time	< 50 ms (45 ms with high speed) for currents at 2 x Pick-up value < 60 ms (55 ms with high speed) for currents at 1.2 x Pick-up value < 75 ms (70 ms with high speed), for currents at 1.05 x Pick-up value < 105 ms (100 ms with high speed) for P5T30, for currents at 1.05 x Pick-up value
Disengaging time	< 75 ms (90 ms with high speed)
Setting group/SetGrp	
Number	4

63. Available for P5T30 only.

Negative sequence overvoltage (ANSI 47)

Description

To protect a rotating machine from being energised with a reverse voltage sequence or to help prevent overheating of the motor due to a broken conductor condition, negative sequence overvoltage protection (ANSI code 47) can be applied. This protection monitors the voltage phase sequence detecting a reverse rotation or voltage unbalance due to a missing (asymmetrical) phase. The detection of these conditions can then be used to trip the machine and help prevent damage to both the motor and the mechanically coupled process.

The PowerLogic P5 protection relay provides two stages of negative sequence overvoltage protection. Each stage can be enabled or disabled independently. The negative sequence voltage is derived from the three phase voltages. If the VT connection is configured as “VPP/VPPy”, the negative sequence voltage cannot be derived, and the negative sequence overvoltage protection is disabled.

If the negative sequence voltage input exceeds the voltage setting, this function starts instantaneously, and it operates with the definite time delay or inverse time delay characteristic that has been selected. The inverse time delay characteristic follows the equation below:

$$t = \frac{T}{\frac{V}{G_S} - 1}$$

P533BKB

where:

t is the theoretical operate time in seconds.

T is the operate delay setting (theoretical operate time for $V = 2 \times G_S$).

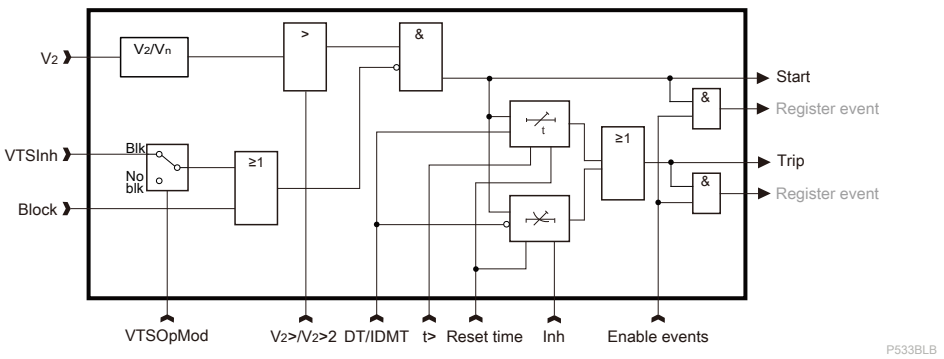
V is the calculated value of negative sequence voltage.

G_S is the pick-up setting value of the negative sequence overvoltage protection.

The V stage has a settable reset delay that enables the detection of intermittent faults. This means that the time counter of the protection function does not reset immediately after the fault is cleared, but resets after the release delay has elapsed. If the fault appears again before the release delay time has elapsed, the delay counter continues from the previous value. This means that the function eventually trips if faults are occurring often enough. This function is blocked by VTS operation if the setting "VTS operating mode" is set to "Blocking".

Block diagram

Figure 223 - Block diagram of the negative sequence overvoltage protection (ANSI 47)



Characteristics

Table 69 - Settings and characteristics of the negative sequence overvoltage protection function

Settings/characteristics (description/label)	Values
VTS operating mode/VTS operating mode	
Options	No action; Blocking
Pick-up value/Pick-up value	
Setting range	0.01...1.00 pu[64]
Resolution	0.01 pu[64]
Accuracy	±2% or ±0.05 V secondary
Operating curve/Delay type	
Options	DT; IDMT(the characteristic follows the equation provided in Description, page 320)
Operate delay/Operate delay	
Setting range	0.00...300.00 s
Resolution	0.01 s
Accuracy	DT: ±2% or ±20 ms; IDMT: ±5% or ±20 ms
Reset delay/Reset delay	
Setting range	0.03...300 s
Resolution	0.01 s
Accuracy	±2% or ±20 ms
Reset ratio	
Value	98% ± 1% fixed
Minimum hysteresis	120 mV secondary
Characteristic times	
Start time	< 55 ms (50 ms with high speed) for voltage from 0.9 Pick-up value to 1.1 Pick-up value
Overshoot time	< 40 ms for voltage from 0.9 Pick-up value to 1.1 Pick-up value
Setting group/SetGrp	
Number	4

64. U_n = VT primary nominal

Thermal overload protection for feeder (ANSI 49F)

Description

The Thermal Overload protection function for Feeder (ANSI code 49F) can be applied to minimise damage to overhead lines and underground cables when operating at temperatures in excess of the designed maximum withstand (deterioration of the insulation, sagging conductors etc.).

The PowerLogic P5 protection relays that are designed for feeder protection incorporate a current based thermal replica, using phase current to reproduce the heating and cooling of the feeder conductors. In this case, the PowerLogic P5 protection relay automatically uses the highest phase current as input information for the thermal model. The current measurement is based on 3 phase RMS currents, that takes into account harmonic rank up to 15. The mathematical model used to compute the thermal level of the feeder conductors is based on the thermal model defined in the IEC 60255-149 standard.

The thermal replica can optionally take account of ambient temperature, preferably when an ambient temperature sensor is available. However, where an ambient temperature sensor is not available, the user may enter a default value for ambient temperature which is different to the value defined in the feeder conductors data sheet (e.g. to take account of summer and winter ambient temperature values).

The Thermal Overload for Feeder protection can be used in two different setting modes:

- Current based setting mode
- Temperature based setting mode

The following sections explain the two setting modes.

Also with transformer differential protection P5T30 one such thermal overload element is provided which can be linked to the measured phase currents of one end as per application requirements.

Current based setting mode

This setting mode is active when "Temperature based mode" is set to "Current". In this setting mode, the thermal level H(t) is computed according to the thermal model defined in the IEC 60255-149.

The thermal level H(t) is computed according to the following equation:

$$H(t) = H(t - \Delta t) + \left(\frac{I_{eq}(t)}{k \times I_b}\right)^2 \times \frac{\Delta t}{\tau} - H(t - \Delta t) \times \frac{\Delta t}{\tau}$$

P533BMB

where:

- H(t) is the thermal level computed at time t ("Thermal level").
- H(t - Δt) is the thermal level computed at time t - Δt.
- $I_{eq}(t)$ is the equivalent heating phase current at time t computed from the maximum of the 3 phase RMS currents.
- I_b is "Basic current setting" or "Feeder basic current".
- k is the "k" factor applied to the basic current to define the maximum continuous current.
- τ is the heating time constant of the feeder ("Heating time constant" or "Time constant τ"), where τ is assumed to be much greater than Δt.

"$[I_{eq}(t) / (k \times I_b)]^2 \times \Delta t / \tau$" expresses the heat transfer due to the phase current $I_{eq}(t)$ and "$H(t - \Delta t) \times \Delta t / \tau$" expresses the natural cooling of the feeder conductors.

The thermal overload protection operates when the thermal level is greater than 100%. This thermal level of 100% can be reached with a permanent current above the basic current value I_b multiplied by the k factor.

With a continuous load current "I_{eq}", the thermal level "H" is equal to:

$$H\,(I_{eq}) = \left(\frac{I_{eq}}{k \times I_b}\right)^2$$

P533BNB

The table below indicates the thermal level with different values of continuous load current:

I_{eq} / (k x I_b) ratio	Thermal Level (%)
1	100% (operation)
0.9	81%
0.8	64%
0.7	49%
0.6	36%
0.5	25%
0.4	16%
0.3	9%

Generally, the basic current I_b is set to the “Basic current” of the feeder, and k factor could be set to take into account the accuracy of the global current measuring chain (phase CTs and the protection relay). The k factor is set to 1.0 by default.

A thermal alarm ("49F alarm" output) is provided which operates when the thermal level is greater than or equal to the "Thermal alarm value" setting (expressed in %) and is usually set to be lower than 100%, the operate level. This threshold, expressed in %, is available only in the current based setting mode.

The thermal level in % is accessible as an output measurement.

When thermal overload is managed in the several setting groups, the thermal level is kept after the setting group change (no thermal level reset), and the thermal level is computed according to the new settings.

Temperature based setting mode

This setting mode is active when "Operating mode" setting is set to "Ambient". In this setting mode, the protected object temperature computation is based on the previous thermal level H(t) calculation (see previous section "Current based setting mode") with an additional reference to the maximum operating temperature of the feeder conductors, the maximum ambient temperature and the working temperature, defined by setting.

In this mode, the thermal level H(t) is computed with the following formula, derived from the equation of thermal level H(t) calculation:

$$H(t) = H(t - \Delta t) + F_a \times \left(\frac{I_{eq}(t)}{k \times I_b}\right)^2 \times \frac{\Delta t}{\tau} - H(t - \Delta t) \times \frac{\Delta t}{\tau}$$

P533BQB

Where common values are identical to the thermal level H(t) calculation formula, and the additional "F_a" ambient temperature factor is defined with the following equation:

$$F_a = \frac{T_{max} - T_{nom}}{T_{max} - T_a}$$

P533BRB

where:

- T_{max} is the maximum temperature of the equipment ("Max object temperature").
- T_{nom} is the limit of the ambient temperature designed for the feeder conductors to operate at rated loads without causing thermal degradation of insulation ("Nominal ambient temperature", typically equal to 40°C).
- T_a is the real time ambient temperature of the feeder conductors measured with the RTD number 8. When no temperature sensor is available or the sensor is faulty, or the temperature measurement exceed "Max object temperature" setting or lower than the "Min ambient temperature", the value of "Default ambient temperature" will be used for this temperature.

The ambient temperature of the feeder conductors is computed with the following formula:

$$T_{object} = H(t) \times (T_{max} - T_a) + T_a$$

P533BSB

Where H(t), T_{max} and T_a are defined according to the previous equations.

The thermal overload protection operates when the computed temperature "T_{object}" is above or equals the maximum temperature T_{max}.

A temperature alarm is provided ("49F T> alarm" output). This output operates when the temperature level is greater than or equal to the alarm temperature setting(expressed in °C).

The ambient temperature (T_a) and object temperature (T_{object}) are accessible as output measurements in °C (T_a = "Ambient temperature" output and T_{object} = "Object temperature" output). The default value of the ambient temperature is equal to the "Default ambient temperature" setting.

Additional features

The thermal level computation expressed in % is always available with the feeder thermal level output. The current thermal level is saved in a non volatile memory when the PowerLogic P5 protection relay is powered off. If the current thermal level is above 90%, a value of 90% is memorised to help prevent possible nuisance tripping on supply restoration.

A measurement output where the estimated time to trip is provided, based on the hypothesis that the load current present remains constant until thermal overload operation occurs.

A time remaining alarm ("49F rsv alarm" output) is provided. It operates when the calculated remaining time is less than or equal to the "Reserve time thermal alarm" setting.

There is a digital input (“Feeder thermal level reset” signal) to reset the thermal level value, when the digital input is asserted, the value of thermal level is set to Zero.

It is possible to block the protection function using the block matrix.

Typical values of heating time constant:

Applications	Time constant (min)
Dry-type transformers	40 (rating < 400 kVA) 60...90 (rating 400...800 kVA)
Air-core reactors	40
Capacitor banks	10
Overhead lines	10 (Cu: cross section greater than or equal to 100 mm^2 (0.15 in^2); or Al: 150 mm^2 (0.23 in^2))
Busbars	60

Time to trip calculation

For a continuous current higher than the current threshold (k x I_b), the operate time of the thermal overload protection can be computed with the following equation:

$$t = \tau \times L_n \times \left(\frac{F_a \times H(I_{eq}) - H_0}{F_a \times H(I_{eq}) - 100\%} \right)$$

P533BOB

where:

- τ is the heating time constant for the protected equipment.
- Ln( ) is natural logarithm function.
- F_a is the ongoing temperature compensation. In current based setting mode, $F_a = 1$.
- $H(I_{eq})$ is the thermal level calculated with the continuous load current (I_{eq}) and the basic current setting (I_b).
- H_0 is the current thermal state corresponding to the last calculation.

In the same way, for a continuous current higher than the current threshold (k x I_b), the time for the alarm to operate is:

$$t = \tau \times L_n \times \left(\frac{F_a \times H(I_{eq}) - H_0}{F_a \times H(I_{eq}) - H_{alarm}} \right)$$

P533BTB

where:

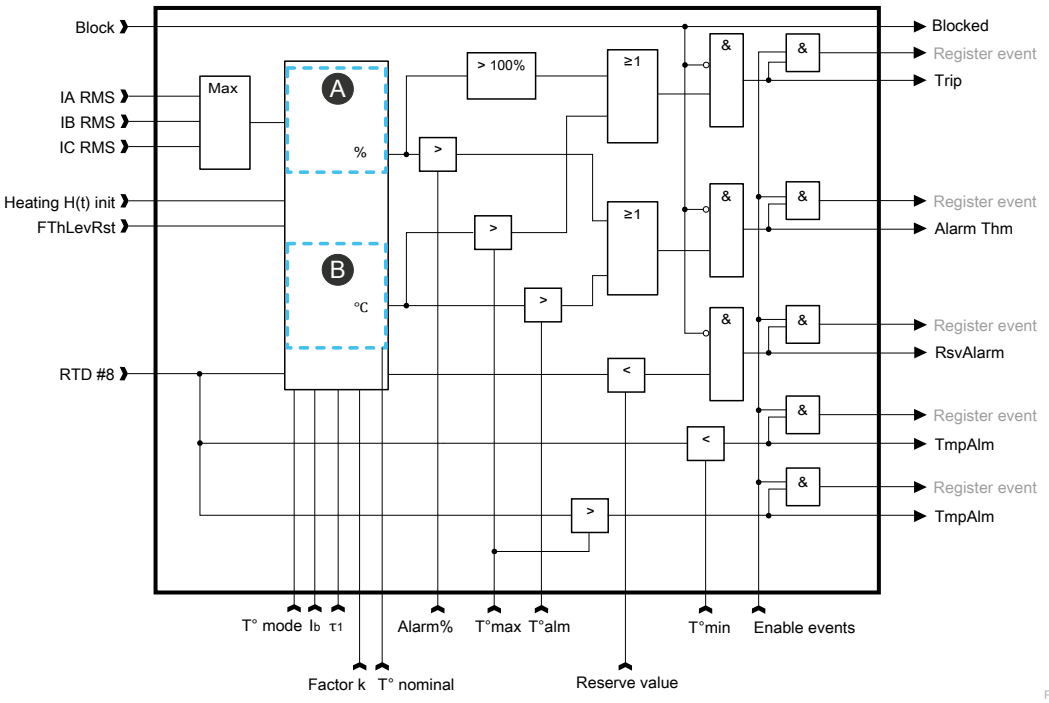
H_{alarm} is "Alarm" (alarm temperature setting, in %). In temperature based setting mode, the alarm temperature setting is expressed in °C. The corresponding thermal level in % (H_{alarm}) is defined by the following equation:

$$H_{alarm} = \frac{T_{alm} - T_a}{T_{max} - T_a} \times 100\%$$

P533BUB

Block diagram

Figure 224 - Block diagram of the thermal overload protection function (ANSI 49F)



A	Current based mode calculation zone	B	Temperature based mode calculation

Characteristics

Table 70 - Settings and characteristics of the thermal overload protection stage 49F

Settings/characteristics (description/label)	Values
Basic current setting/I_b	
Setting range	0.1...4.0 pu[65]
Resolution	0.01 pu[65]
CT input selection[66]	
Setting range	CT-1, CT-2
Max permissive I factor/Factor k	
Setting range	0.1...1.5
Resolution	0.01
Heating time constant/Time constant τ1	
Setting range	1.0...1000.0 min
Resolution	0.1 min
Thermal alarm value/Alarm	
Setting range	50%...100% of thermal level
Resolution	1%
Reserve time thermal alarm/Reserve value	
Setting range	1.0...1000.0 min
Resolution	0.1 min
Operating mode/T°mode	
Options	Current; Ambient
Nominal ambient temperature/T°nominal	
Setting range	-40... +300 °C (-40... +572 °F)
Resolution	1 °C (1.8 °F)
Max object temperature/T°max	
Setting range	-40 - +300 °C (-40...+572 °F)
Resolution	1 °C (1.8 °F)
Alarm temperature/T°alm	
Setting range	0... +300 °C (32...+572 °F)
Resolution	1 °C (1.8 °F)
Min ambient temperature/T°min	
Setting range	-40... 300 °C (-40... +572 °F)
Resolution	1 °C (1.8 °F)
Default ambient temperature/T def ambient	
Setting range	-40...300 °C (-40...+572 °F)
Resolution	1 °C (1.8 °F)

65. I_{nom}
66. Available for P5T30 only.

Table 70 - Settings and characteristics of the thermal overload protection stage 49F (Continued)

Settings/characteristics (description/label)	Values
Thermal level init value/ Heating H(t) init	
Setting range	0%...90%
Resolution	0.1%
Characteristics	
Tripping time accuracy	±5% or ±500 ms (with the applicable factor according to IEC 60255-149)
Setting group/SetGrp	
Number	4

Motor status

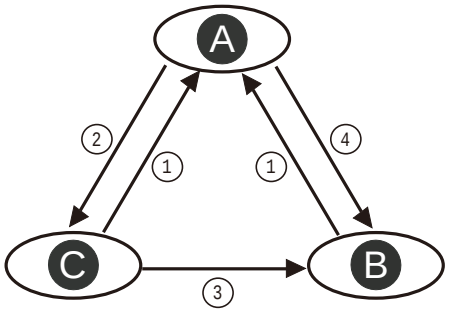
Description

There are three possible status for a motor: stopped, starting or running.

The PowerLogic P5 detects motor start by CB position, motor current, or both CB position and motor current using “Motor start detection mode”.

- CB Position: The CB position changes from open to closed.
- Current: Three phase currents have been less than 5% Inom(phase CT primary nominal). Then any of the three phase currents increases and exceeds the motor start detection current.
- CB Position and Current: Any of the three phase currents exceeds the motor start detection current in 90 ms after CB position changes from open to close.

Figure 225 - Motor status



P533BWB

A	Stopped	B	Running
C	Starting		

Criterion for motor in starting state

1. As soon as the motor start is detected, the motor changes from “Stopped” state to “Starting” state.②

   NOTE: Motor start counter counts the number of successful starts, not including the emergency restart.

Criterion for motor in stopped state

1. If the motor start criterion is “CB Position”, the motor is in “Stopped” state when CB is open. ①
2. If the motor start criterion is “Current” or “CB & Current”, the motor is in “Stopped” state when three phase currents are all less than 5% Inom (phase CT primary nominal). ①

Criterion for motor in running state

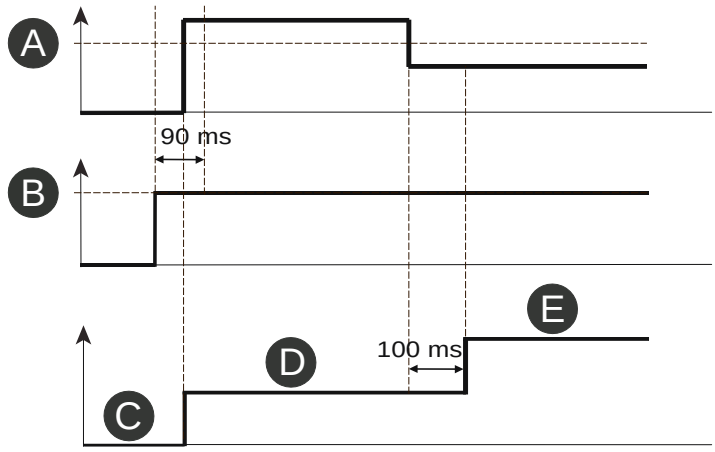
1. When the motor is in “Starting” state and three phase currents drop below the motor start detection current for 100 ms, the motor state changes to “Running”. ③

2. If the motor start is not detected successfully and the criteria for motor in “Stopped” state are not satisfied, the relay will consider the motor is in “Running” state.

   For example: if the motor start detection mode is “CB & Current” and all three phase currents do not exceed the motor start detection current within 90 ms after CB is closed, the motor start is not detected. Motor state changes from “Stopped” state to “Running” after the 90 ms timing window. ④

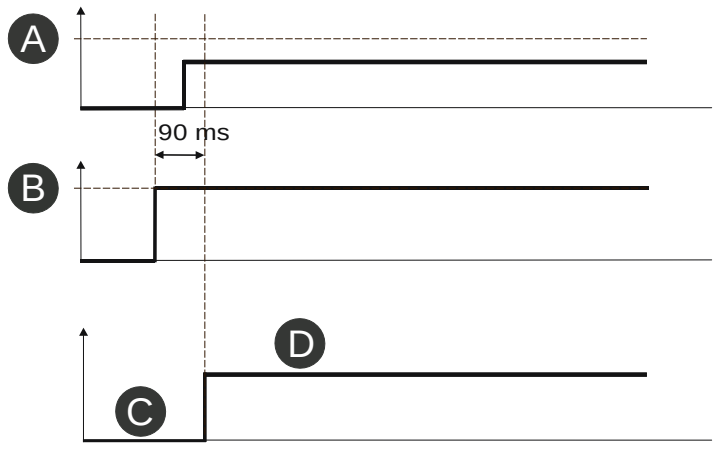
Typical diagrams for the detection of successful direct-on-line start and soft start are shown in the following diagrams, with the use of the “CB & Current” mode.

Figure 226 - Successful DOL start



A	Motor start detection current	B	CB Closed
C	Motor stopped	D	Motor starting
E	Motor running		

Figure 227 - Successful soft start



A	Motor start detection current	B	CB Closed
C	Motor stopped	D	Motor running

If the corresponding condition is satisfied in two consecutive executions, the motor status is changed.

General settings

Settings (description/label)	Value
Nom motor start current/Imot nom start	
Setting range	1.50...10.00 pu[67]
Resolution	0.01 pu[67]
Motor start detection current/I_{start}>	
Setting range	0.10...10.00 pu[67]
Resolution	0.01 pu[67]
Reset ratio	95% ± 2%
Minimum hysteresis	5 mA secondary
Motor start detection mode/StrDetMod	
Options	CB Position; Current; CB & Current

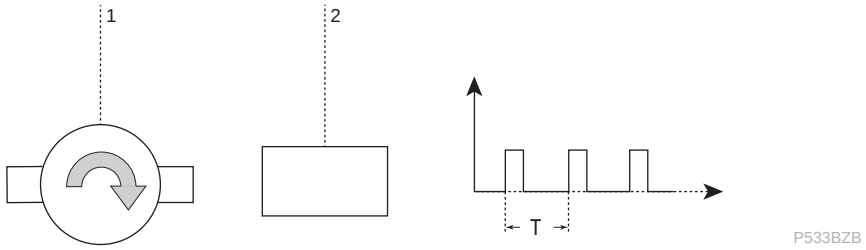
67. I_{nom}

Motor speed detection

Description

Motor rotation speed (Ω) can be measured based on cams mounted on a rotor with a proximity sensor. The output from the proximity sensor is a train of electrical pulses, where each pulse corresponds to the detection of an individual cam. Hence, if a given application has R number of cams mounted 360º/R apart on a rotor, the number of cams R is equal to the number of pulses per rotation of the rotor shaft. The time interval T (in seconds) between consecutive pulses can be used to calculate the revolutions per minutes (rpm), using: Ω = 60 / (R x T).

Figure 228 - Proximity sensor



1 Rotor with 2 cams

2 Proximity sensor

Table 71 - Characteristics of proximity sensor

Characteristics	Values
Pass-band (in Hz)	> 2 Ω_n x R/60 Ω_n is rated motor rotation speed.
Output	24...250 V DC, 3 mA minimum
Leakage current in open status	< 0.5 mA
Voltage dip in closed status	< 4 V (with 24 V power supply)
Pulse duration	0 status > 120 µs 1 status > 200 µs

The proximity detector output pulses are at a voltage level which is compatible with the logic inputs (24...240 V DC), which means that a logic input must be mapped to a given proximity detector to perform the speed measurement. The 12I4O module contains a specific digital input (DI1) to detect the motor speed. It can recognise the high voltage signal as status 1 with > 200 us pulse width and the low voltage signal as status 0 with > 120 us pulse width.

PowerLogic P5 protection relay can only use one speed detection input. If several 12I4O modules (such as Slot C, Slot D, Slot E) are fitted in the PowerLogic P5 protection relay, the user can select the dedicated digital input from any of the 12I4O modules for motor speed detection. If there is no 12I4O module fitted in the relay, the motor speed detection and motor overspeed / underspeed protection will be invisible.

NOTICE

IMPROPER EQUIPMENT OPERATION

If the counting input DI1 on 12I4O is selected for motor speed detection, this input cannot be used by any other protection functions.

Failure to follow this instruction can result in equipment damage.

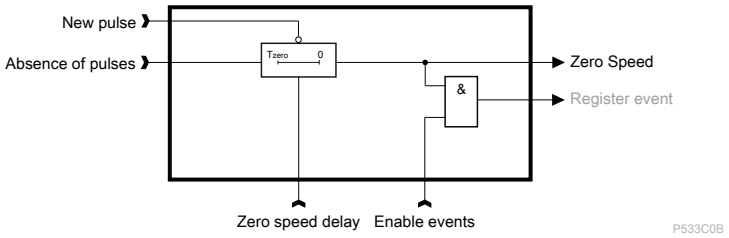
When the motor speed detection function is Enabled and one specific digital input is selected as motor speed input, the settings, such as “Delay”, “On Event”, “OFF

Event” and “Debounce” settings in “Control/digital inputs” are automatically noneffective for this selected digital input.

This function provides an output signal “Zero speed”. If the PowerLogic P5 protection relay does not detect the pulse from the proximity sensor for motor speed measurement for a settable duration, the zero speed output signal is ON.

Block diagram

Figure 229 - Block diagram of zero speed detection



Characteristics

Table 72 - Settings and characteristics of motor speed detection protection

Settings/characteristics (description/label)	Values
Motor speed input/Speed input	
Options	Selection of DI for motor speed • PowerLogic P5U20 12I4O DI1 on Slot C • PowerLogic P5M30 12I4O DI1 on Slot C, D, E This selection is dependent on the hardware configuration of the device.
Rated motor speed Ω_n/Ω_n	
Setting range	100...3600 rpm
Resolution	1 rpm
Pulse per rotation/R	
Setting range	1...900 (with limitation Ω_n x R / 60 ≤ 1500)
Resolution	1
Zero speed confirm time/Zero speed delay	
Setting range	1...300 s
Resolution	1 s
Accuracy	±2% or ±150 ms
Motor speed measurement	
Range	0...7200 rpm
Resolution	1 rpm
Accuracy	±1 rpm
Refresh interval	1 s
Measurement time	100 ms
Setting group/SetGrp	
Number	1

Motor start time supervision (ANSI 48)

Description

The motor start time supervision protection function (ANSI code 48) helps to protect the motor against prolonged direct-on-line (DOL) starts caused by, for example, a stalled rotor, too high inertia of the load or too low voltage.

During the motor starting, the current exceeds the motor full load current and motor thermal stress increases quickly. So motor overheating is possible if the duration of the motor starting exceeds the set period.

This function is sensitive to the fundamental frequency component of the phase currents.

The motor start time supervision protection Ist> measures the fundamental frequency component of the phase currents.

The Ist> stage can be configured for definite operate time or dependent operate time characteristic. For a weak voltage supply, the dependent characteristic is useful allowing more start time when a voltage drop decreases the start current and increases the start time. Equation 7.7 defines the dependent operate time. Example of an dependent operation time of the motor start time supervision protection function, page 333 shows an example of the dependent characteristic. If the measured current is less than the specified start current I_{start}, the operate time is longer than the specified start time T_{start}.

$$T = \left(\frac{I_{nomMotSt}}{I} \right)^2 \times T_{start}$$

P533C1B Equation 7.7

Where:

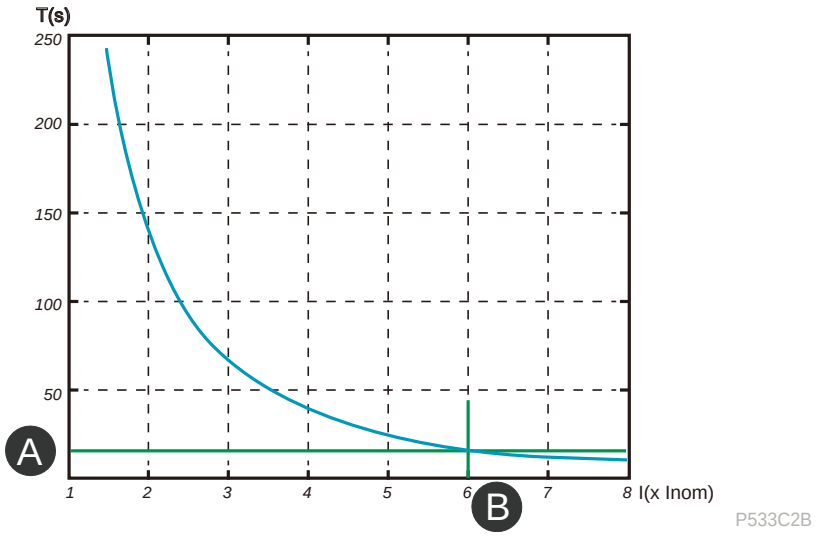
T = Dependent operate time

$I_{nomMotSt}$ = Nominal motor start current

I = Maximum of IA, IB, IC

T_{start} = Motor start time

Figure 230 - Example of an dependent operation time of the motor start time supervision protection function



A T_{start} = 15 s, maximum allowed start time.

B I_{start} = 6 x Inom, rated start current.

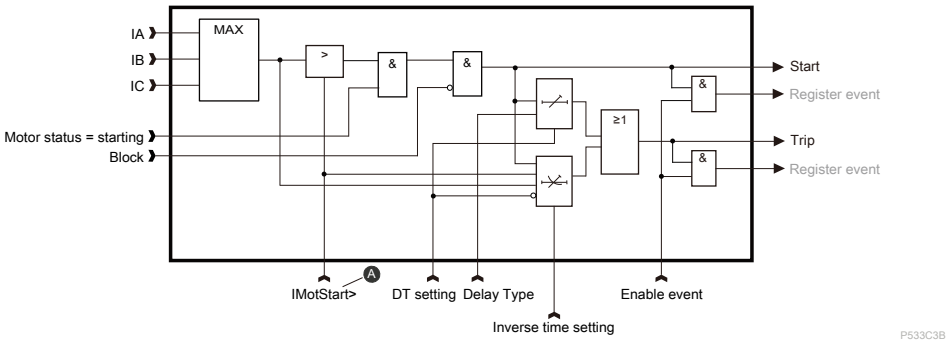
NOTE:

The pick-up current setting I_{start}> is the start detection level of the start current. While the motor status is starting and the current exceeds the pick-up setting I_{start}>, the motor start-up supervision stage starts to count the operate time.

When current drops below the setting I_{start}>, the motor start-up supervision stage releases. Motor start-up supervision is active only during the starting of the motor.

Block diagram

Figure 231 - Block diagram of the motor start time supervision function (ANSI 48)



A IMotStr is set in motor status function as motor start detection current.

Characteristics

Table 73 - Settings and characteristics of the motor start time supervision protection stage Ist>

Settings/characteristics (description/label)	Value
Operating curve/Delay type	
Options	DT (definite time); INV (inverse time)
Motor start time/Motor start time	
Setting range	1.0...300.0 s
Resolution	0.1 s
Accuracy	±1% or ±20 ms (DT) ±5% or ±20 ms (INV)
Characteristic times	
Start time	< 70 ms (65 ms with high speed)
Disengaging time	< 85 ms (100 ms with high speed)
Setting groups/SetGrp	
Number	1

NOTE: For motor start detection current and nominal start current settings, see Motor status, page 328.

Thermal overload protection for machine (ANSI 49M)

Description

The Thermal Overload protection function for machine (ANSI code 49M) can be applied to help prevent damage on the stator and rotor against overloading conditions due to balanced and unbalanced currents.

- The PowerLogic P5 protection relays designed for protecting machines incorporate a current based thermal replica, using phase current to reproduce the heating and cooling of the equipment to be protected. In this case, the PowerLogic P5 protection relay automatically uses the highest phase current as input information for the thermal model. The current measurement is based on 3 phase RMS currents, that takes into account harmonic rank up to 15. The mathematical model used to compute the thermal level of the protected equipment is based on the thermal model defined in the IEC 60255-149 standard.
- The thermal replica takes into account the overheating generated by the negative sequence current in the motor, with a weighting defined by a settable coefficient, depending on the motor characteristics.
- The thermal replica provides the capability to set two heating time constants, one for starting sequence or the phase current is greater than the motor start threshold (e.g. locked stator in running state) and one for normal running, in addition to the cooling time constant applied when the motor is stopped. The selection of the time constants are decided according to the motor state input from the motor status function. Besides, the time constant τ_2 is also decided by the max phase current which is greater than the motor start value. Indication of the time constant τ_1 and time constant τ_2 active is provided by means of digital outputs.
- The thermal replica can optionally take account of ambient temperature, preferably when an ambient temperature sensor is available. However, where an ambient temperature sensor is not available, the user may enter a default value for ambient temperature which is different to the value defined in the protected equipment data sheet (e.g. to take account of summer and winter ambient temperature values).

  NOTE: The motor thermal level in thermal overload (ANSI code 49M) function can be reset by Modbus communication.

The Thermal Overload for machine protection can be used in two different setting modes:

- Current based setting mode
- Temperature based setting mode

The following sections explain the two setting modes.

Current based setting mode

This setting mode is active when "Operating mode" is set to "Current". In this setting mode, the thermal level H(t) is computed according to the thermal model defined in the IEC 60255-149.

According to the user settings, in general, the thermal level is computed by three different ways according to the three different motor states:

- Running state
- Starting state
- Stopped state

Motor in running state

When the motor is running, the thermal level H(t) is computed according to the following equation:

$$H(t) = H(t - \Delta t) + \left(\frac{I_{eq}(t)}{k \times I_b}\right)^2 \times \frac{\Delta t}{\tau_1} - H(t - \Delta t) \times \frac{\Delta t}{\tau_1}$$

P533C4B

where:

- H(t) is the thermal level computed at time t.
- H(t - Δt) is the thermal level computed at time t - Δt.
- $I_{eq} = \sqrt{max\ (IA,IB,IC)^2 + q \times (I2)^2}$

  P533C5B

  where:
  - IA, IB, IC are the RMS phase currents.
  - q is a user setting to define the unbalance factor ("Unbalance factor" or "Factor q").

    For an asynchronous motor, q is determined as follows:

    $$q = 2 \times \frac{T_{LR} / I_{LR}^2}{S_n} - 1$$

    P533C6B

    I_{LR} is the motor locked rotor current/ starting current in pu value.

    T_{LR} is the motor locked rotor torque in pu value.

    S_n is rated slip.

    NOTE: In 2 CT mode it is recommended to set q = 0.
  - I2 is the negative sequence current.

    NOTE: The actual measured equivalent current is displayed as I% load = I_{eq} / (k x I_b) in the function.
- I_b is the "Basic current setting" or "Machine nominal current".
- k is the “Max. permissive current factor” or the "k" factor applied to the basic current to define the maximum continuous current.
- τ_1 is the heating thermal time constant of the motor ("Heating time constant" or "Time constant τ_1"), where τ_1 is assumed to be much greater than Δt.

In the equation above the term "$[I_{eq}(t) / (k \times I_b)]^2 \times \Delta t / \tau_1$" expresses the heat transfer due to the phase current $I_{eq}(t)$, and the term "$H(t - \Delta t) \times \Delta t / \tau_1$" expresses the natural cooling of the devices (in the running state).

The digital output Motor TC1 active is asserted in this state.

Motor in starting state

When the motor is starting, the user can set a different time constant, to take into account the heating effect on rotor windings during the starting sequence. In that state, the thermal level H(t) is computed according to the same equation than above, where the time constant τ_1 is replaced by the time constant τ_2.

$$H(t) = H(t - \Delta t) + \left(\frac{I_{eq}(t)}{k \times I_b}\right)^2 \times \frac{\Delta t}{\tau_2} - H(t - \Delta t) \times \frac{\Delta t}{\tau_2}$$

P533C7B

Where τ_2 is the heating time constant during starting sequence or the phase currents is greater than the motor start threshold ("Time constant for motor starting " or "Time constant τ_2").

The digital output Motor TC2 active is asserted in this state.

Motor in stopped state

When the motor is stopped, the cooling effect is dominant since there is no heating contribution, so a cooling time constant must be taken into account in the stopped state. In that state, the thermal level H(t) is computed according to the following equation:

$$H(t) = H(t - \Delta t) - H(t - \Delta t) \times \frac{\Delta t}{\tau_3}$$ P533C8B

Where τ_3 is the cooling thermal time constant of the protected equipment ("Cooling time constant" or "Time constant τ_3").

The digital outputs Motor TC1 active and Motor TC2 active are reset in this state.

The thermal overload protection operates when the thermal level is greater than 100%. This thermal level of 100% can be reached with a permanent current above the basic current value ("Basic current setting" or "I_b") multiplied by the k factor (Max. permissive current factor).

With a continuous load current "I_{eq}", the thermal level "H" is equal to:

$$H\,(I_{eq}) = \left(\frac{I_{eq}}{k \times I_b}\right)^2$$ P533BNB

The table below indicates the thermal level with different values of continuous load current:

I_{eq} / (k x I_b) ratio	Thermal Level (%)
1	100% (operation)
0.9	81%
0.8	64%
0.7	49%
0.6	36%
0.5	25%
0.4	16%
0.3	9%

Generally, the basic current I_b is set to the "Basic current" of the machine, and k factor could be set to take into account the accuracy of the global current measuring chain (phase CTs and the protection relay). The k factor is set to 1.0 by default.

An thermal alarm ("49M alarm" output) is provided which operates when the thermal level is greater than or equal to the "Thermal alarm value" setting (expressed in %) and is usually set to be lower than 100%, the operate level. This signal can be used to lock the CB reclosing until thermal state is back under the alarm level.

The thermal level in % is accessible as an output measurement.

When thermal overload is managed in the several setting groups, the thermal level is kept after the setting group change (no thermal level reset), and the thermal level is computed according to the new settings.

Temperature based setting mode

This setting mode is active when "Operating mode" setting is set to "Ambient". In this setting mode, the protected equipment temperature computation is based on the previous thermal level H(t) calculation (see previous section Current based setting mode, page 335) with an additional reference to the maximum operating temperature of the equipment, the nominal ambient temperature and the working ambient temperature, defined by setting.

In this mode, the thermal level H(t) is computed with the following formula, derived from the equation of thermal level H(t) calculation:

$$H(t) = H(t - \Delta t) + F_a \times \left(\frac{I_{eq}(t)}{k \times I_b}\right)^2 \times \frac{\Delta t}{\tau} - H(t - \Delta t) \times \frac{\Delta t}{\tau}$$ P533BQB

Where common values are identical to the thermal level H(t) calculation formula, and the additional "F_a" ambient temperature factor is defined with the following equation:

$$F_a = \frac{T_{max} - T_{nom}}{T_{max} - T_a}$$

P533BRB

where:

- T_{max} is the maximum temperature of the equipment ("Max object temperature" setting).
- T_{nom} is the limit of the ambient temperature designed for the protected equipment to operate at rated loads without causing thermal degradation of insulation ("Nominal ambient temperature" setting, typically equal to 40 °C).
- T_a is the real time ambient temperature of the protected equipment measured with the RTD number 8.

The ambient temperature of the protected equipment is computed with the following formula:

$$T_{object} = H(t) \times (T_{max} - T_a) + T_a$$

P533BSB

Where H(t), T_{max} and T_a are defined according to the previous equations.

The thermal overload protection operates when the computed temperature "T_{object}" is above or equals the maximum temperature T_{max}.

A temperature alarm is provided ("49M T> alarm" output). This output operates when the temperature level is greater than or equal to the alarm temperature setting(expressed in °C).

The ambient temperature (T_a) and machine temperature (T_{object}) are accessible as output measurements in °C (T_a = "Ambient temperature" output and T_{object} = "Machine temperature" output).

Additional features

The thermal level computation expressed in % is always available with the motor thermal level output. The current thermal level is saved in a non volatile memory when the PowerLogic P5 protection relay is powered off. If the current thermal level is above 90%, a value of 90% is memorised to help prevent possible nuisance tripping on supply restoration.

A measurement output about the remaining time to trip ("Estimated time to trip") is provided, based on the hypothesis that the load current present remains constant until thermal overload operation occurs.

A time remaining alarm ("49M rsv alarm" output) is provided. It operates when the calculated remaining time is less than or equal to the "Reserve time thermal alarm" time setting.

A remote command can be used to reset the thermal level (e.g. after commissioning tests). This reset can be also performed from the local panel.

It is possible to block the protection function using the block matrix.

After each motor start sequence, the function is able to compute the thermal level consumed by the latest start. This measurement is accessible with the measurement output "Motor start thermal level/Motor start H(t)". When the thermal level calculation is above (100% - Motor start H(t)), the output signal "Block motor start" is asserted to inhibit CB Closing from taking place. The output time measurement output "Time left for motor start" provides the remaining time until the motor can be started.

There is a digital input (“MThLevRst” signal) to reset the thermal level value, when the digital input is asserted, the value of Thermal level H(t) shall be set to Zero.

Operating state	Conditions (defined by settings)	Impact on thermal level computation
Stopped state	Stopped state	$I_{eq}(t) = 0$ Cooling time constant τ_3 is used
Starting state	I > MotStrVal setting or starting state	Heating time constant τ_2 is used
Running state	Running state	Heating time constant τ_1 is used

Time to trip calculation

For a continuous current higher than the current threshold (k x I_b), the operate time of the thermal overload protection can be computed with the following equation:

$$t = \tau \times L_n \times \left(\frac{F_a \times H(I_{eq}) - H_0}{F_a \times H(I_{eq}) - 100\%} \right)$$

P533BOB

where:

- τ is the heating time constant for the protected equipment.
  - When the motor is in starting state, the time constant for motor starting is used;
  - When the motor is in running state, the heating time constant is used;
- $L_n( )$ is natural logarithm function.
- F_a is the ongoing temperature compensation. In current based setting mode, $F_a = 1$.
- $H(I_{eq})$ is the thermal level calculated with the continuous load current and the basic current setting.
- H_0 is the current thermal state corresponding to the last calculation.

In the same way, for a continuous current higher than the current threshold (k x I_b), the time for the alarm to operate is:

$$t = \tau \times L_n \times \left(\frac{F_a \times H(I_{eq}) - H_0}{F_a \times H(I_{eq}) - H_{alarm}} \right)$$

P533BTB

where:

H_{alarm} is "Alarm", the alarm threshold setting in % of thermal level. In temperature based setting mode, the threshold alarm threshold is expressed in °C with "T_{alm}" setting. The corresponding thermal level in % (H_{alarm}) is defined by the following equation:

$$H_{alarm} = \frac{T_{alm} - T_a}{T_{max} - T_a} \times 100\%$$

P533BUB

Time left for motor start

The thermal level of last motor start state need firstly be calculated through following equation:

$$H_{start} = F_a \times \left(\frac{I_{start}}{k \times I_b} \right)^2 \times \frac{t_{start}}{\tau_{start}}$$

P533Q1B

where:

- F_a is ambient temperature factor calculated by:

$$F_a = \frac{T_{max} - T_{nom}}{T_{max} - T_a}$$ P533BRB

  If it is current only mode, then $F_a = 1$.
- I_{start} is the start current detected during last motor start.
- I_b is the basic current of the machine (setting).
- k is the factor (setting) applied to the basic current to define the maximum continuous current.
- t_{start} is the time duration of motor starting state.
- τ_2 is the thermal time constant for motor starting.

When the thermal level H(t) is above (100% - H_{start}), time left for motor start is defined with the following equation:

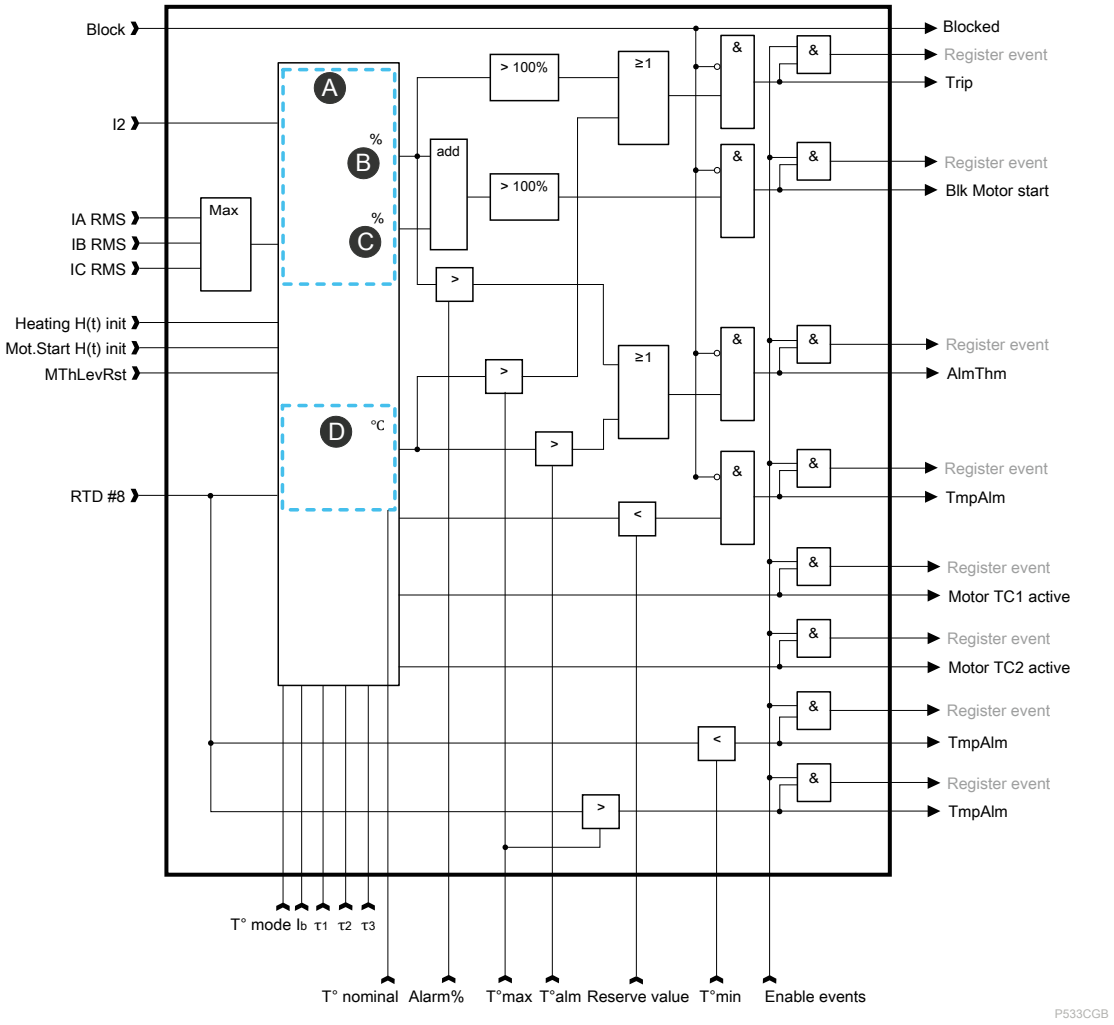
$$t = \tau_{cooling} \times L_n\left(\frac{H(t)}{100\% - H_{start}}\right)$$ P533Q2B

where:

- H(t) is the thermal level calculated at the moment.
- τ_3 is the cooling time constant when motor is stopped.

Block diagram

Figure 232 - Block diagram of thermal overload protection function (ANSI 49M)



A	Current based mode calculation	B	Therm level
C	Motor str level	D	Temperature based mode calculation

Characteristics

Table 74 - Settings and characteristics of the thermal overload protection stage 49M

Settings/characteristics (description/label)	Values
Basic current setting/I_b	
Setting range	0.1...4.0 pu[68]
Resolution	0.01 pu[68]
Max permissive I factor/Factor k	
Setting range	0.10...1.50
Resolution	0.01

68. I_{nom}

Table 74 - Settings and characteristics of the thermal overload protection stage 49M (Continued)

Settings/characteristics (description/label)	Values
Heating time constant/Time constant Ƭ1	
Setting range	1.0...1000.0 min
Resolution	0.1 min
Time constant for motor starting /Time constant Ƭ2	
Setting range	1.0...1000.0 min
Resolution	0.1 min
Cooling time constant/Time constant Ƭ3	
Setting range	1.0...1000.0 min
Resolution	0.1 min
Unbalance factor/Unbalance factor	
Setting range	0.0...10.0
Resolution	0.1
Thermal alarm value/Alarm	
Setting range	50%...100% of thermal level
Resolution	1%
Reserve time thermal alarm/Reserve value	
Setting range	1.0...1000.0 min
Resolution	0.1 min
Operating mode/T°mode	
Options	Current; Ambient
Nominal ambient temperature/T° nominal	
Setting range	-40...+300 °C (-40...+572 °F)
Resolution	1 °C (1.8 °F)
Max object temperature/T° max	
Setting range	-40...+300 °C (-40...+572 °F)
Resolution	1 °C (1.8 °F)
Alarm temperature/T° alm	
Setting range	0...+300 °C (32...+572 °F)
Resolution	1 °C (1.8 °F)

Table 74 - Settings and characteristics of the thermal overload protection stage 49M (Continued)

Settings/characteristics (description/label)	Values
Min ambient temperature/T° min	
Setting range	-40...300 °C (-40...+572 °F)
Resolution	1 °C (1.8 °F)
Default ambient temperature/T° dft ambient	
Setting range	-40...300 °C (-40...+572 °F)
Resolution	1 °C (1.8 °F)
Characteristics	
Tripping time accuracy	±5% or ±500 ms (with the applicable factor according to IEC 60255-149)
Setting group/SetGrp	
Number	4

NOTE: To test the thermal overload protection more easily and faster, it is possible to set a thermal level init. value and a motor start thermal level init. value from 0% to 90%. After test, it is possible to reset the values to 0%.

Locked rotor (ANSI 51LR)

Description

The locked rotor protection function (ANSI code 51LR) stage I_{lr}> measures the fundamental frequency component of the phase currents and calculates the maximum of the measured three phase currents.

The locked rotor stage protects the motor when too heavy load or a mechanical failure of the motor causes rotor jam during the motor running condition.

The stage's start setting is relative to the motor's nominal starting current. The nominal starting current can be configured in the **Motor status** view of the **Protection** menu in eSetup Easergy Pro.

The locked rotor stage can be configured for definite time or inverse time operation characteristic. *Equation 7.8* defines the dependent operate time.

$$T = \left(\frac{I_{motNomSt}}{I}\right)^2 T_{start}$$ P533FNB Equation 7.8

T = Dependent operate time

$I_{motNomSt}$ = Nominal motor start current

I = Maximum of IA, IB, IC (to be unique with Ist> function)

T_{start} = Operation delay

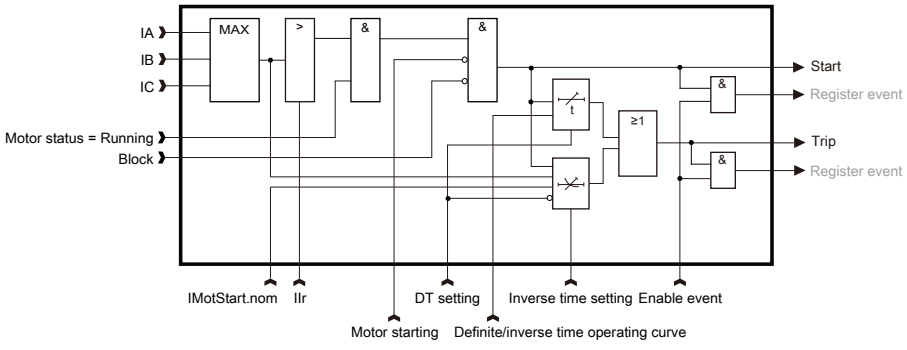
When the measured maximum phase current I exceeds the defined start setting, the locked rotor protection stage starts operation delay calculation. When the calculated delay exceeds the operation delay in DT or INV delay mode, the protection operates.

The stage releases when the maximum phase current I drops below the start setting.

The stage operation is automatically blocked when the motor status is “starting”.

Block diagram

Figure 233 - Block diagram of the locked rotor protection stage I_{lr}>



Characteristics

Table 75 - Settings and characteristics of the locked rotor protection stage I_{Ir}>

Settings/characteristics (description/label)	Values
Pick-up value/I_{Ir}>	
Setting range	10%...100% IMotStart.nom[69]
Resolution	0.1%[69]
Accuracy	±3%[69]
Reset ratio	97% ± 2%
Operating curve/Delay type	
Options	DT (definite time); INV (inverse time)
Operate delay/Operate delay	
Setting range	1.0...300 s
Resolution	0.1 s
Accuracy	±1% or ±20 ms (DT) ±5% or ±20 ms (INV)
Characteristic times	
Start time	< 60 ms (55 ms with high speed) for currents at 2 x I_{Ir} < 70 ms (65 ms with high speed) maximum
Disengaging time	< 85 ms (100 ms with high speed)
Setting group/SetGrp	
Number	1

69. IMotStr.nom is set in motor status function.

Motor restart inhibition (ANSI 66)

Description

Any motor has a restriction on the number of starts within a defined period to avoid the over temperature of the motor, mainly inside the rotor. A settable time interval between two consecutive starts is also necessary to allow the motor to cool down following the previous start. The motor restart inhibition function (ANSI code 66) includes two elements “number of starts limitation” and “minimum time between starts”.

To enable the motor restart inhibition function (ANSI code 66), as well as other protection functions (ANSI 48, ANSI 49M, ANSI 51LR), which are all related with motor, the “Motor status” detection function shall be enabled. Since the motor restart inhibition function uses the “Thermal Level” input to differentiate between motor cold start and hot start, the motor thermal overload protection (ANSI 49M) must also be enabled.

Number of starts limitation

Depending on the initial motor thermal level, there are two types of motor start.

- Cold start

  The initial thermal state is not greater than setting “Hot status limit”.

- Hot start

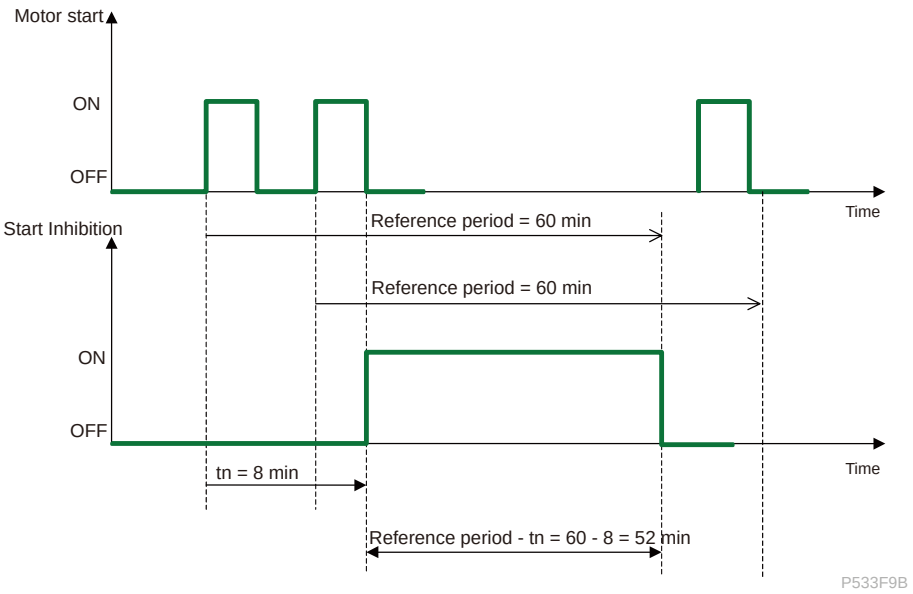
  The initial thermal state is greater than setting “Hot status limit”.

Once the motor start is detected (refer to Motor status section for details), the PowerLogic P5 protection relay initiates a monitor timer defined by the setting “Reference period”, and the cold start counter or hot start counter is incremented by one. Each motor start has one corresponding monitor timer. When the monitor timer expires, the motor start related with that monitor timer will be removed from the cold or hot start counter (decremented by one). When the motor is stopped, the PowerLogic P5 protection relay will compare the cold and hot start counters with the settings “Max motor cold starts” and “Max motor hot starts”, respectively. If either of these two counters reaches the related setting, the motor restart is inhibited (“N> motor start inhibition” = True) until the concerned monitor timer expires and the cold or hot start counter is below the setting.

Example:

The maximum number of motor cold starts is 2 and maximum number of motor hot starts is 1. Two cold starts are detected. When the 2nd motor stop is detected, the cold start counter reaches the setting. So, motor restart is inhibited until the first monitor timer expires.

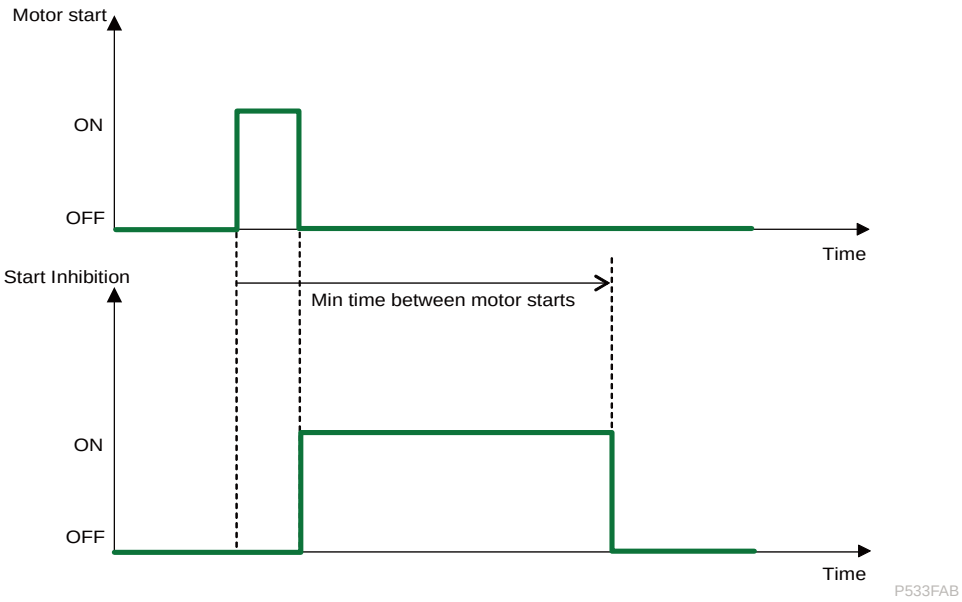
Figure 234 - Motor restart inhibition example 1



Minimum time between starts

Once the motor start is detected (refer to Motor status section for details), the PowerLogic P5 protection relay initiates another monitor timer defined by setting “Min time between motor starts”. When the motor is stopped (CB is open or current is less than 5% Inom depending on the motor start detection mode), and the monitor timer of the last motor start has not expired, the PowerLogic P5 will also inhibit the restart until the monitor timer expires.

Figure 235 - Motor restart inhibition example 2



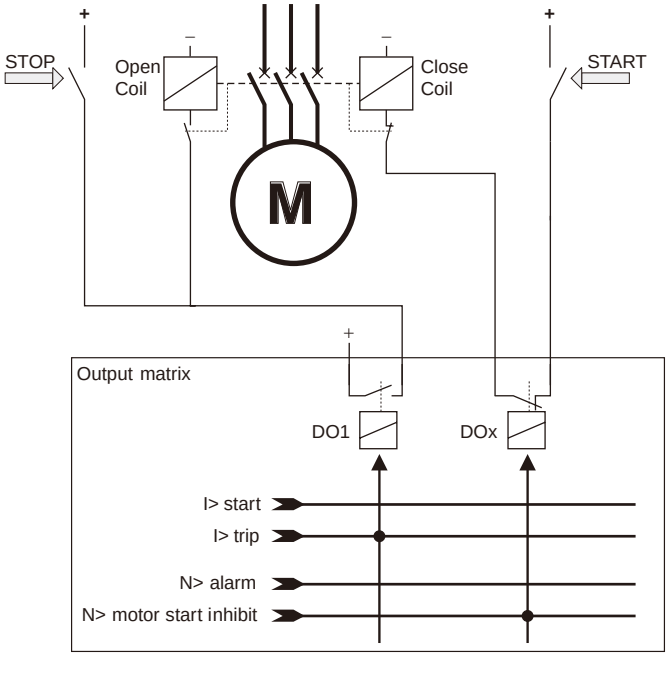
So, the motor restart inhibition function is active if any one of the following conditions is satisfied:

- Blocking due to number of starts limitation
- Blocking due to minimum time between 2 starts

Motor connection example

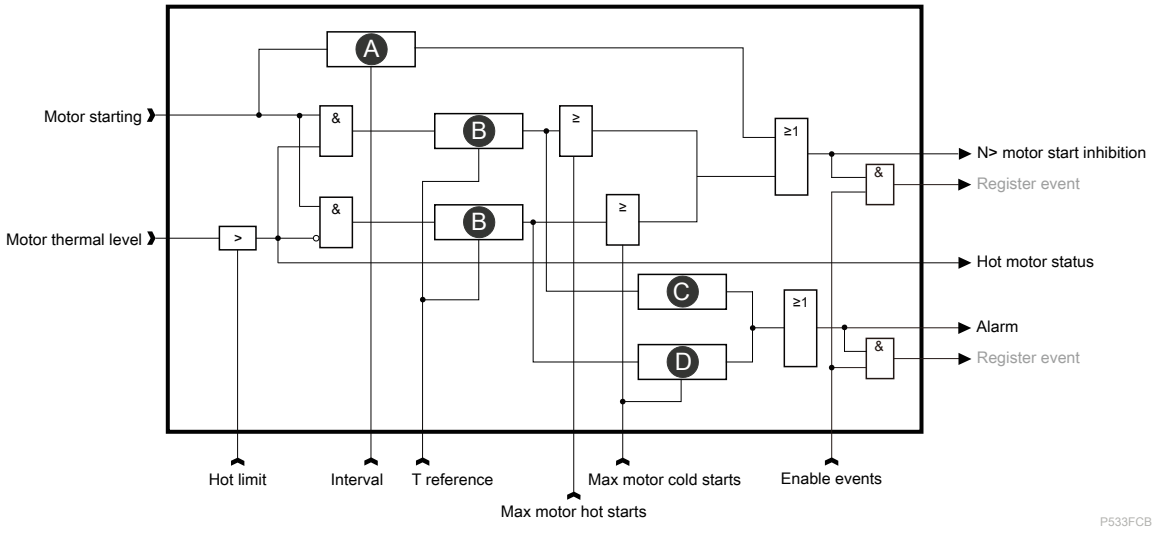
Motor restart inhibition application example, page 348 shows an application for preventing too frequent motor starts using the N> stage. The close coil wire has been connected through the normally closed (NC) contact of the signal relay , which is controlled with the N> start inhibit signal. Whenever the N> motor start inhibit signal becomes active, it prevents the circuit breaker from closing.

Figure 236 - Motor restart inhibition application example



Block diagram

Figure 237 - Block diagram of the motor restart inhibition function (ANSI 66)



A	Min. time between motor starts	B	Count num. during reference period
C	≥ Hot starts/t -1	D	≥ Cold starts/t -1

Characteristics

Table 76 - Settings and characteristics of the motor restart inhibition function (ANSI 66)

Settings/characteristics (description/label)	Values
Reference period/T reference	
Setting range	10.0...120.0 min
Resolution	0.1 min
Hot status limit/Hot limit	
Setting range	0%...100.0% H(t)[70]
Resolution	0.1% H(t)[70]
Max motor/Hot starts	
Setting range	1...20
Resolution	1
Max motor/Cold starts	
Setting range	1...20
Resolution	1
Min time between motor starts/Interval	
Setting range	0.0...100.0 min
Resolution	0.1 min
Def. motor start elap. time/Time by default	
Options	0 min; 120 min
Setting groups/SetGrp	
Number	1

70. Motor thermal level

Motor overspeed (ANSI 12)

Description

Based on the direct measurement of motor speed, the motor overspeed protection function (ANSI code 12) detects racing when the motor is driven by the load, or a loss of synchronisation for synchronous motors, or for process monitoring.

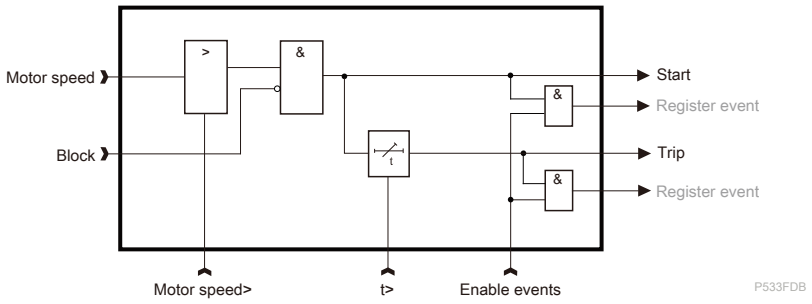
Motor overspeed protection is only available when motor speed detection function is Enabled.

The PowerLogic P5 protection relay provides two stages of motor overspeed protection. Whenever the motor speed reaches the pick-up value of a particular stage, this stage starts and a start signal is issued. If the fault remains active longer than the operating delay setting, a trip signal is issued.

If there is no 12I4O module fitted in the relay, the motor overspeed protection will be invisible.

Block diagram

Figure 238 - Block diagram of the motor overspeed stages Motor overspeed Ω>1 12 and Ω>2 12



Characteristics

Table 77 - Settings and characteristics of the motor overspeed protection function (ANSI 12)

Settings/characteristics (description/label)	Values (stage Motor overspeed Ω>1 12)	Values (stage Motor overspeed Ω>2 12)
Pick-up value		
Setting range	100%...160% Ω_n	
Resolution	1% Ω_n	
Accuracy	±2%	
Reset ratio	95% ± 2%	
Operate delay		
Setting range	1...300 s	
Resolution	1 s	
Accuracy	±1% or ±25 ms	
Characteristic times		
Start time	< 250 ms + 2 x (60000 ms/ (Ω x R))	
Disengaging time	< 250 ms + 2 x (60000 ms/ (Ω x R))	

Table 77 - Settings and characteristics of the motor overspeed protection function (ANSI 12) (Continued)

Settings/characteristics (description/label)	Values (stage Motor overspeed Ω>1 12)	Values (stage Motor overspeed Ω>2 12)
Setting group/SetGrp		
Number	1	

Motor underspeed (ANSI 14)

Description

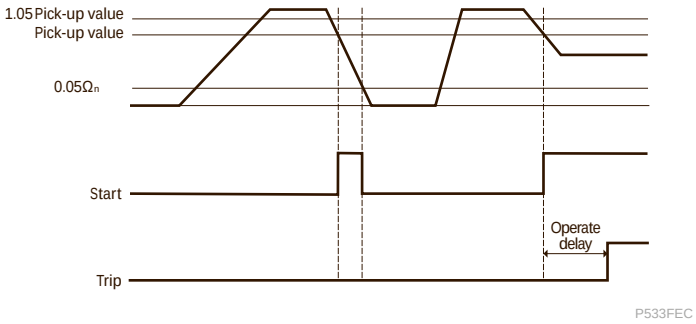
Based on the direct measurement of motor speed, the motor underspeed protection function (ANSI code 14) detects the slow-downs of motor speed after motor starting, possibly resulting from the mechanical overloads or locked rotor.

Motor speed protection is only available when motor speed detection function is Enabled.

The motor underspeed protection is active after the motor speed has successful achieved the speed pick-up value. As shown in figure below, the underspeed protection function picks up if the speed measured drops below the speed pick-up value after having first exceeded the set point by 5%. The underspeed protection is blocked when the motor speed drops below 5% of Ω_n rated motor speed to avoid unwanted tripping when the motor is switched off. If the underspeed protection starts longer than the operating delay setting, a trip signal is issued.

If there is no 12I4O module fitted in the relay, the motor underspeed protection will be invisible.

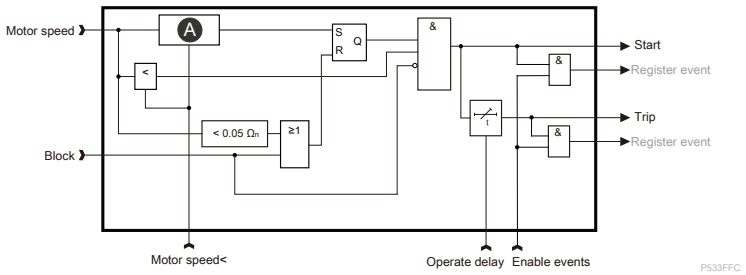
Figure 239 - Motor underspeed start and trip conditions



The PowerLogic P5 protection relay provides two stages of motor underspeed protection.

Block diagram

Figure 240 - Block diagram of the motor underspeed stages Motor speed<1 and Motor speed<2



A > 1.05 Pick-up value

Characteristics

Table 78 - Settings and characteristics of the motor underspeed protection function (ANSI 14)

Settings/characteristics (description/label)	Values (stage Motor speed<1)	Values (stage Motor speed<2)
Pick-up value/Motor speed<1, Motor speed<2		
Setting range	10%...100% Ω_n	
Resolution	1% Ω_n	
Accuracy	±2%	
Reset ratio	105% ± 2%	
Low motor speed self-blocking		
Value	5% Ω_n, fixed	
Accuracy	±2% x (5% Ω_n)	
Time delay/Operate delay		
Setting range	1...300 s	
Resolution	1 s	
Accuracy	±1% or ±25 ms	
Characteristic times		
Start time	< 250 ms + 2 x (60000 ms / (Ω x R))	
Disengaging time	< 250 ms + 2 x (60000 ms / (Ω x R))	
Setting group		
Number	1	

Motor Anti-backspin (ABS) protection

Description

For a motor with high inertia, once the CB/Contactor supplying power to the motor is switched off, the rotor may continue to turn for a considerable length of time. In that case, the motor terminal voltage is out of phase and the motor re-starting operation may result in serious damage. In some other applications for example when a motor is on a down-hole pump, after the motor stops, the liquid may fall back down the pipe and spin the rotor backwards. It would be very undesirable to start the motor at this time. In these circumstances the motor anti-backspin function is used to detect when the rotor has completely stopped, to allow restarting of the motor.

Three criteria can be used to detect whether rotor has completely stopped.

- Speed measured mode

  “Zero Speed” signal from motor speed detection function is ON. If there is no 12I4O module fitted in the relay, the speed measured mode will be invisible.
- External zero speed mode

  “Zero Speed DI” digital input is ON when a rotation detection sensor is available.
- Motor status

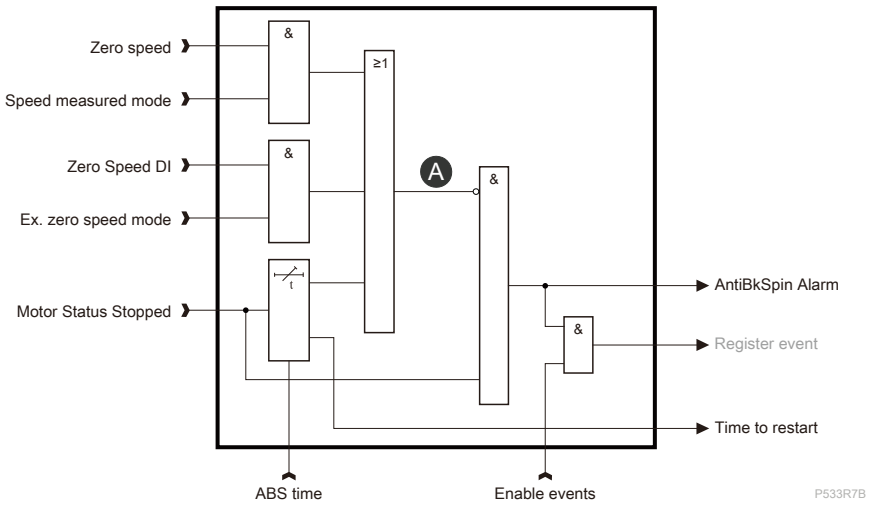
  Motor “Stopped” input from motor status function is ON and the delay timer expired.

When the “Zero Speed” input and the “Zero Speed DI” digital input are not available or disabled, this protection function simply provide a “Restart Delay” feature after the motor is stopped.

Only when “Motor Status” function is Enabled, “Motor Anti-backspin” protection can be activated. The output signal “AntiBkSpin Alarm” is ON when the motor status turns to be “Stopped” and the internal signal “ABSAllowRestart” is not satisfied. The “ABSAllowRestart” signal indicates if the rotor has completely stopped. The timer “Time to restart” is based on the setting “ABS Time” to indicate the left time before the motor restart is allowed. If the zero speed is detected, the timer “Time to restart” will be reset and the motor restart is allowed immediately.

Block diagram

Figure 241 - Block diagram of Motor Anti-backspin (ABS)



A ABSAllowRestart

Characteristics

Table 79 - Settings and characteristics of Motor Anti-backspin (ABS) protection

Settings/characteristics (description/label)	Values
Measured zero speed mode/Speed measured mode	
Options	Enable; disable
Zero speed external mode/Ex. zero speed mode	
Options	Enable; disable
Zero speed input DI/Zero speed DI	
Options	Selection of one digital input (DIx)
Anti-backspin time/ABS time	
Setting range	1...7200 s
Resolution	1 s
Accuracy	±1% or ±25 ms
Setting group	
Number	1

Emergency restart

Description

It may be necessary to restart a hot motor when the system is in emergency. An emergency restart can be enabled through digital input/HMI/remote communication, then it removes all motor start inhibit. For a successful emergency restart, the emergency restart input should keep asserted during the whole motor starting period.

An operation counter is provided to record the number of emergency restarts. Emergency restart counter can be cleared via a command in HMI or remote communication.

When emergency restart is triggered, motor thermal overload protection (49M) responds to it

- When the motor is stopped, the signal “Block motor start” is reset and the motor thermal level is limited to **100% - Motor start thermal level** if the thermal level is higher than **100% - Motor start thermal level**.
- When the motor is starting, the thermal level is limited to 90%.
  Before the completion of motor starting, if the emergency restart is Off, the motor thermal level can increase to more than 90% during starting.
- When the motor is running, it has no impact on the motor thermal level.

When emergency restart is triggered, motor restart inhibition (66) protection responds to it

- When the motor is stopped, the signal “N> motor start inhibition” is reset and the value of emergency restart counter is incremented by 1.
- When the motor is starting, the detected motor start will neither impact the number of cold starts and hot starts nor trigger the timer of “Minimum time between motor starts”.
  If the emergency restart condition changes from On to Off prior to the completion of the motor starting, this motor starting is considered as a normal start.

  NOTE: The emergency restart will not impact the motor start counter and the minimum time between two starts.
- When the motor is running, it has no impact on motor restart inhibition (66).

When emergency restart is triggered, motor anti-back spin (ABS) protection responds to it

- When the motor is stopped, ABS works on timer between a stop and a start, then the signal “AntiBkSpin” is reset **(Measured zero speed mode** is OFF and **Zero speed external mode** is OFF).

  NOTE: The emergency restart will only impact ABS timer, it will not impact **Measured zero speed mode** and **Zero speed external mode**.
- When the motor is starting or running, it has no impact on ABS function.

Characteristics

Table 80 - Settings and characteristics of Emergency restart protection

Settings/characteristics (description/label)	Values
EMRE input/EMRE input	
Options	DIx; VIx; Fx

Inrush detection (ANSI 68H2)

Description

Second harmonic inrush blocking detects high transient current flows that usually occur when transformers are energised at no-load or the voltage is restored to the transformer after a brief voltage dip/interruption. It helps prevent tripping for this normal operation condition.

There are two ways to enable inrush blocking of protection functions:

- Within individual phase and neutral OC protection stages, check the **Inrush blocking** in any or all setting group(s).
- By using the Block Matrix, map the “inrush detection” signal to individual protection functions. This configuration is valid for all setting groups.

During transformer inrush conditions, the second harmonic level may not be the same for all phases. So PowerLogic P5 protection relay calculates the ratio between the second harmonic component and the fundamental frequency component for each phase. When the ratio of the second harmonic component of any phase is higher than the ratio setting, after a fixed delay (20 ms), the inrush detection signal will be activated and the inrush current will be discriminated.

There are two operating modes for inrush detection which is configured via the "Inrush operating mode" setting. When it is in the "Phase block" mode, after inrush current is detected, it will block the related overcurrent function only in that phase (or phases); when it is in the "Cross block" mode, if any phase inrush current is detected, it will block the related overcurrent function in all 3 phases.

To avoid maloperation, the inrush detection is only active if the phase current is greater than a fixed minimum current of 10% Inom. Otherwise, the output of the inrush detection is reset. As additional constraint, a maximum threshold current is settable. Currents above this threshold will bypass any inrush blocking. This threshold is set based on the transformer reactance. This reactance will limit any inrush current, therefore currents greater than this are treated as short circuits.

Conversely, to secure proper operation during evolving faults or for faults fed from sources with high amount of harmonics, any established overcurrent protection starting will block the inrush blocking function.

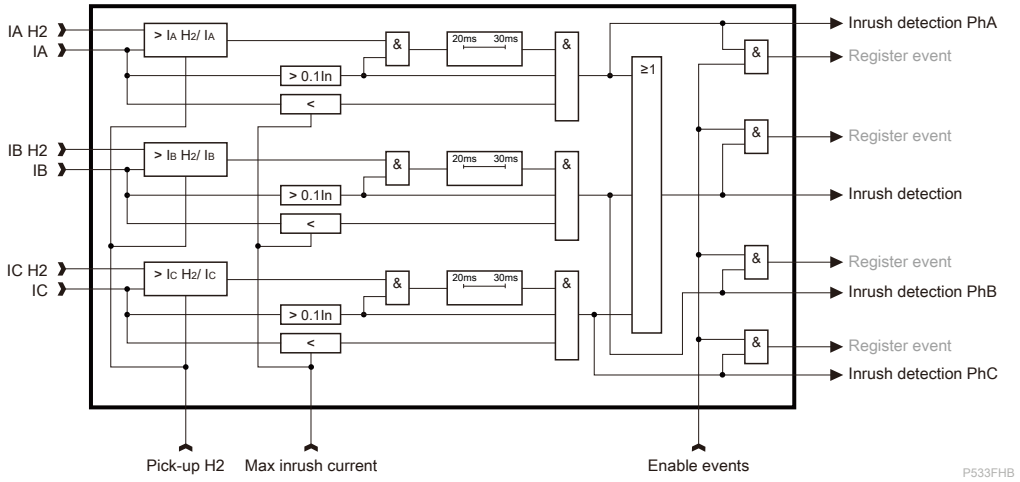
A fixed reset delay (30 ms) of the "inrush detection" signal is implemented to avoid signal chattering and potential maloperation because of too fast unblocking the protection stages, especially at the end of the inrush condition.

The inrush blocking signal requires the presence of second harmonic current for 1 period (20 ms). Similarly the reset of this condition requires the absence of second harmonic component for 30 ms.

In transformer differential protection application P5T30 two stages of this inrush blocking function are available with common functionality. Each stage evaluates the currents from one end and determines inrush condition and its inrush blocking signals accordingly for its end. This allows selective use of these signals in the block matrix, namely to have a common link to one end from which currents are measured in the OC stage and in the inrush blocking function.

Block diagram

Figure 242 - Block diagram of inrush blocking



IX.H2	Second harmonic component of phase current
IX.fund	fundamental component of phase current

Characteristics

Table 81 - Settings and characteristics of the inrush blocking function

Settings/characteristics (description/label)	Values
Pick-up value/Pick-up H2	
Setting range	10%...35%
Resolution	1%
Accuracy	±1%
Hysteresis	1%
CT input selection[71]	
Setting range	CT-1 is fixed for stage 1, CT-2 is fixed for stage 2.
Max inrush current/CurBlkVal	
Setting range	1.00...20.00 pu[72]
Resolution	0.01 pu[72]
Accuracy	±3% or ±0.005 pu[72]
Inrush operating mode	Phase block; Cross block
Characteristic times	
Start time	< 40 ms
Setting group	
Number	1

71. Available for P5T30 only.
72. I_n = phase CT primary nominal

Switch On To Fault (ANSI 50HS)

Description

The switch-on-to-fault (SOTF) protection function (ANSI code 50HS) offers protection when the circuit breaker (CB) is closed on a faulty line. In this case a fast trip is required and instantaneous trip is inherently selective. Overcurrent-based protection does not clear the fault until the intended time delay has elapsed. SOTF gives a trip signal without additional time delay if the CB is closed and a fault is detected within a set time window after closing the CB.

Some faults may be caused by conditions not removed from the feeder after a reclosing cycle or a manual close, or due to earthing/grounding clamps left on after maintenance work.

The manual closing order from the circuit breaker may be initiated from one of several sources:

- Local close switch via digital inputs
- CB close command from local panel or eSetup Easergy Pro
- Remote communication

Operation

Switch-on-to-fault function operates within the SOTF active operation time, page 360 and Switch-on-to-fault function does not operate after the SOTF active operation time elapses, page 361 illustrate the operation of the SOTF function:

1. Switch-onto-fault gets not activated if the CB has not been in open position before the fault. Open CB detection is noticed from the highest phase current value which has to be under a fixed low threshold (0.02 x I_n). Opening of the CB can be detected also with digital inputs (Dead line detection input = DI1 – DIx, Fx, VI1 – VIx). In this case, digital input which is connected to 52a need to be configured to this "Dead line detection input". The default detection method is based on the current threshold, so the dead line detection input parameter has value “–“.
2. Dead line detection delay defines how long the CB has to be open so that the SOTF function gets active. If the set detection delay time is not elapsed when the highest phase current value (maximum of IA, IB, IC) rises over the start setting, the SOTF does not operate.
3. If the highest phase current value of IA, IB, IC goes successfully under the low limit and rises to a value between the low limit and the start value, then if the highest phase current value rises over the start setting value before the SOTF active operation time expires, the SOTF trips. If this SOTF active operation time is exceeded, the SOTF does not trip even if the start setting value is exceeded.

Figure 243 - Switch-on-to-fault function operates within the SOTF active operation time

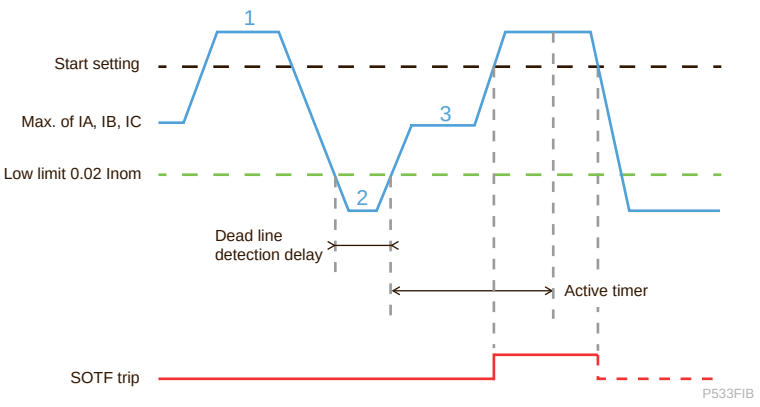
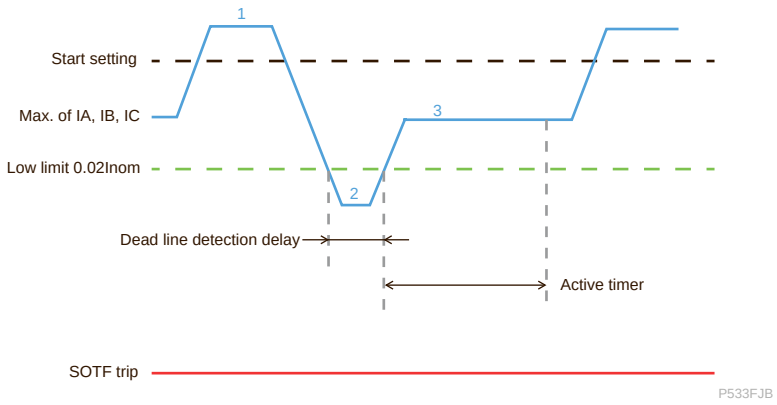
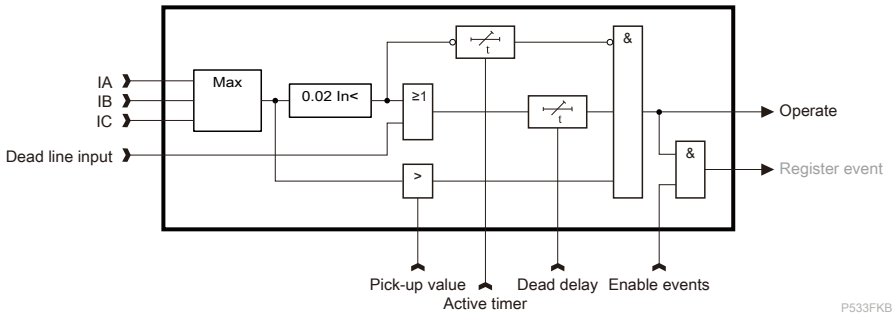


Figure 244 - Switch-on-to-fault function does not operate after the SOTF active operation time elapses



Block diagram

Figure 245 - Block diagram of the Switch On To Fault protection function (ANSI 50HS)



Characteristics

Table 82 - Settings and characteristics of the switch-on-to-fault protection function (ANSI 50HS)

Settings/characteristics (description/label)	Values
Pick-up value/SOTF	
Setting range	1.00...40.00 pu[73]
Resolution	0.01 pu[73]
Accuracy	±3%
Reset ratio	97% ±1%
Dead line detection delay/Dead delay	
Setting range	0.00...60.00 s
Resolution	0.01 s
SOTF active after CB closure/Act time	
Setting range	0.10...60.00 s
Resolution	0.01 s
Dead line detection input	

73. phase CT primary nominal

Table 82 - Settings and characteristics of the switch-on-to-fault protection function (ANSI 50HS) (Continued)

Settings/characteristics (description/label)	Values
Options	Selection of one digital input (DI), one virtual input (VI), or one function key.
Characteristic times	
Start time	< 30 ms (25 ms with high speed) when $I/I_{set} > 2$
Disengaging time	< 60 ms (75 ms with high speed)
Setting group	
Number	1

Non-directional/directional phase overcurrent protection (ANSI 50/51/67)

Description

The overcurrent protection function is used against short circuit faults and overloads. It provides three-phase and six-stage non-directional/directional overcurrent protection. All the six overcurrent stages can be selected to be either non-directional, forward or reverse. Further more, phase segregated start and trip signals are available for each overcurrent stage. All the six stages have the same settings and performance. Typical applications are:

- Short-circuit protection of two parallel cables or overhead lines in a radial network.
- Short-circuit protection of a looped network with a single feeding point.
- Short-circuit protection of a two-way feeder, which usually supplies loads but is used in special cases as an incoming feeder.

All 6 overcurrent stages are also available with transformer differential protection P5T30 as back-up protection. Each stage can be individually linked to the measured phase currents of one end. As no voltage measurement is available, these stages can operate in non-directional mode only, and also no voltage-controlled adjustment of operate threshold and time is available.

Phase directional element

The directional element get polarised by the quadrature phase-phase voltages, as shown in the table below:

Phase of protection	Operate current	Polarizing voltage phase rotation ABC	Polarizing voltage phase rotation ACB
A Phase	IA	VBC = VB - VC	VCB = VC - VB
B Phase	IB	VCA = VC - VA	VAC = VA - VC
C Phase	IC	VAB = VA - VB	VBA = VB - VA

The directional check is performed based on the following criteria:

Forward directional	-90° < (angle(I) - angle(V) - RCA) < 90°
Reverse directional	-90° > (angle(I) - angle(V) - RCA) > 90°

Where RCA = 90° - feeder impedance angle

Under system fault conditions, the fault current vector will lag its nominal phase voltage by an angle dependent upon the system X/R ratio. Therefore, the relay should operate with the maximum sensitivity for currents lying in this region. This is achieved by means of the Relay Characteristic Angle (RCA) setting. It defines the angle by which the current applied to the relay must be displaced from the voltage applied to the relay to obtain the maximum relay sensitivity. This is the "Characteristic angle" setting in the overcurrent menu. On the P5 relay, it is possible to set characteristic angles anywhere in the range –95° to +95°.

For a close-up three-phase fault, all three voltages will collapse to zero and no healthy phase voltages will be present. For this reason, the relay will store the pre-fault voltage information and continues to apply it to the directional overcurrent elements for a time period of 5 s under the circumstance. This feature ensures that either instantaneous or time delayed directional phase overcurrent elements will be allowed to operate, even with a three-phase voltage collapse. This function uses memorised voltages for calculation if the polarisation voltages drop below the minimum voltage threshold (0.015 pu[74]), in case of close-up three-phase fault. These memorised voltages will be used until at least one polarisation voltage

74. Vnom = VT primary nominal (PP) or Vnom/√3 = VT primary nominal (PN) depending on P5 voltage mode

is going above the minimum voltage threshold (0.015 pu[75]), or during a maximum time period of 5 s. If the input voltage loss continues longer than 5 s the directional overcurrent is blocked.

VTS blocking

Voltage Transformer Supervision (VTS) blocking only affects the directional overcurrent protection. When the “Direction mode” is selected as “Forward” or “Reverse”, the setting "VTS blocking" will show up. When "VTS blocking" is set to "Non-directional", the directional element will be ignored, and the directional overcurrent protection will be switched to non-directional protection under VT failure condition. When "VTS blocking " is set to "Blocked", the directional overcurrent protection will be blocked under VT failure condition.

Dynamic setting element

Dynamic mode allows the overcurrent protection settings dynamically adjusted during the transient period. It can be applied to cooperate between the Cold Load Pick-up, and also to realize voltage-controlled overcurrent.

When "Dynamic Mode" is ON and the digital input signal " DynamicInput" in Output Matrix is ON:

1. It will switch to the "Dynamic threshold" setting for fault detection.
2. For DT operating curve, it will switch to the "Dynamic operate delay" setting.
3. For IDMT, it will switch to the "Dynamic TMS" setting.

For Cold Load Pickup application, an output signal "CLP Operation" to indicate cold load energised condition will be available. In Output Matrix, "CLP Operation" will be linked to "DynamicInput" to realize this functionality.

Selective overcurrent logic

Selective overcurrent logic can be activated when the setting "SOL status" is set to "SOL1" or "SOL2" and the related digital input signal "SOLInputx" in Output Matrix is ON. For DT operating curve, it will switch to the setting "SOL operate delay" for logic discrimination. For IDMT curve, it will switch to the "SOL TMS" setting for logic discrimination.

The CLP and SOL functions have dynamic impacts on the overcurrent settings of timer and start value. The associated inputs could be activated at the same time. In this case, SOL takes precedence over CLP.

Inrush blocking

The user can block the overcurrent function by selecting the setting "Inrush blocking" of each stage. The purpose is to make the overcurrent function inoperative during the transformer energisation, otherwise a large primary current flow for a transient period will cause an unwanted trip.

It is highly possible that inrush blocking is determined later than the trip of instantaneous OC stage. Therefore, when the "Inrush blocking" setting is enabled in overcurrent stage, an additional delay (25 ms fixed) gets applied to wait for potential inrush blocking signal before start is ON.

To secure proper protection operation during evolving faults or for faults fed from sources with high amount of harmonics, a confirmed starting from any overcurrent protection stage will remove the inrush blocking from all overcurrent stages. This needs to be considered in the setup of inrush blocking: all OC stages, with operate threshold below the expected maximum inrush current have to be subjected to inrush blocking. Alternatively, use of the blocking matrix could be considered.

75. Vnom = VT primary nominal (PP) or Vnom/√3 = VT primary nominal (PN) depending on P5 voltage mode

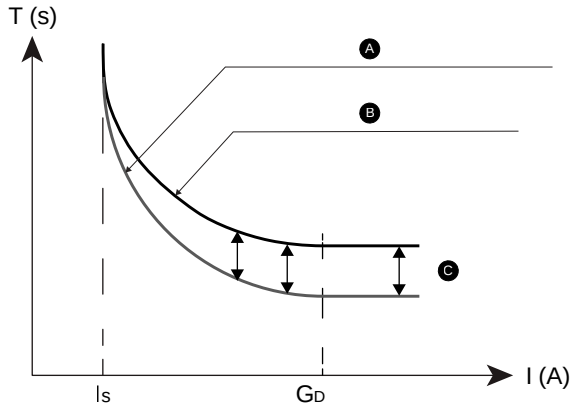
For further details please also refer to the related application note.

Operating curve selection

The operating curve of the overcurrent protection can be selected to DT, standard dependent operate delay, and programmable dependent operate delay, for details refer to Dependent time and definite time operation, page 264.

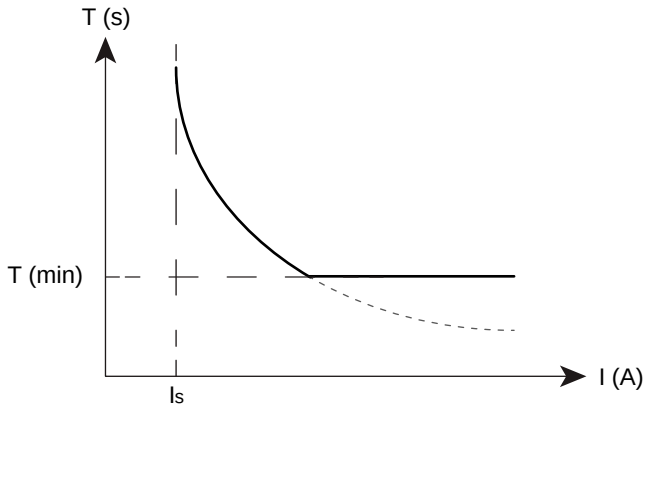
When the “Operating Curve” is set to IDMT curve, the settings “DT adder” and “Minimum operate time” will show up. “DT adder” defines the additional time delay plus the IDMT timer (see DT adder setting impacts on IDMT operating curve, page 365). “Minimum operate time” defines the minimum operating time for IDMT curves to help ensure the IDMT stage will not trip faster than the DT stage when the fault current is very large (see Minimum operate time setting impacts on IDMT operating curve, page 365).

Figure 246 - DT adder setting impacts on IDMT operating curve



A	IDMT curve without DT adder	B	IDMT curve with DT adder
C	DT adder		

Figure 247 - Minimum operate time setting impacts on IDMT operating curve



Tripping logic

When the “Tripping logic” is set to "1 out of 3" and any phase starts, the output of the "Trip Logic Check" is TRUE. That means tripping can be allowed at any

started phase. When the “Tripping logic” is set to "2 out of 3" and any two phases start, the output of the "Trip Logic Check" is TRUE. That means tripping can be allowed at the two started phases. The tripping logic is shown in following diagram.

Six independent stages

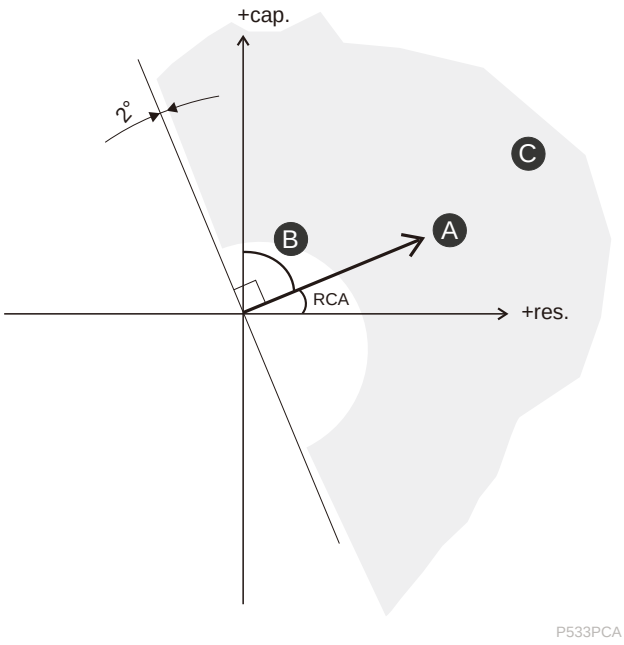
There are six separately adjustable stages: I>1, I>2, I>3, I>4, I>5, and I>6. All the six stages have the same settings and performance. All the stages have definite operate time (DT) and dependent operate time (IDMT).

Examples

Three modes are available: Non-directional, Forward and Reverse. In the Non-directional mode, the stage is acting just like an ordinary overcurrent protection function stage.

An example of directional overcurrent characteristic with the phase A fault is shown as below.

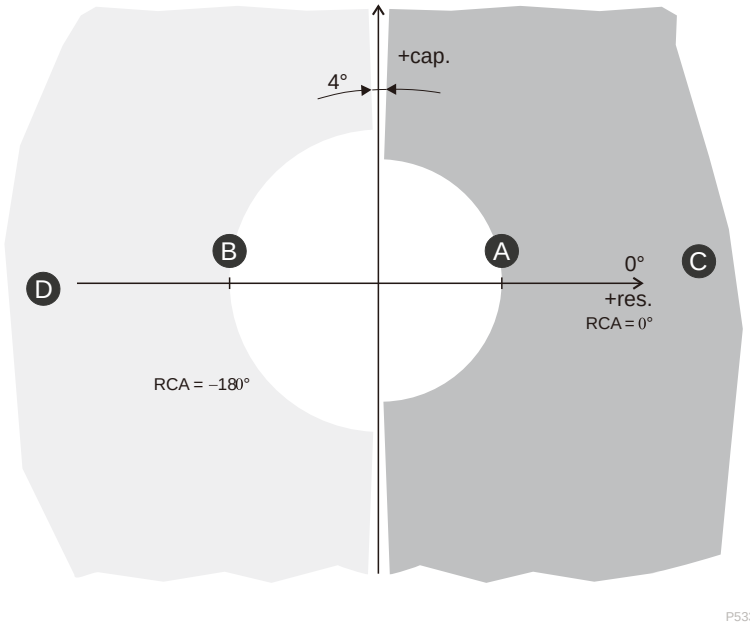
Figure 248 - Example of the directional overcurrent function characteristic



A	IA fault: fault current in phase A	B	φ_z: feeder impedance angle
C	Forward trip area		

An example of bi-directional operation characteristic is shown as below. The RCA of the two stages are 0° and -180°.

Figure 249 - Bi-directional application with two stages

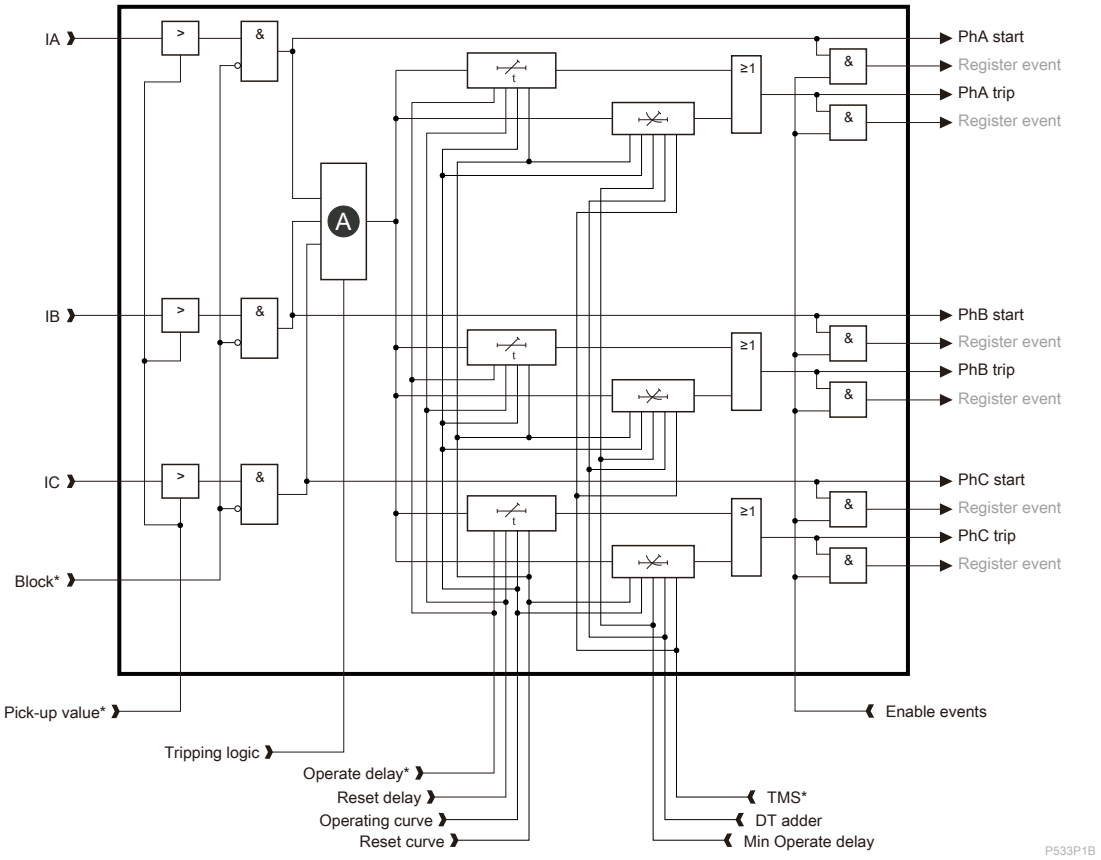


A	Directional overcurrent stage1 pickup value setting	B	Directional overcurrent stage2 pickup value setting
C	Directional overcurrent stage1 trip area	D	Directional overcurrent stage2 trip area

When the setting "Tripping logic" is set to "1 out of 3", any of the three phase currents exceeds the setting value and, in directional mode (Forward or Reverse), the direction is located in the trip area, this stage starts and issues a start signal. If the fault situation is present longer than the operate time setting, a trip signal is issued.

Block diagram

Figure 250 - Block diagram of non-directional overcurrent protection function

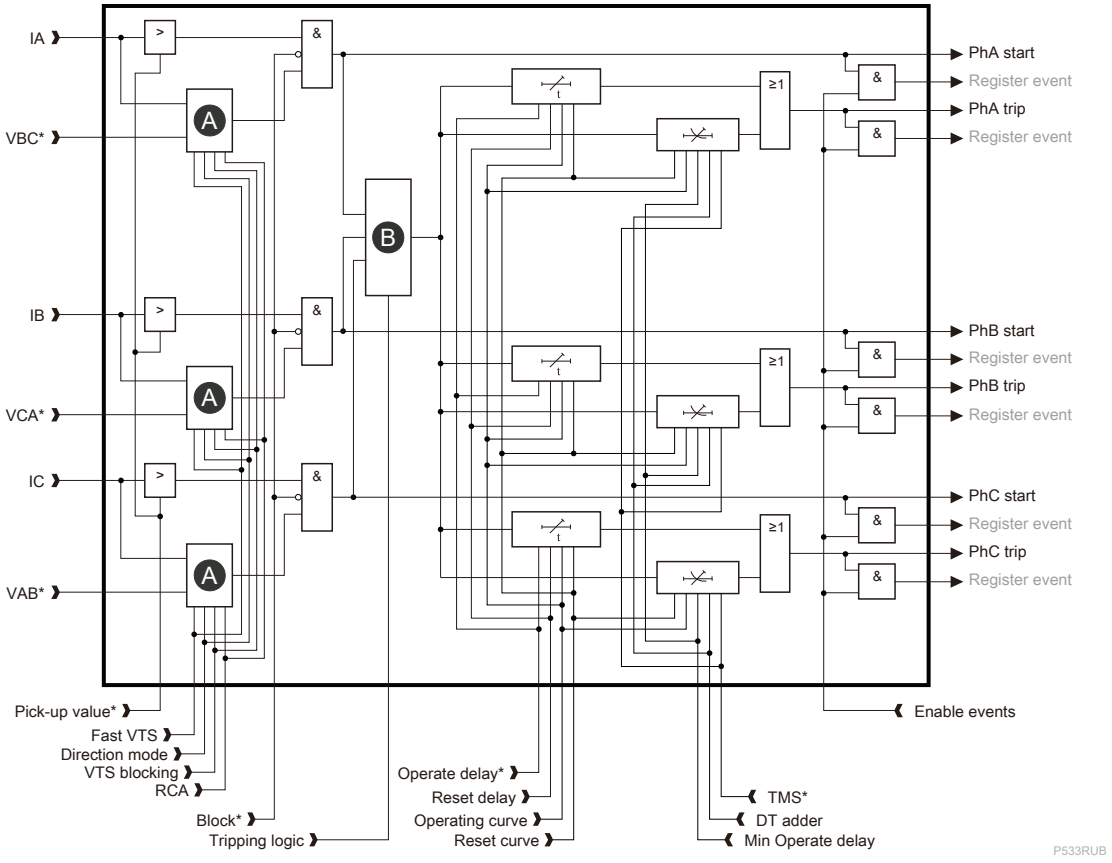


A Tripping logic

NOTE:

- Block input can be signals configured via Block matrix, due to inrush condition detected.
- Pick-up value can be value from "Pick-up value" setting, "Dynamic threshold" setting depending on the configuration.
- Operate delay can be the value from "Operate delay" setting, "SOL operate delay" setting or "Dynamic operate delay" setting depending on the configuration.
- TMS value can be the value from "TMS" setting, "SOL TMS" setting or "Dynamic TMS" setting depending on the configuration.

Figure 251 - Block diagram of directional overcurrent protection function



A	Direction check logic, for Forward direction, it should follow the equation: -90° < (angle(I) - angle(U) - RCA) < 90°, and for Reverse direction, it should follow the equation: -90° > (angle(I) - angle(U) - RCA) > 90°	B	Tripping logic

NOTE:

- Block input can be signals configured via Block matrix, due to inrush condition detected.
- Pick-up value can be value from "Pick-up value" setting, "Dynamic threshold" setting depending on the configuration.
- Operate delay can be the value from "Operate delay" setting, "SOL operate delay" setting or "Dynamic operate delay" setting depending on the configuration.
- TMS value can be the value from "TMS" setting, "SOL TMS" setting or "Dynamic TMS" setting depending on the configuration.
- VAB/VBC/VCA can be the calculated phase to phase voltage, or memory value for close-up three-phase fault.

Voltage-controlled overcurrent

Voltage-controlled overcurrent protection can be used as system back-up protection or as transformer back-up protection. Normally voltage-controlled overcurrent protection is preferred for the applications where a generator is directly connected to a busbar without a step-up transformer. It is recommended as well to use this solution to increase the sensitiveness of overcurrent back-up transformer protection. P5 relays provide a dynamic setting mode for each overcurrent protection stage, so that overcurrent pick-up setting and operate delay

setting will be replaced by dynamic threshold and dynamic operate delay settings. So the overcurrent protection adjusts the current setting according to the detected undervoltage condition. The information about application and setting examples can be found in the Application Book.

High Impedance Busbar Differential Protection

The PowerLogic P5 overcurrent elements I> can be used for high impedance busbar protection based on the high impedance differential protection principle, offering stability for any type of fault occurring outside the protected zone and satisfactory operation speed for faults within the zone. For this application instantaneous operation is commonly applied, which can be obtained in a simple way by selecting definite time delay characteristic with minimum time delay setting. The information about application, calculations, setting examples and recommendations for resistors can be found in the Application Book.

Characteristics

Table 83 - Setting and characteristics of the non-directional/directional phase overcurrent protection (6 stages have the same settings)

Setting/characteristics (description/label)	Values
Pick-up value/I>1	
Setting range	0.05...40.00 pu[76] (DT) 0.05...5.00 pu[76] (IDMT)
Resolution	0.01 pu[76]
Accuracy	±2% or ±0.005 pu[76]
Reset ratio	95% ± 2%
CT input selection[77]	
Setting range	CT-1, CT-2
Operating Curve	
Options	DT; IEC: SI, VI, EI, LTI, UTI; IEEE: MI, VI, EI ANSI: NI, STI, LTI Others: UK_Rectifier, FR_STI, RI, STI_CO2, LTI_CO5, MI_CO7, NI_CO8, VI_CO9, EI_CO11, BPN Prg1-3
Accuracy	±5% or ±20 ms
Operate delay/Operate delay	
Setting range	0.00...600.00 s
Resolution	0.01 s
Accuracy	±1% or ±10 ms
TMS/TMS	
Setting range	0.020...20.000
Resolution	0.001
DT adder/DT adder	
Setting range	0.00...1.00 s
Resolution	0.01 s

76. Inom
77. Available for P5T30 only.

Table 83 - Setting and characteristics of the non-directional/directional phase overcurrent protection (6 stages have the same settings) (Continued)

Setting/characteristics (description/label)	Values
Minimum operate delay/Min operate delay	
Setting range	0.00...10.00 s
Resolution	0.01 s
Direction mode/Direction mode	
Options	Non-directional; Forward; Reverse
Characteristic angle/Char angle	
Setting range	-95° - +95°
Resolution	1°
Accuracy	±2°
VTS blocking	
Options	Blocked; Non-directional
Tripping logic/Tripping Logic	
Setting range	1 out of 3; 2 out of 3
Reset curve/Reset curve	
Options	DT; IDMT; Prg1-3
Reset delay/Reset delay	
Setting range	0.00...100.00 s
Resolution	0.01 s
Accuracy	±1% or ±30 ms
Inrush blocking/Inrush blocking	
Options	Off/On
SOL status/SOL status	
Options	Off; SOL1; SOL2
SOL operate delay/SOL operate delay	
Setting range	0.00...600.00 s
Resolution	0.01 s
Accuracy	±1% or ±10 ms
SOL TMS/SOL TMS	
Setting range	0.020...20.000
Resolution	0.001
Dynamic mode/Dynamic mode	
Options	Off/On
Dynamic threshold/Dyn pick-up value	
Setting range	0.05...40.00 pu[78] (DT) 0.05...5.00 pu[78] (IDMT)
Resolution	0.01 pu[78]
Accuracy	±2% or ±0.005 In
Dynamic operate delay/Dynamic op delay	
Setting range	0.00...600.00 s
Resolution	0.01 s

78. Inom

Table 83 - Setting and characteristics of the non-directional/directional phase overcurrent protection (6 stages have the same settings) (Continued)

Setting/characteristics (description/label)	Values
Accuracy	±1% or ±10 ms
Dynamic TMS/Dynamic TMS	
Setting range	0.020...20.000
Resolution	0.001
Voltage memory time	
Value	5 s fixed
Angle memory	
Value	5 s fixed
Minimum voltage for the direction determination	
Value	0.015 pu[79]
Characteristic times	
Start time	< 30 ms (25 ms with high speed) for currents at 2 x Is pick-up value (non-directional) < 35 ms (30 ms with high speed) for currents at 1,2 x Is pick-up value (non-directional)
	< 40 ms (35 ms with high speed) for currents at 2 x Is pick-up value (directional) < 40 ms (35 ms with high speed) for currents at 1,2 x Is pick-up value (directional)
Disengaging time	< 55 ms (70 ms with high speed)
Overshoot time	< 30 ms
Setting group	
Number	4

79. Vnom

Arc-flash (ANSI 50ARC)

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH

Information on this product is offered as a tool for conducting arc flash hazard analysis. It is intended for use only by qualified persons who are knowledgeable about power system studies, power distribution equipment, and equipment installation practices. It is not intended as a substitute for the engineering judgement and adequate review necessary for such activities.

Failure to follow these instructions will result in death or serious injury.

Description

The arc-flash protection function (ANSI code 50ARC) is a high speed protection function able to detect arcing events in a few millisecond, to minimise equipment damages.

The arc-flash protection contains 8 arc stages that can be used to trip the circuit breakers. Arc stages are activated with overcurrent and light signals (or light signals only). The allocation of light or "light + current confirmation" signal to arc stages is defined in arc-flash protection matrix: current, light and output matrix. The matrix are programmed via the dedicated arc-flash matrix menus. Available matrix signals depend on the order code (see Order information, page 589).

Available signal inputs for arc-flash protection depend on the PowerLogic P5 protection relay's configuration with 3 or 6 light inputs.

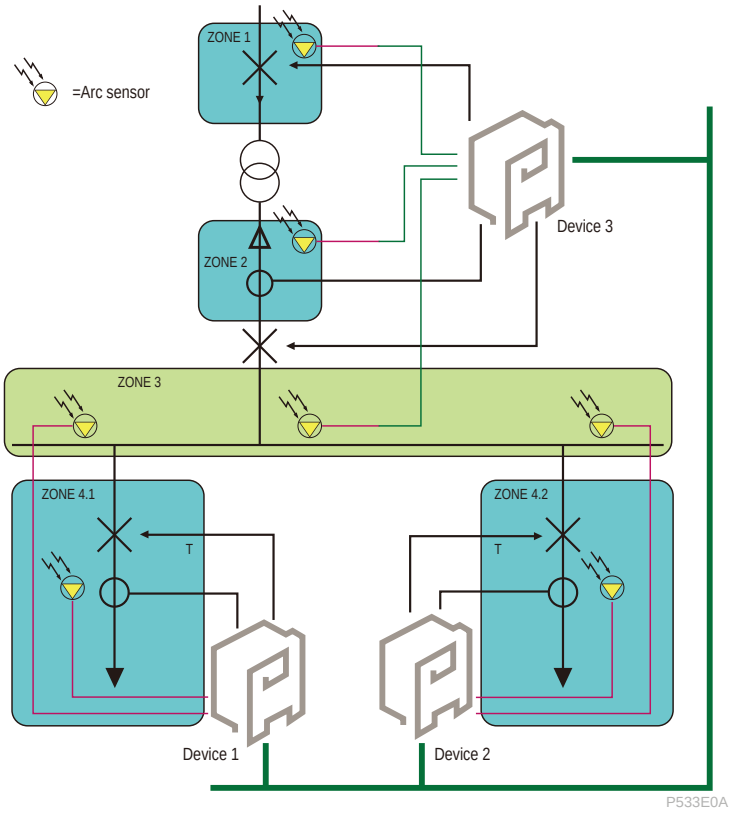
In transformer differential protection application P5T30 the current inputs of the arc-flash protection can be assigned to one of the 2 ends.

With 3 to 6 arc-flash input options, the PowerLogic P5x30 protection relay allows to build a multi-zone arc-flash protection system.

Information like arc detection or current detection can be exchanged across the system using two communication ways:

- GOOSE messages using the IEC 61850 protocol (preferred solution)
- Virtual outputs

Figure 252 - Application example of the arc-flash protection function



In this application example, the arc-flash sensor for zone 4.1 is connected to Device 1. If the arc-flash sensor detects the fault and simultaneously Device 3 sends a current signal, the zone 4.1 is isolated by the outgoing feeder breaker.

The arc-flash sensor for zone 4.2 is connected to the Device 2 and operates the same way.

The arc-flash sensors for zone 3 are connected to Device 1, 2 or 3. If a sensor detects the fault in zone 3, the light-only signal is transferred to Device 3 which also detects overcurrent and then trips the main circuit breaker.

An eventual arc-flash fault in zone 1 or 2 does not necessarily activate the current element in Device 3. However, arc detection can be achieved by using the light-only principle. If an arc-flash occurs in cable termination, zone 1 or zone 2, the fault is cleared by the upstream circuit breaker.

Each arc-flash protection stage provides:

- One arc detection function, which can be connected either to one of the available arc sensors (for local detection) or to a digital input or GOOSE information (for remote detection).
- One current detection function, which can be connected either to phase or earth/ground fault high-speed overcurrent (for local detection) or to a digital input or GOOSE information (for remote detection).
- One trip input to other relays

  The trip signal of arc-flash protection is not a part of the global trip. In this case it is convenient to use Goose which provides a fast signal to the other relay.

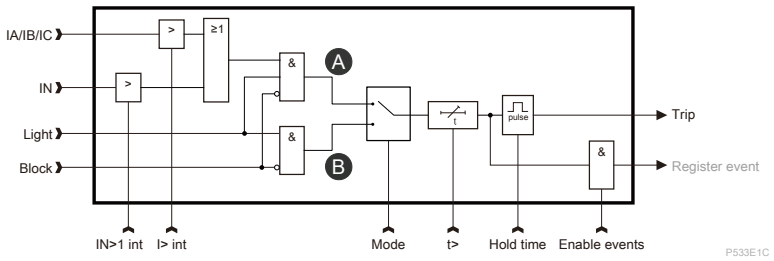
Earth/ground fault current can be only measured and detected, according to the PowerLogic P5 protection relay, from:

- 1/5A neutral CT input
- CSH/CSH30 neutral current input

Each stage of the arc-flash protection can be blocked individually by a control inputs such as digital input, virtual inputs and function keys.

Block diagram

Figure 253 - Block diagram of the arc-flash protection function



A	Light + Current	B	Light

Operation

Before configuring the arc flash protection, the arc sensors need to be installed through eSetup Easergy Pro.

The installation process is as follows:

1. In eSetup Easergy Pro, select **PROTECTION** menu/**ARC protection** sub-menu.
2. Under **Settings** view, click the “Install arc sensors” drop-down list and select Install.
3. Wait until the Installation state shows Ready.

   The installation of the sensors is now done.

The installed sensors and the sensor status can be viewed at the bottom of the ARC protection view.

This is an online process only. The installation process is only applicable when eSetup Easergy Pro is connected to an PowerLogic P5 protection relay. The offline configuration does not have this menu visible.

The arc-flash protection is implemented by configuration in the following three matrix (see **Matrix** menu in eSetup Easergy Pro):

- Arc matrix - current
- Arc matrix - light
- Arc matrix - output

The event configuration for the protection is done in the **Event enabling - ARC** view of the **Log** menu in eSetup Easergy Pro.

NOTE: When an arc-flash sensor is disconnected, an alarm message is automatically generated and displayed on the local panel.

Arc matrix – current

In the Arc matrix – current setting view, the available current signals (left column) are linked to the appropriate arc stages (1...8).

Figure 254 - View of Arc matrix – current

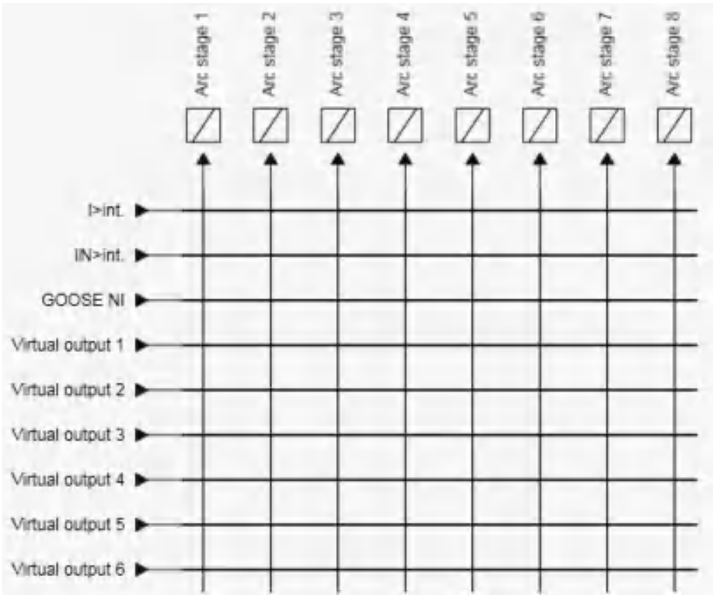


Table 84 - Arc matrix – current parameter group

Item	Range	Description
I>int.	On, Off	Phase IA, IB, IC internal overcurrent signal
67NI	On, Off	Earth/ground fault overcurrent signal
GOOSE NI	On, Off	Goose network input (IEC 61850)
Virtual output 1...20	On, Off	Virtual output
Arc stage 1...8	On, Off	Arc protection stage 1 to 8

Arc matrix – light

In the **Arc matrix – light** setting view, the available arc light signals (left column) are linked to the appropriate arc stages (1...8).

Figure 255 - View of Arc matrix – light

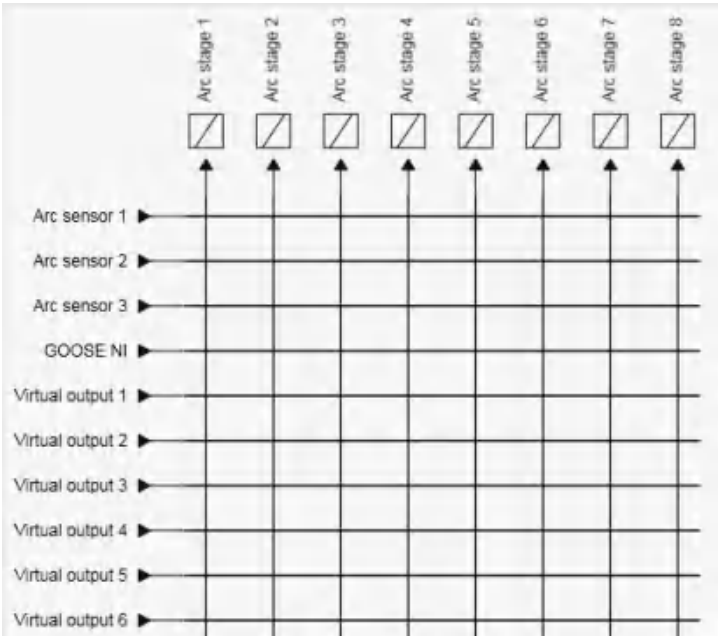


Table 85 - Arc matrix – light parameter group

Item	Range	Description
Arc sensor 1...6	On, Off	Internal arc-flash sensor 1 to 3 or 1 to 6, according to the configuration
GOOSE NI	On, Off	Goose network input
Virtual output 1...20		Virtual output
Arc stage 1...8	On, Off	Arc protection stage 1 to 8

Arc matrix – output

In the **Arc matrix – output** setting view, the used Arc stages (1...8) are connected to the required outputs. Possible latched function per output is also determined in this view. The available outputs depend on the order code.

NOTE: Arc matrix is the only way to configure arc stage signals to the output relay in PowerLogic P5, it is not configurable via standard Output matrix. But the configured signals will be reflected in the Output matrix.

Figure 256 - View of Arc matrix – output

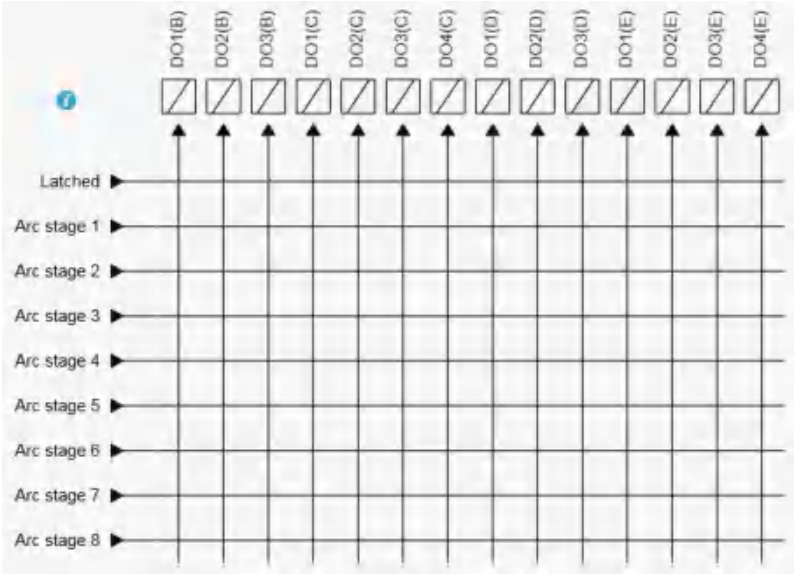


Table 86 - Arc matrix – output parameter group Setting Range

Setting	Range	Description
Latched	On, Off	Output latch
Arc stage 1...8	On, Off	Arc protection stage 1 to 8
Digital output	On, Off	DO1 to DO3 (slot B) or DO1 to DO4 (slots C, D, E) according to the PowerLogic P5 configuration

Event enabling matrix

This matrix is used to generate events when the current elements, light signals from the arc sensors, and the arc stages are activated or drop off.

Characteristics

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

Do not use the arc operation delay for primary trip.

Failure to follow these instructions will result in death or serious injury.

The arc operation delay is intended, with the separate arc stage, for the circuit breaker failure scheme only.

Table 87 - Setting and characteristics of the arc-flash protection function (ANSI 50ARC)

Setting/characteristics (description/label)	Values	
Stage Mode/Mode		
Options	Light; Light and I	
I>int. pick-up value/I>int		
Setting range	0.50...8.00 pu[80]	
Resolution	0.01pu[80]	
Accuracy	±2.5%	
CT input selection[81]		
Setting range	CT-1, CT-2	
IN>int. pick-up value/IN>int.		
Setting range	0.10...5.00 pu[80]	
Resolution	0.01pu[80]	
Accuracy	±2.5%	
DI to block stage		
Options	Selection of one digital input (DI), one virtual input (VI), or one function key (Fx).	
Operate delay/Delay		
Setting range	0...255 ms	
Accuracy	±1% or 20 ms	
Min. hold time (1~8)/Hold time		
Setting range	20...2500 ms	
Resolution	1 ms	
Accuracy	±1% or 20 ms	
Characteristic time		
Tripping time [82]		
Light only	2 ms minimum	4 ms maximum
Light + I> (earth fault) at 2xI>	5 ms minimum	11 ms maximum
Light + I> (phase fault) at 2xI>	4 ms minimum	7 ms maximum
Light by Goose + I> (earth fault)	5 ms minimum	11 ms maximum
Light by Goose + I> (phase fault)	4 ms minimum	10 ms maximum

80. I_{nom}
81. Available for P5T30 only.
82. With high speed high break contact relay (PowerLogic P5x30) only.

Table 87 - Setting and characteristics of the arc-flash protection function (ANSI 50ARC) (Continued)

Setting/characteristics (description/label)	Values	
Light + I> by Goose (earth fault)	7 ms minimum	16 ms maximum
Light + I> by Goose (phase fault)	5 ms minimum	12 ms maximum

Circuit breaker failure (ANSI 50BF)

Description

If a circuit breaker fails to open, following a tripping order (mainly detected by the non-extinction of the fault current), the circuit breaker failure protection function (ANSI code 50BF) sends a tripping order to the upstream or adjacent breakers.

With transformer differential protection P5T30 two CBF elements are available with a fix link to the measured currents of one end (CBF-1 to end 1, CBF-2 to end 2).

The circuit breaker failure protection has three types of inputs to operate:

- Current protection
- Non-current protection like frequency protections or voltage protections
- External trip

The circuit breaker failure protection incorporates two timers, CB Fail 1 Timer and CB Fail 2 Timer, allowing configuration for these scenarios:

- Simple CB failure protection, where only CB Fail 1 Timer is enabled. For any protection trip, the CB Fail 1 Timer is started, and normally reset when the circuit breaker opens to isolate the fault. If breaker opening is not detected, CB Fail 1 Timer times out and closes an output contact assigned to breaker fail (using the output matrix). This contact is used to backtrip upstream switchgear, generally tripping all infeeds connected to the same busbar section.
- A re-tripping scheme, plus delayed back-tripping. Here, CB Fail 1 Timer is used to route a trip to a second trip circuit of the same circuit breaker. This requires duplicated circuit breaker trip coils, and is known as re-tripping. Should re-tripping fail to open the circuit breaker, a back-trip may be issued following an additional time delay. The back-trip uses CB Fail 2 Timer, which is also started at the instant of the initial protection element trip.

CB failure protection elements CB Fail 1 Timer and CB Fail 2 Timer can be configured to operate for trips triggered by protection elements within the protection relay or via an external protection trip. The latter is achieved by allocating one of the digital inputs to External Trip selected with the "DI for external trip signal" parameter.

Resetting of the CB failure protection is possible from a breaker open indication (from the pole dead logic) or from a protection reset. In these cases, resetting is only allowed provided the undercurrent elements have also reset. The resetting options are summarised in this table:

Table 88 - CB fail timer reset mechanisms

Initiation	CB fail timer reset
Current based protection (linked to CBF_ITrp in Output matrix)	[IA<] & [IB<] & [IC<] & [IN<] according to PowerLogic P5 model
IN.sens based protection (fixed to IN>x (x = 1...6),when the IN>x input is set to IN.sens)	[IN.sens<] according to PowerLogic P5 model
Non-current based protection (linked to CBF_nITrp in Output matrix)	Three options are available: • Current protection reset only • Pole dead • Reset of the non-current protection
External protection (from DI selected in CBF settings)	Three options are available. • Current protection reset only • Pole dead • Reset when external trip signal disappears

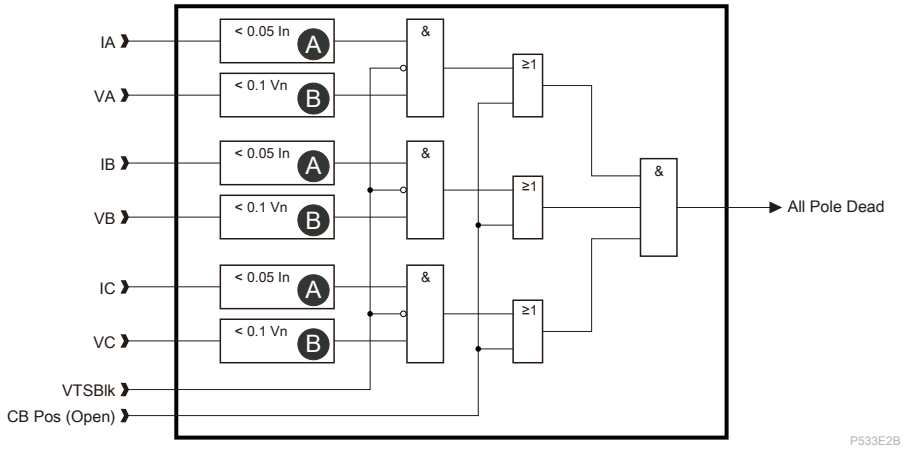
Pole dead logic

The pole dead logic can be used to give an indication if one or more phases of the line are dead. A pole dead condition is determined by either monitoring the status of the circuit breaker auxiliary contacts or by measuring the line currents and voltages. If a "CB Open" signal is given the protection relay will automatically initiate a pole dead condition regardless of the current and voltage measurement. Similarly, if both the line current and voltage fall below a pre-set threshold the protection relay will also initiate a pole dead condition.

This is necessary so that a pole dead indication is still given even when an upstream circuit breaker is opened. The undervoltage (V<) and undercurrent (I<) thresholds have the following, fixed, pickup and drop-off levels as shown in Pole dead logic, page 381.

If the VT fails a signal is taken from the VTS logic to block the pole dead indications that would be generated by the under-voltage and under-current thresholds. However, the VTS logic will not block the pole dead indications if they are initiated by a "CB Open" signal. The object for used CB is directly set in the **Objects** view of the **Control** menu in eSetup Easergy Pro.

Figure 257 - Pole dead logic



A	Drop off 0.055 In
B	Drop off 0.3 Vn

NOTE: For PowerLogic P5U20 and P5T30, undervoltage detection logic is ignored. For PowerLogic P5V20, only CB position is used to check pole dead, undercurrent and undervoltage logic are disabled.

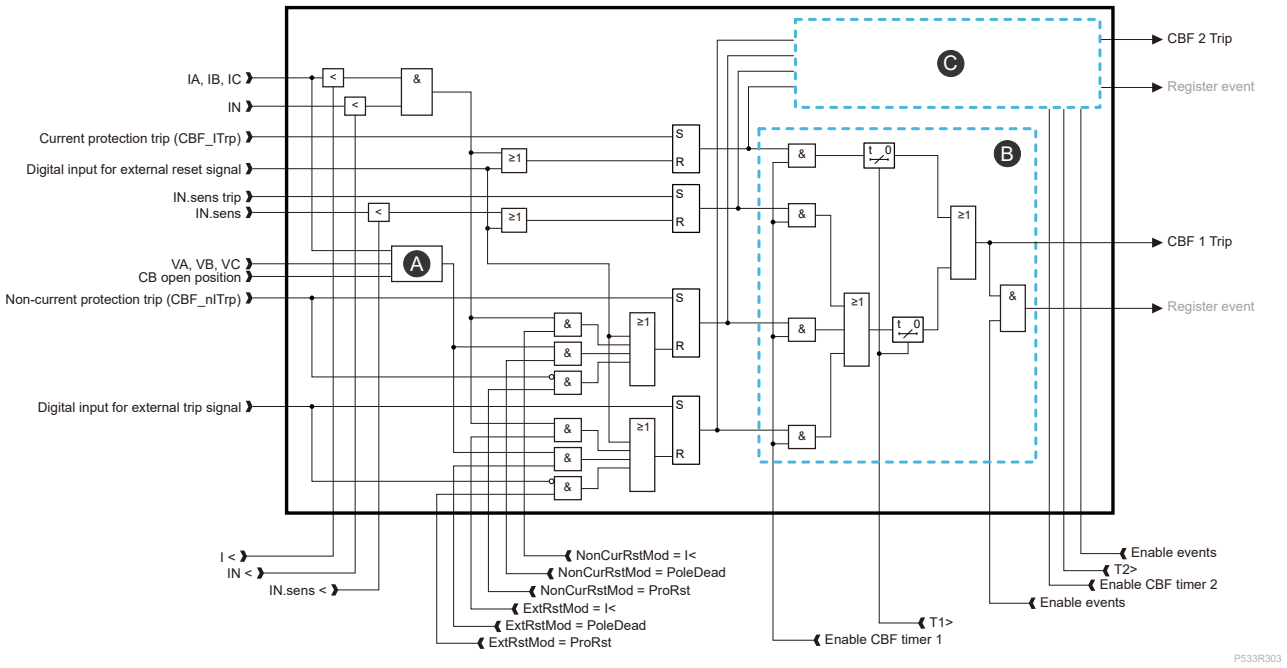
Matrix use

To activate the circuit breaker failure function with current protection trip or with non-current protection trip, it is required to connect the relevant signals in Output matrix. These are the CBF_ITrp signal or CBF_nITrp signal respectively.

The digital inputs used for the external trip signal as well as for external reset signal are directly set in the breaker failure function.

Block diagram

Figure 258 - Block diagram of the circuit breaker failure protection function



A	Pole Dead Detection	B	CBF 1
C	CBF 2 (same diagram as CBF 1)		

NOTE: The IN.sens trip is the signal of IN> protection trip when the input of IN> is set to IN.sens.

Characteristics

Table 89 - Settings and characteristics of the breaker failure protection function (ANSI 50BF)

Settings/characteristics (description/label)	Values
I< current set/I<	
Setting range	0.02...4.00 pu
Resolution	0.01 pu
CT input selection[83]	
Setting range	CT-1 is fixed for stage 1, CT-2 is fixed for stage 2.
IN< current set/IN<	
Setting range	0.050...4.000 pu[84] for IN measured by CSH; 0.020...4.000 pu[84] for IN measured by standard earth/ground fault CT 0.020...4.000 pu[84] for IN measured by standard earth/ground fault CT (for CSH30 use)
Resolution	0.001
IN.sens< current set/IN.sens<	
Setting range	0.002...0.800 pu[84] for sensitive earth/ground fault

83. Available for P5T30 only.
84. Inom for IN.calc; IN.nom for IN.meas; IN.CSH.nom for IN.CSH

Table 89 - Settings and characteristics of the breaker failure protection function (ANSI 50BF) (Continued)

Settings/characteristics (description/label)	Values
Resolution	0.001 pu[85]
Timer1 operate delay/T1 operate delay	
Setting range	0.00...50.00 s
Resolution	0.01 s
Accuracy	±1% or ±20 ms
Timer2 operate delay/T2 operate delay	
Setting range	0.00...50.00 s
Resolution	0.01 s
Accuracy	±1% or ±20 ms
Noncurrent CBF reset mode	
Options	I<only; PoleDead; ProtRst
Ext. CBF reset mode	
Options	I<only; PoleDead; ProtRst
DI for external trip signal	
Options	Selection of one digital input DI, one virtual input VI, or one function key
DI for external reset signal	
Options	Selection of one digital input DI, one virtual input VI, or one function key
Characteristic times	
Reset time[86]	< 30 ms for any trip initiate, reset by I<; < 30 ms for any trip initiate, reset by IN<; < 50 ms for non-current protection initiate, reset by Pole Dead[87]
Setting group	
Number	1

85. Inom for IN.calc; IN.nom for IN.meas; IN.CSH.nom for IN.CSH
86. Does not take into account any contact relay
87. Considering by default, 10 ms of debounce time filter on digital inputs.

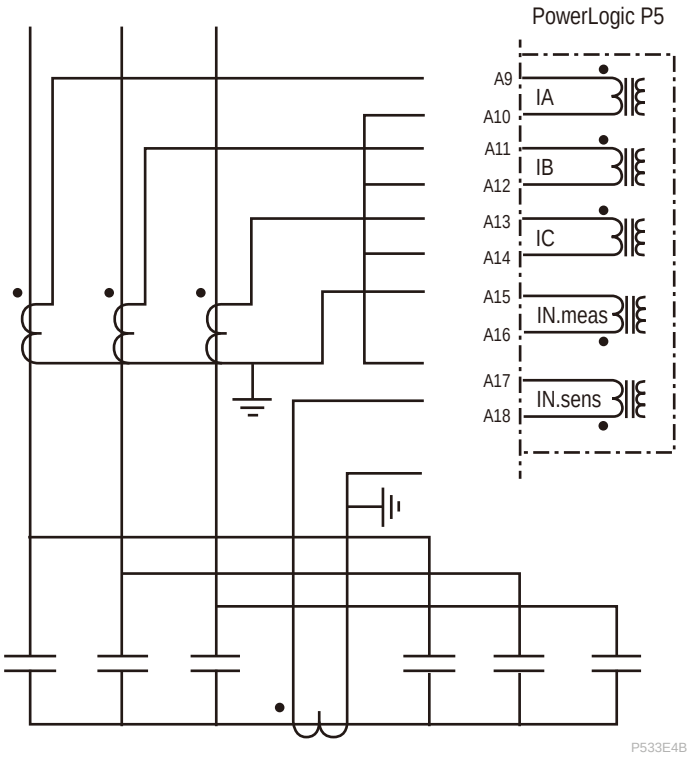
Capacitor bank unbalance (ANSI 51C)

Description

The capacitor bank unbalance protection function (ANSI code 51C) detects unbalance current flowing between the neutral points of a double-star connected capacitor, filter and reactor bank. The typical connection for capacitor bank unbalance protection is shown in Typical capacitor bank protection application with the PowerLogic P5 protection relay, page 384. The unbalance current is measured with a dedicated current transformer (Standard earth/ground fault CT, or CSH core balance CT) between two star-points of the bank.

Under healthy conditions any standing unbalance current caused by small differences in each side of the banks is limited and it can be compensated as described in the following section. When there are failures within one capacitor unit, the unbalance current will increase, depending on the number of failed capacitor elements.

Figure 259 - Typical capacitor bank protection application with the PowerLogic P5 protection relay



Normally, stage 1 is applied as the trip stage and stage 2 is applied as the alarm stage. As well as current input IN , the phase current IA is used to polarise the capacitor bank unbalance current for the standing unbalance current compensation and the faulty phase location.

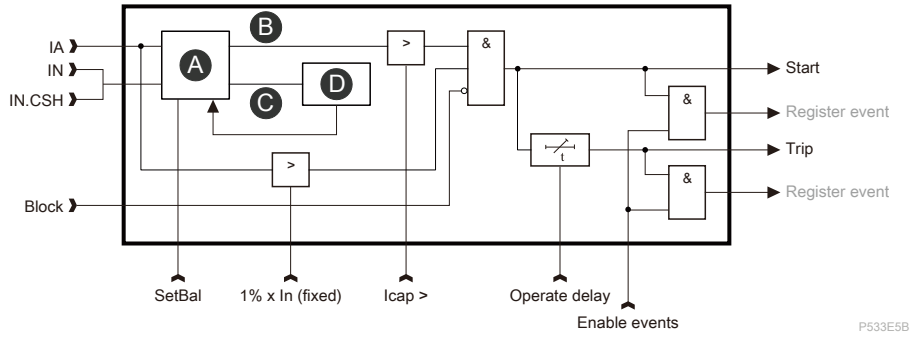
Compensation method

The unbalance current under normal conditions can be compensated to get better protection sensitivity. There are two compensation modes, Normal mode and Location mode. Stage 1 can only select Normal mode. Stage 2 can select Normal mode or Location mode.

Normal mode

The compensation is performed manually during commissioning. Using eSetup Easergy Pro (**PROTECTION** menu/**Capacitor unbalance I_{cap}>1** sub-menu/**I_{cap}>1 unbalance** view) or relay HMI, the relay can get the standing unbalance current vector (here, IA is the angle reference) and record the magnitude and angle. For flexible compensation purpose, the magnitude of the standing unbalance current to be compensated is user settable under Normal Mode (setting SetBal), while the angle of the standing unbalance current is not settable, fixed as the recorded angle during commissioning.

Figure 260 - Capacitor unbalance protection with Normal compensation method



A	Compensation value: IN.compensate = IN - IN.cmp	B	Mag(IN.compensate)
C	Angle(IN) - Angle(IA)	D	Recorded IN angle

Location mode

As in the Normal mode, the initial standing unbalance current vector (magnitude, angle referred to IA) can be recorded during commissioning. The magnitude of the standing unbalance current to be compensated is not user settable, but the automatic compensation feature is provided. In Location Mode the branch of each faulty element can be estimated and thus improve the fault finding and maintainability of the capacitor bank.

Sensitive Setting

The stage I_{cap}>2 Pick up value should be set based on the calculated unbalance current change of one faulty element. The calculation can use the following formula:

$$3I_N = \frac{\frac{V_{P\text{-}N}}{(2\cdot\pi\cdot f\cdot C_1)^{-1}} - \frac{V_{P\text{-}N}}{(2\cdot\pi\cdot f\cdot C_2)^{-1}}}{3}$$

P533E6B

C1 = Capacitor unit capacitance (µF)

C2 = Capacitor unit capacitance, after one element fails (µF)

The entered setting should be smaller than the calculated value. As a rule of thumb 90% of the calculated unbalance current under one capacitor element faulty is recommend as the current setting.

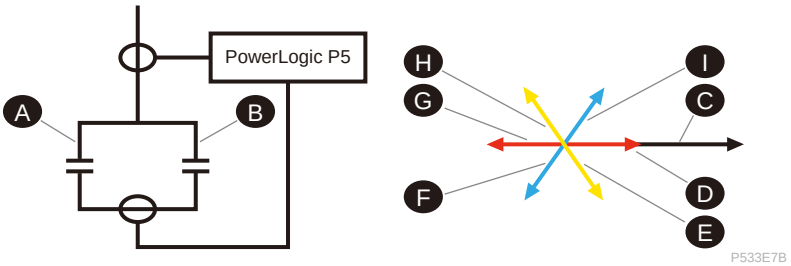
Counter Calculation

If there is an element failure in the bank, the relay checks the phase angle of the unbalance current (referred to IA). Based on this angle, the protection relay can detect the location of the faulty element and increase the corresponding counter with the calculated faulty elements number. For a double-star connected capacitor bank, there are a total of six counters to indicate six options for the location of the faulty element, as shown in How a failure in different branches of the bank affects the IN measurement, page 386.

The current setting is based on the unbalance current with one faulty capacitor element, and the setting Max Allowed Faults is provided to specify how many faulty capacitor elements are allowed without the relay operating. The faulty element number can be calculated as follows:

N = compensated IN magnitude / IN setting

Figure 261 - How a failure in different branches of the bank affects the IN measurement



A	Branch 1	F	Phase 2 fault in branch 1
B	Branch 2	G	Phase 1 fault in branch 2
C	IA as reference	H	Phase 3 fault in branch 1
D	Phase 1 fault in branch 1	I	Phase 2 fault in branch 2
E	Phase 3 fault in branch 2		

Automatic Compensation

The operation time setting for stage I_{cap}>2 specifies how long the relay must wait until it is certain that there is a faulty element in the bank. After this time has elapsed, the corresponding counter will contain the number of faults. If none of the six counters reach the setting Max Allowed Faults, the stage I_{cap}>2 makes a new compensation automatically and the compensated unbalance current for this stage is now zero. The I_{cap}>2 stage will reset and be sensitive to a new faulty element. Note the counters are not reset by this action and will continue to accumulate any further faulty elements. As shown in Automatic compensation under location mode, page 387, the current vector A is the initial recorded standing unbalance current and the current vector B is the unbalance current with the faulty capacitor elements. The new compensation current is “vector B – vector A”. If one of the six counters reach the setting Max Allowed Faults, stage I_{cap}>2 will operate and the compensation current vector is recovered to the initial recorded standing unbalance current vector A.

Note, the automatic compensation does not affect the measured unbalance current of stage I_{cap}>1.

Figure 262 - Automatic compensation under location mode

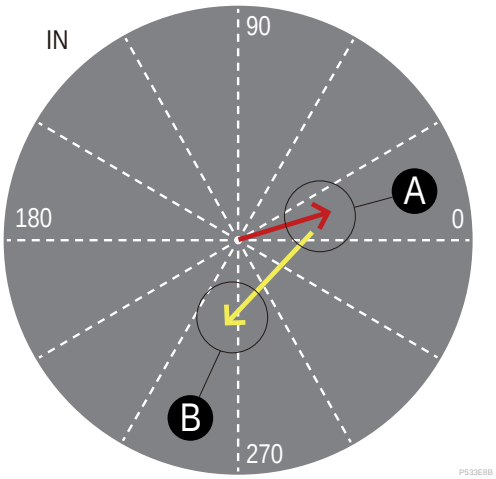
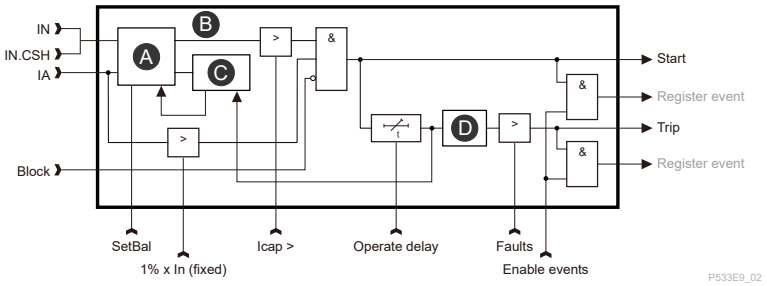


Figure 263 - Capacitor unbalance protection with Location compensation mode



A	Compensation value: IN.compensate = IN - IN.cmp	B	Mag(IN.compensate)
C	Recorded IN	D	Counter calculation

Characteristics

Table 90 - Settings and characteristics of the capacitor bank unbalance protection stage (ANSI 51C)

Settings/characteristics (description/label)	Values
IN input/Input	
Options	IN.CSH , IN.calc, IN.meas
Pick-up setting/Pick-up setting	
Setting range	0.02...20.00 pu[88] for IN measured with standard EF CT; 0.02...10.00 pu[88] for IN measured with standard EF CT (for CSH30 use); 0.05...20.00 pu[88] for IN measured with CSH;
Resolution	0.01 pu
Accuracy	±3% or ±0.002 pu for IN measured with standard EF CT; ±3% or ±0.002 pu for IN measured with standard EF CT (for CSH30 use); ±3% or ±0.005 pu for IN measured with CSH;
Reset ratio	95% ± 3%
Transient overreach	< 10% with X/R up to 120
Operate delay/Operate delay	
Setting range	0.00...300.00 s
Resolution	0.01 s
Accuracy	±1% or ±20 ms
Compensation Mode	
Options	Off; Normal; Location
Compensation Current (only available under Normal Compensation Mode)	
Setting range	0.010...3.000 pu[89]
Resolution	0.001 pu
Max Allowed Faults (only available under Location Compensation Mode)	
Setting range	0...10
Characteristic times	
Start time	< 40 ms (35 ms with high speed)
Overshoot time	< 40 ms
Disengaging time	< 95 ms (110 ms with high speed)
Setting group	
Number	4

88. PU is the per unit value based on Inom = phase CT primary nominal (IN.calc) or IN.nom = standard neutral CT primary nominal (IN.meas) or IN.CSH.nom = CSH CT primary nominal (IN.CSH) or IN.sens.nom = sensitive neutral CT primary nominal (IN.sens)
89. PU is the per unit value based on Inom = phase CT primary nominal (IN.calc) or IN.nom = standard neutral CT primary nominal (IN.meas) or IN.CSH.nom = CSH CT primary nominal (IN.CSH) or IN.sens.nom = sensitive neutral CT primary nominal (IN.sens)

Overvoltage (ANSI 59)

Description

The Overvoltage protection function (ANSI code 59) is used to detect system voltages that are too high or to check that there is sufficient voltage to authorise a source transfer.

The Overvoltage function provides the selection of phase to phase voltage or phase to ground voltage. Whenever any of these voltages exceeds the pickup value setting of a particular stage, this stage starts and a start signal is issued. If the fault situation remains on longer than the operate time setting, a trip signal is issued.

This function operates with either the definite time delay or inverse time delay characteristic or programmable curves. The inverse time delay characteristic follows the equation below:

$$t(G) = \frac{T}{(\frac{G}{G_S})-1}$$

P533OUB

where:

- t(G) is the theoretical operate time in seconds with constant value of G.
- T is the time delay setting (theoretical operate time for G = 2Gs).
- G is the measured value of the characteristic quantity.
- Gs is the setting value.

Reset delay

The reset delay of V> stage is configurable, it enables the detection of intermittent faults. The time counter of the protection function does not reset immediately after the fault is cleared, but resets after the release delay has elapsed. If the fault appears again before the release delay time has elapsed, the delay counter continues from the previous value. This means that the function eventually trips if faults are occurring often enough.

There are three delay types for select: DT, IDMT, or Prg 1-3. For the detail of Prg 1-3, please refer to Programmable dependent time curves, page 268.

Operate mode

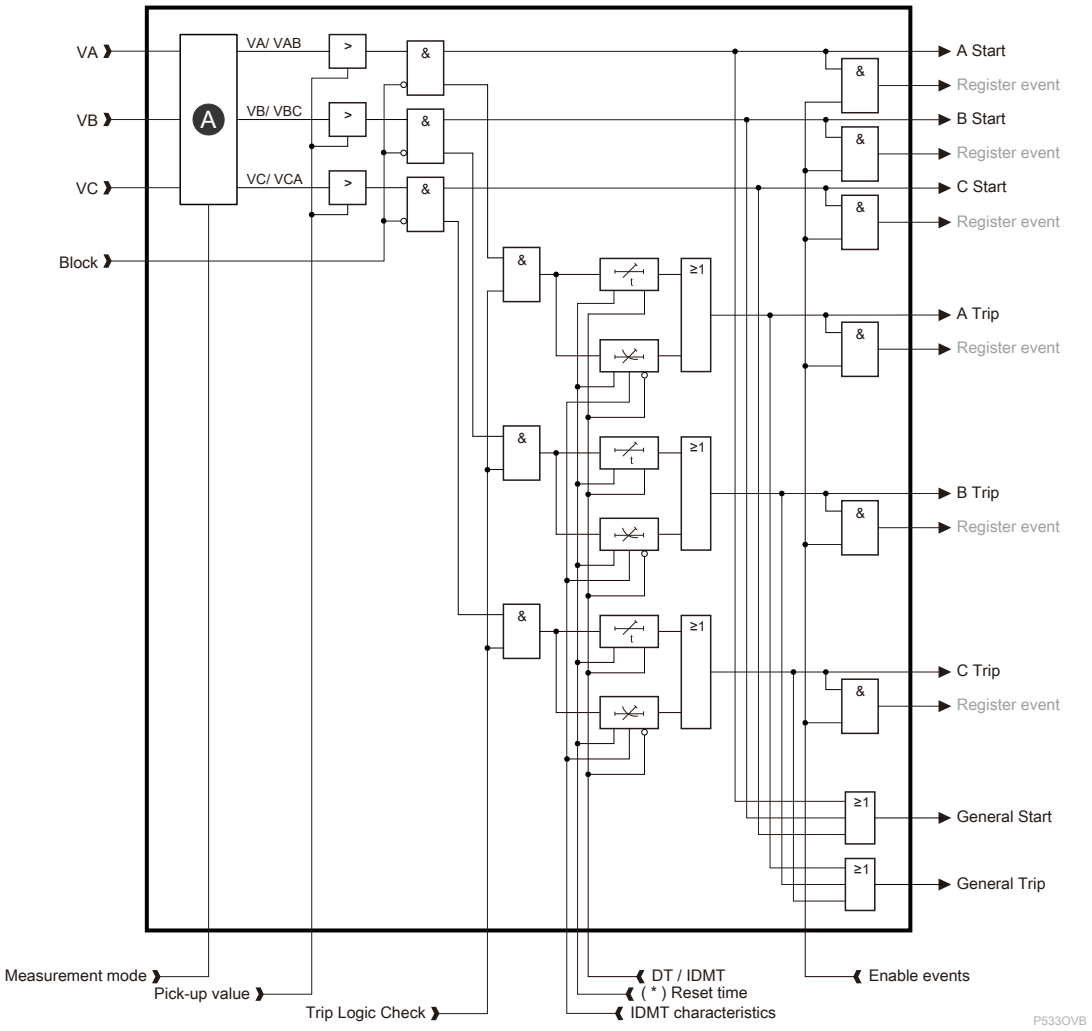
The setting "Tripping logic" shall be available to configure the operate mode. When "Tripping logic" is "Any Phase", the signal "General Trip" is ON when any phase operates. When "Tripping logic" is "Three Phases", the signal "General Trip" is ON when all three phases operate.

Three independent stages

There are three separately adjustable stages. All these stages have the same settings and performance.

Block diagram

Figure 264 - Block diagram of the Overvoltage protection function (ANSI 59)



A Select setting

For the block diagram of the Tripping Logic, refer to Block diagram of the Tripping Logic, page 298.

Characteristics

Table 91 - Settings and characteristics of the Overvoltage protection (ANSI 59)

Settings/characteristics (description/label)	Values
Enable V>	
Options	Off/On
Pick-up value/V>	
Setting range	0.02...1.50 pu[90]

90. Vnom = VT primary nominal (PP) or Vnom/√3 = VT primary nominal (PN) depending on measurement mode parameter setting

Table 91 - Settings and characteristics of the Overvoltage protection (ANSI 59) (Continued)

Settings/characteristics (description/label)	Values
Resolution	0.01 pu[91]
Accuracy	±2% or ±0.05 V secondary
Measurement mode/MeasMode	
Options	Phase-Phase; Phase-Ground
Delay type/Type	
Options	DT; IDMT; Prg 1-3
Tripping logic/Triplogic	
Options	Any Phase; Three Phases
Operate delay/Operate delay	
Setting range	0.00...600.00 s
Resolution	0.01 s
Accuracy	DT: ±1% or ±10 ms
	IDMT: ±5% or ±20 ms
Reset time/Reset time	
Setting range	0.00...100.00 s
Resolution	0.01 s
Accuracy	DT: ±5% or ±30 ms
Hysteresis	
Setting range	1.0%...5.0%
Resolution	1.0%
Accuracy	±2%
Characteristic times	
Start time	< 40 ms (35 ms with high speed)
Overshoot time	< 40 ms
Disengaging time	< 55 ms (70 ms with high speed)
Setting group/SetGrp	
Number	4

91. Vnom = VT primary nominal (PP) Vnom/√3 = VT primary nominal (PN)

Neutral overvoltage (ANSI 59N)

Description

The neutral overvoltage protection function (ANSI code 59N) is used as non-selective backup for earth/ground faults and also for selective earth/ground fault protection for motors having a unit transformer between the motor and the busbar.

This function is sensitive to the fundamental frequency component of the neutral displacement voltage. The attenuation of the third harmonic is more than 60 dB because third harmonics are present between the neutral point and earth/ground even when there is no earth/ground fault.

Whenever the neutral voltage VN exceeds the start setting of a particular stage, this stage issues a start signal. If the fault situation is present longer than the operate time setting, a trip signal is issued.

Measuring the neutral overvoltage

The neutral displacement voltage is either measured with a single voltage transformer between the motor's neutral point and earth/ground or calculated from the measured phase to neutral voltages according to the selected voltage measurement mode (see Voltages, page 468):

- When the voltage measurement mode contains "+VN": The neutral displacement voltage is measured with voltage transformer(s), for example using a broken delta connection such as 3VP+VN, 2VPP+VN and 2VPP+VN+VPPy, the measured neutral voltage exists. In this scenario, user can select:
  - in secondary volts,

    $$VN_{sec.meas}\,[V]$$

  - as per unit value,

    $$VN_{sec.meas}\,[p.u.] = \frac{VN_{sec.meas}\,[V]}{VN_{sec.nom}\,[V]}$$

  - in primary kilovolts,

    $$VN_{prim.meas}\,[kV] = \frac{VN_{sec.meas}\,[V]}{VN_{sec.nom}\,[V]} \times VN_{prim.nom}\,[kV]$$

- When the voltage measurement mode is 3VP: The neutral displacement voltage is calculated from the phase voltages and therefore no separate neutral displacement voltage transformer is needed. The calculated neutral voltage exists:
  - in secondary volts,

    $$VN_{sec.calc}\,[V] = (VA_{sec.meas} + VB_{sec.meas} + VC_{sec.meas})\,[V]$$

  - as per unit value,

    $$VN_{sec.calc}\,[p.u.] = \frac{VN_{sec.calc}\,[V]}{VN_{sec.nom}\,[V]}$$

  - in primary kilovolts,

    $$VN_{prim.calc}\,[kV] = \frac{VN_{sec.calc}\,[V]}{VN_{sec.nom}\,[V]} \times VN_{prim.nom}\,[kV]$$

- When the “Voltage measurement mode” is VPP/VPPy, the neutral voltage displacement feature is not applicable, as the calculated neutral voltage is not reliable.

Three independent stages

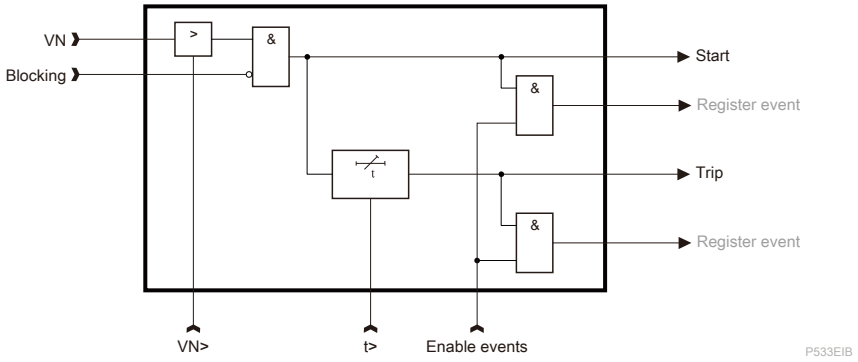
There are three separately adjustable stages: VN>1, VN>2 and VN>3. All stages operate with definite time (DT) operation characteristics.

Block diagram

The neutral overvoltage protection function (ANSI code 59N) is used as non-selective backup for earth/ground faults also for selective earth/ground fault protection for motors having a unit transformer between the motor and the busbar.

This function is sensitive to the fundamental frequency component of the neutral voltage. Whenever the selected neutral voltage value, measured or calculated, exceeds the pick-up setting of a particular stage, this stage starts and issues a start signal. If the fault situation is present longer than the operate time delay setting, a trip signal is issued.

Figure 265 - Block diagram of the neutral voltage displacement protection function



Characteristics

Visibility of VT setting sections and VN setting sections depends on the fitted VTs (and the selected measurement mode). The setting range will be updated as required in the table below.

Table 92 - Settings and characteristics of the neutral overvoltage protection function

Settings/characteristics (description/label)	Values
Pick-up value	
Setting range	0.02...1.50 pu[92]
Resolution	0.01 pu[92]
Accuracy	±2% or ± 0.005 pu[92]
Reset ratio	97% ± 2%
Operate delay	
Setting range	0.00...300.00 s
Resolution	0.01 s
Accuracy	±1% or ±10 ms
Reset time	
Setting range	0.00...300.00 s

92. √3 x Vnom

Table 92 - Settings and characteristics of the neutral overvoltage protection function (Continued)

Settings/characteristics (description/label)	Values
Resolution	0.01 s
Accuracy	±1% or ±30 ms
Characteristic times	
Start time	< 50 ms (45 ms with high speed)
Overshoot time	< 40 ms
Disengaging time	< 55 ms (70 ms with high speed)
Setting groups	
Number	4
Evaluation VN	
Options	Measured/Calculated

Capacitor overvoltage (ANSI 59C)

Description

This capacitor overvoltage protection function (ANSI code 59C) calculates the voltages of a three-phase Y-connected capacitor bank using the measured currents of the capacitors and the capacitor reactance. No voltage measurements are needed. Especially in filter applications, there are harmonics and, depending on the phase angles, the harmonics can increase the peak voltage. This protection function calculates the worst-case overvoltage in per-unit values according to IEC 60871-1 standard. Harmonics up to 15th are taken into account.

$$U_c = \frac{X_c}{U_{cLN}} \sum_{n=1}^{15} \frac{I_h}{n}$$ P533EJB

where

$$X_c = \frac{1}{2 \cdot \pi \cdot f \cdot C_{set}}$$ P533EKA

U_c = Amplitude of a pure fundamental frequency sine wave voltage, whose peak value is equal to the maximum possible peak value of the actual voltage (including harmonics) over a Y-coupled capacitor.

X_c = Reactance of the capacitor at the measured frequency

U_{cLN} = Nominal voltage of the capacitance C.

n = Order number of harmonic. n = 1 for the fundamental frequency component. n = 2 for 2nd harmonic etc.

I_h = nth harmonic of the measured phase current. h = 1 - 15.

f = Measured system frequency.

C_{set} = Single phase capacitance between phase and starpoint.

The above equation gives the maximum possible voltage, while the actual voltage depends on the phase angles of the involved harmonics. The protection is sensitive to the highest voltage of the three phase to neutral voltages. Whenever this value exceeds the start setting of a particular stage, this stage starts and issues a start signal. If the fault situation is present longer than the definite operation delay setting, a trip signal is issued.

Reactive power of the capacitor bank

The rated reactive power per phase-earth/ground capacitor is calculated as follows:

$$Q_n = 2 \cdot \pi \cdot f_n \cdot U_{cLN}^2 \cdot C_{set}$$ P533ELA

Q_n = Rated reactive power of the three-phase capacitor bank

f_n = Rated frequency. 50 Hz or 60 Hz.

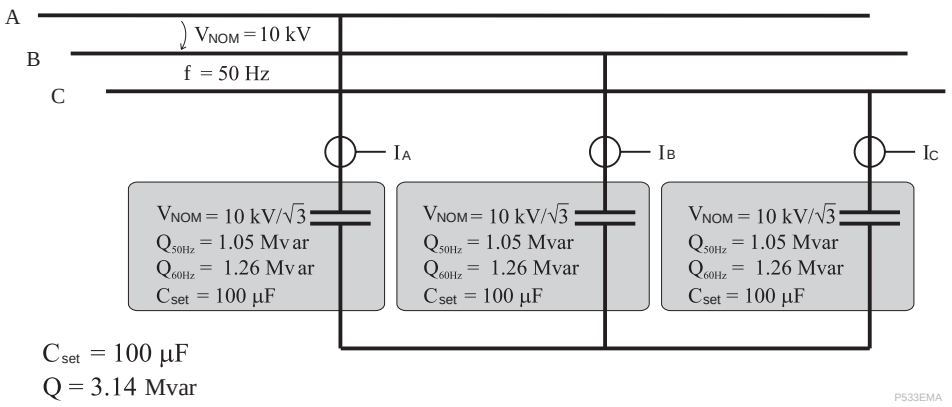
U_{cLN} = Nominal voltage of the capacitance C.

C_{set} = Single phase capacitance between phase and starpoint.

Three separate capacitors connected in star (III Y)

In this configuration, the capacitor bank is built of three single-phase sections without internal interconnections between the sections. The three sections are externally connected to a star (Y). The single-phase to starpoint capacitance is used as the setting value.

Figure 266 - Example of star (III Y) connected capacitor bank

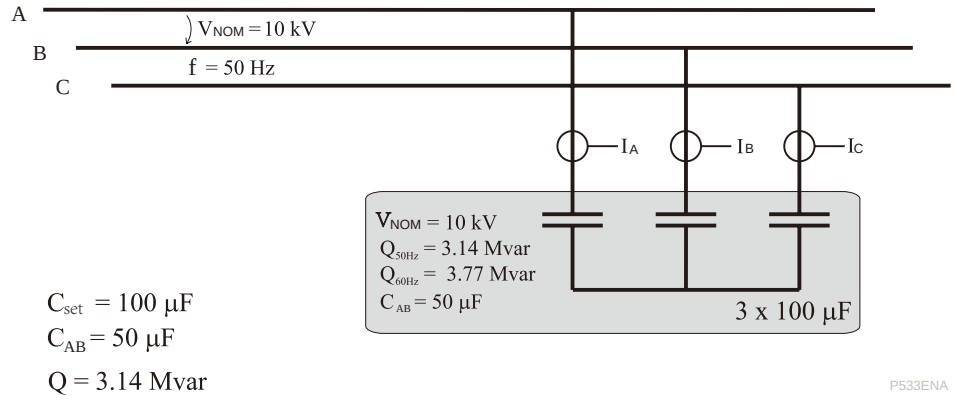


Three phase capacitor connected internally in star (Y)

In this configuration, the capacitor bank consists of a three-phase capacitor connected internally to a star (Y).

The single-phase to starpoint capacitance is used as the setting value, which can be calculated from the capacitance C_{AB} between phases A and B (as given on the nameplate): $C_{set} = 2C_{AB}$

Figure 267 - Three-phase capacitor bank connected internally in star (Y)



Capacitance between phases A and B is 50 µF and the equivalent phase to neutral capacitance is 100 µF whose value is also used as the setting value.

Overvoltage and reactive power calculation example

The capacitor bank is built of three separate 100 µF capacitors connected in star (Y). The rated voltage of the capacitors is 8 kV; the measured frequency is 50.04 Hz and the rated frequency is 50 Hz.

The measured fundamental frequency current of phase A is: IA = 181 A; the measured relative 2nd harmonic is: 2% = 3.62 A; the measured relative 3rd harmonic is: 7% = 12.67 A; the measured relative 5th harmonic is: 5% = 9.05 A.

According to equation $C_{set} = C_{nameplate}$, the phase to starpoint capacitance is: C_{set} = 100 µF

The rated power is: Q_n = 2011 kvar

$$Q_n = 2 \cdot \pi \cdot f_n \cdot U_{cLN}^2 \cdot C_{set}$$

P533ELA

The reactance is: X_c = 1 / (2π x 50.04 x 100 x 10 - 6) = 31.806 Ω

$$X_c = \frac{1}{2 \cdot \pi \cdot f \cdot C_{set}}$$ P533EKA

The pure fundamental voltage U_c having a peak value equal to the highest possible voltage with similar harmonic content as the measured reactive capacitor currents is: Ucp1 = 31.806 x (181 / 1 + 3.62 / 2 + 12.67 / 3 + 9.05 / 5) = 6006 V

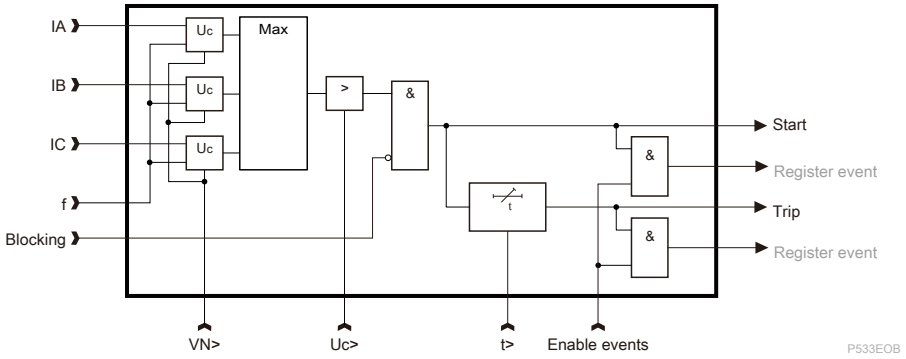
and in per-unit values: Ucp1 = 6006/8000 = 0.75

$$U_c = \frac{X_c}{U_{cLN}} \sum_{n=1}^{15} \frac{I_h}{n}$$ P533EJB

The same calculation is executed for phases B and C. The highest of the three values is compared to the start setting.

Block diagram

Figure 268 - Block diagram of the capacitor overvoltage protection function (ANSI 59C)



Characteristics

Table 93 - Settings and characteristics of the capacitor overvoltage protection Vcap>1

Settings/characteristics (description/label)	Values
Pick-up value/U_c>	
Setting range	0.10...2.50 xU_cLN[93]
Resolution	0.01
Accuracy	±3%
Reset ratio	97% ± 2%
L-N capacitance of one phase/C	
Setting range	1.00...650.00 µF
Resolution	0.01 µF
Rated L-N voltage U_cLN/U_cLN	
Setting range	100...260000 V
Resolution	1 V
Operate delay/t> (DT)	
Setting range	0...30.0 s

93. Phase to ground voltage rating of capacitor

Table 93 - Settings and characteristics of the capacitor overvoltage protection Vcap>1 (Continued)

Settings/characteristics (description/label)	Values
Resolution	0.5 s
Accuracy	< 1.5 s
Characteristic times	
Start time	< 1.5 s
Disengaging time	< 1.5 s
Setting group	
Number	4

Non-directional/directional earth/ground fault overcurrent (ANSI 50N/51N/67N)

Description

The earth/ground fault overcurrent protection function (ANSI code 50N/51N/67N) is used in networks or motors where a selective and sensitive earth/ground fault protection is needed and in applications with varying network structure and length.

The directional earth/ground fault protection is adapted for various network earth/ground systems.

According to the model of the PowerLogic P5 protection relay, the neutral current can be:

- Measured with standard earth/ground fault CT;
- Measured with sensitive earth/ground fault CT;
- Measured with a CSH core balance CT;
- Calculated with the sum of the three phase currents.

The function is sensitive to the fundamental frequency component of the non-directional/directional earth/ground fault overcurrent. When it is used as a directional overcurrent, it is also sensitive to the neutral voltage plus the angle between earth/ground fault current and neutral voltage, and the neutral voltage and the phase angle between them. It is not sensitive to the third harmonic. For directional mode, whenever the magnitude of neutral current IN and neutral voltage VN and the phase angle between IN and VN fulfils the start criteria, the stage starts and issues a start signal. If the fault situation is present longer than the operate delay setting, a trip signal is issued.

All 6 neutral overcurrent stages are also available with transformer differential protection P5T30 as back-up protection. Each stage can be individually linked to the measured neutral current or the calculated sum of the three phase currents of one end. If neutral voltage measurement from one end is available (depending on VT configuration), the stages linked to that end can operate in directional mode, too. Stages linked to the other end can operate in non-directional way only.

Polarisation

The neutral displacement voltage used for polarisation is either directly measured by neutral voltage channel of the PowerLogic P5 protection relay or, alternatively, internally calculated from the three phase voltages depending on the selected voltage measurement mode.

- 3VP, 3VP/VPPy and 3VP/VPy:

  The neutral voltage is calculated from the phase voltages and therefore no separate neutral voltage transformers are needed. The setting values are relative to the VT primary value.

- 3VP+VN, 2VPP+VN, and 2VPP+VN+VPPy:

  The neutral voltage is measured with dedicated voltage transformer for example using a broken delta connection. The setting values are relative to the VN primary value.

- VPP/VPPy

  In this voltage measurement mode, only earth/ground fault overcurrent is available in the eSetup Easergy Pro.

Dynamic setting element

Dynamic mode allows the earth/ground fault overcurrent protection settings dynamically adjusted during the transient period. It can be applied to cooperate

between the Cold Load Pick-up, and also to realize voltage-controlled overcurrent. For more information, refer to Dynamic setting element, page 364.

Selective overcurrent logic

The SOL function have dynamic impacts on the earth/ground fault overcurrent settings of timer and start value. For more information on activating the SOL function, refer to Selective overcurrent logic, page 364.

Inrush blocking

The user can block the overcurrent function by selecting the setting "Inrush blocking" of each stage. The purpose is to make the earth overcurrent function inoperative during the transformer energisation, otherwise a large primary current flow for a transient period will cause an unwanted trip. For more information, refer to Inrush blocking, page 364.

Operating curve selection

The operating curve of the earth/ground fault overcurrent protection can be selected to DT, standard dependent operate delay, and programmable dependent operate delay. When the “Operating Curve” is set to IDMT curve, the settings “DT adder” and “Minimum operate time” will show up. “DT adder” defines the additional time delay plus the IDMT timer. “Minimum operate time” defines the minimum operating time for IDMT curves to help ensure the IDMT stage will not trip faster than the DT stage when the fault current is very large. For more information, refer to Operating curve selection, page 365.

Modes for different network types

The available modes are:

- ResCap

  This feature can be used with compensated networks when the Petersen coil is temporarily switched off. This mode consists of two sub modes, Res and Cap. A digital signal can be used to dynamically switch between these two submodes. When the digital input is active (DI = 1), Cap mode is in use and when the digital input is inactive (DI = 0), Res mode is in use.

  - Res

    The stage is sensitive to the resistive component of the selected IN signal. This mode is used with compensated networks (resonant earthing/grounding) and networks earthed/grounded with a high resistance (resistive earthing/grounding). Compensation is usually done with a Petersen coil between the neutral point of the main transformer and earth/ground. In this context, high resistance means that the maximum earth/ground fault current is limited to a certain value, e.g. to the rated phase current. The trip area is a half plane as drawn in Operation characteristic of the directional earth/ground fault protection in Res or Cap mode, page 401. The base angle is usually set to zero degrees.

  - Cap

    The stage is sensitive to the capacitive component of the selected IN signal. This mode is used with unearthed/ungrounded (isolated) networks. The trip area is a half plane as drawn in Operation characteristic of the directional earth/ground fault protection in Res or Cap mode, page 401. The base angle is usually set to zero degrees.

- Sector

  This mode is used with networks earthed/grounded with a small resistance. In this context, "small" means that a fault current may be more than the rated phase currents. The trip area has a shape of a sector as drawn in Two examples of operation characteristic of the directional earth/ground fault stages in Sector mode, page 401. The angle offset is usually set to zero degrees or slightly on the lagging inductive side (negative angle).

- NoDir

  This mode makes the stage equal to the non-directional stage IN>. The phase angle and VN amplitude setting are discarded. Only the amplitude of the selected IN input matters.

Figure 269 - Operation characteristic of the directional earth/ground fault protection in Res or Cap mode

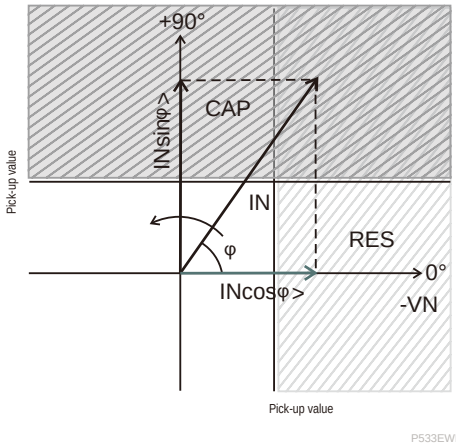
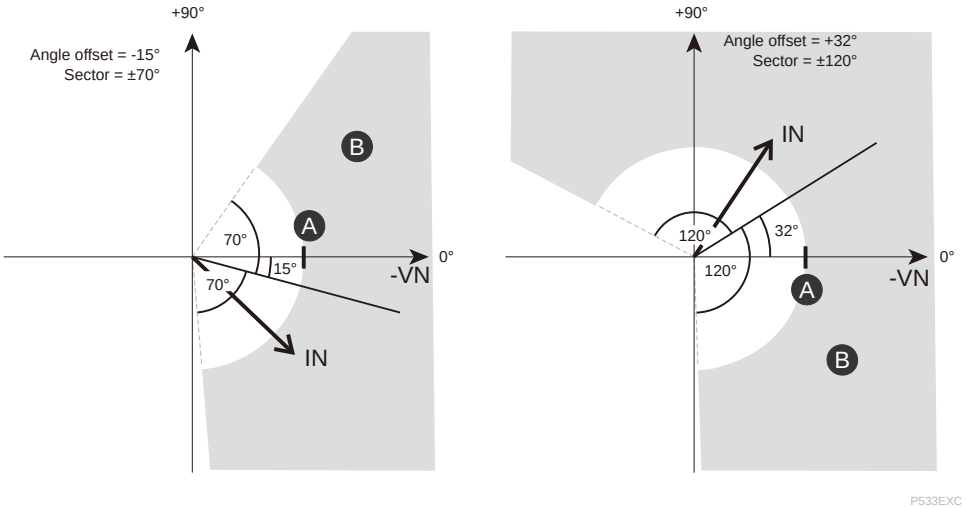


Figure 270 - Two examples of operation characteristic of the directional earth/ground fault stages in Sector mode



A	IN pick-up setting	B	Trip area

The drawn IN phasor in both figures is inside the trip area. The angle offset and half sector size are user's parameters.

Input signal selection

Each stage can be connected to supervise any of the following inputs and signals:

- Input IN measured for all networks other than solidly earthed/grounded.

- Calculated neutral current IN_{calc} for solidly and low-impedance earthed/grounded networks.

Intermittent earth/ground fault detection

Short earth/ground faults make the protection start but do not cause a trip. A short fault means one cycle or more. For transient intermittent earth/ground faults shorter than 1 ms in compensated networks, there is a dedicated protection stage IN.int>. When starting happens frequently, such intermittent faults can be cleared using the intermittent time setting.

When a new start happens within the set intermittent time, the operation delay counter is not cleared between adjacent faults and finally the stage trips.

Faulty phase detection during earth/ground fault

Phase recognition

A neutral voltage displacement has been detected.

A faulted phase or phases are detected in the two-stage system.

1. Use delta principle to detect the faulty phase/phases.
2. Configuration of the faulty phase with neutral current angle comparison to the suspected faulted phase.

For an ideal, grounded network, when there is a forward earth/ground fault in phase A, its current increases, creating a calculated or measured zero sequence current with a phase angle of 0 degrees. If there is a reverse earth/ground fault in phase A, its current decreases creating a calculated or measured zero sequence current with a phase angle of 180 degrees.

When there is a forward earth/ground fault in phase B, its current increases creating a calculated or measured zero sequence current with a phase angle of -120 degrees. If there is a reverse earth/ground fault in phase B, its current decreases creating a calculated or measured zero sequence current with a phase angle of 60 degrees. When there is a forward earth/ground fault in phase C, its current increases creating a calculated or measured zero sequence current with a phase angle of 120 degrees. If there is a reverse earth/ground fault in phase C its current degreases creating a calculated or measured zero sequence current with a phase angle of -60 degrees.

For a compensated network, the stability of the protection depends on the network compensation degree. So for compensated networks, this feature can be turned off to avoid confusion.

For high-impedance earthed/grounded networks, there is a drop-down menu in all setting groups to choose between RES/CAP. RES is the default and it is for earthed/grounded networks. When CAP is chosen, the IN angle is corrected to an inductive direction of 90 degrees.

Possible outcomes and conditions for those detections

- FWD IA

  Phase A increases above the set limit and two other phases remain inside the set (delta) limit. IN current angle is +/- 60 degrees from phase A's phase angle.

- FWD IB

  Phase B increases above the set limit and two other phases remain inside the set (delta) limit. IN current angle is +/- 60 degrees from phase B's phase angle.

- FWD IC

  Phase C increases above the set limit and two other phases remain inside the set (delta) limit. IN current angle is +/- 60 degrees from phase C's phase angle.

- FWD IA - IB

  Phase A and B increase above the set limit and phase C remains inside the set (delta) limit. IN current angle is between phase A's and phase B's phase angles.

- FWD IB - IC

  Phase B and C increase above the set limit and phase A remains inside the set (delta) limit. IN current angle is between phase B's and phase C's phase angles.

- FWD IC - IA

  Phase C and A increase above the set limit and phase B remains inside the set (delta) limit. IN current angle is between phase C's and phase A's phase angles.

- FWD IA - IB - IC

  All three phase currents increase above the set delta limit.

- REV 1 (any one phase)

  One phase decreases below the set delta limit and other two phases remain inside the delta limit.

- REV 2 (any two phases)

  Two phases decrease below the set delta limit and third phase remains inside the delta limit.

- REV 3 (all three phases)

  All three phase currents decrease below the set delta limit.

Different simulated fault scenarios

Figure 271 - Phase A forward

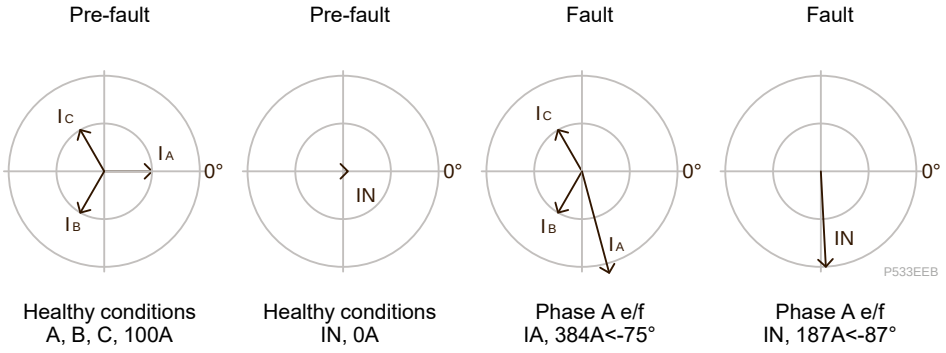


Figure 272 - Phase B forward

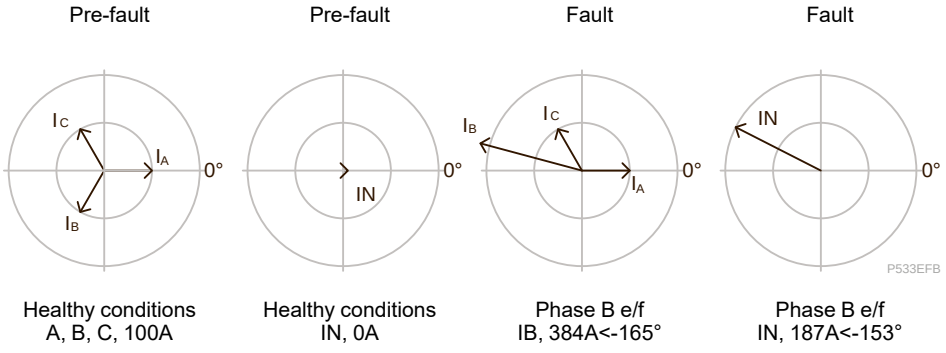
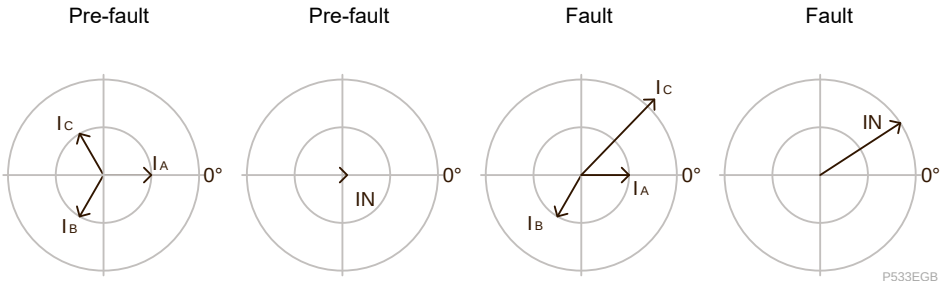


Figure 273 - Phase C forward



Fault recording

When a faulty phase is recognised, it is recorded in the earth/ground fault current protection fault log (also in the event list and alarm screen). This faulted phase and direction recording function have a tick box in eSetup Easergy Pro for enabling/disabling in the protection stage settings.

Six independent stages

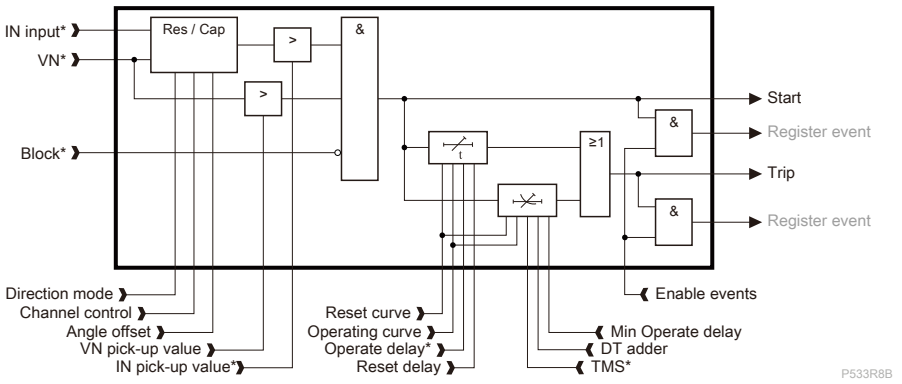
There are six separately adjustable stages: IN>1, IN>2, IN>3, IN>4, IN>5 and IN>6.

All the stages can be configured for definite operation time (DT) or dependent operation time.

NOTE: The PowerLogic P5 protection relay shows a scalable graph of the configured delay on the local panel display.

Block diagram

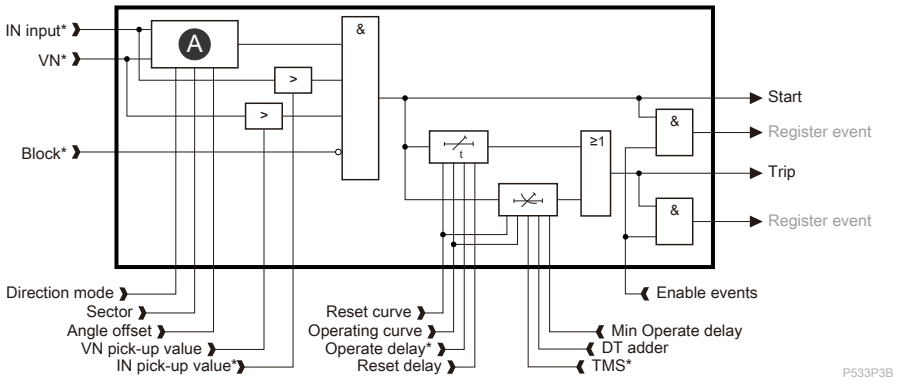
Figure 274 - Block diagram of the non-directional/directional earth/ground fault overcurrent protection function operating in ResCap mode (ANSI 50N/51N/67N)



NOTE:

- The **IN input** can be *IN.calc, IN.meas, IN.sens* based on the configuration.
- The **VN** can be directly measured from an open delta VT or calculated from three phase VTs.
- **Block** input can be signals configured via Block Matrix, due to inrush condition detected, or blocked under the VTS condition based on the configuration and operating condition.
- **IN pick-up value** is either the setting **IN pick-up value** or the **Dynamic threshold** depending on the configuration and operating condition.
- **Operate delay** is either the setting **Operate delay**, the **SOL operate delay** or the **Dynamic operate delay** setting depending on the configuration and operating condition.
- **TMS** value is either the setting **TMS**, the **SOL TMS** or the **Dynamic TMS** setting depending on the configuration and operating condition.
- **Res / Cap**: when working as Res mode, the operate characteristic follows the equation: IN* cos (Angle (IN) - Angle(-VN) - Angle offset) > IN pick-up value. when working as Cap mode, the operate characteristic follows the equation: IN* sin (Angle (IN) - Angle(-VN) - Angle offset) > IN pick-up value.

Figure 275 - Block diagram of the non-directional/directional earth/ground fault overcurrent protection function operating in Sector mode (ANSI 50N/51N/67N)

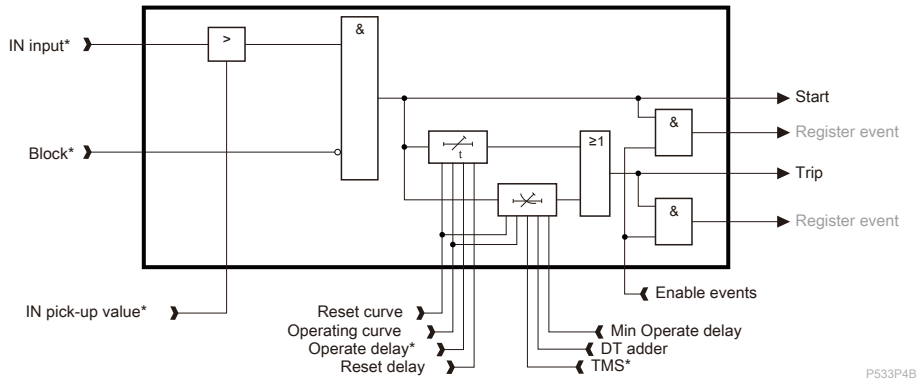


A Directional check
The operate characteristic should follow the equation: | Angle (IN) - Angle(-VN) - Angle offset | < Sector

NOTE:

- The **IN input** can be *IN.calc, IN.meas, IN.sens* based on the configuration.
- **Block** input can be signals configured via Block Matrix, due to inrush condition detected, or blocked under the VTS condition based on the configuration and operating condition.
- **IN pick-up value** is either the setting **IN pick-up value** or the **Dynamic threshold** depending on the configuration and operating condition.
- **Operate delay** is either the setting **Operate delay**, the **SOL operate delay** or the **Dynamic operate delay** setting depending on the configuration and operating condition.
- **TMS** value is either the setting **TMS**, the **SOL TMS** or the **Dynamic TMS** setting depending on the configuration and operating condition.

Figure 276 - Block diagram of the non-directional/directional earth/ground fault overcurrent protection function operating in Non-dir mode (ANSI 50N/51N/67N)



NOTE:

- The **IN input** can be *IN.calc, IN.meas, IN.sens* based on the configuration.
- **Block** input can be signals configured via Block Matrix, due to inrush condition detected, or blocked under the VTS condition based on the configuration and operating condition.
- **IN pick-up value** is either the setting **IN pick-up value** or the **Dynamic threshold** depending on the configuration and operating condition.
- **Operate delay** is either the setting **Operate delay**, the **SOL operate delay** or the **Dynamic operate delay** setting depending on the configuration and operating condition.
- **TMS** value is either the setting **TMS**, the **SOL TMS** or the **Dynamic TMS** setting depending on the configuration and operating condition.

Restricted earth-fault with external connection (high-impedance)

The high impedance protection principle can be applied as differential protection for machines, power transformers and busbar installations. It is offering stability for any type of fault occurring outside the protected zone and satisfactory operation speed for faults within the zone. The PowerLogic P5 protection relays can realize this application. Both the standard neutral overcurrent element and the very sensitive neutral overcurrent element can be used for high-impedance restricted earth fault (REF) protection. The information about application, setting examples and recommendations for resistors can be found in the Application Book.

Characteristics

Table 94 - Setting and characteristics of the non-directional/directional earth/ground fault overcurrent protection function (ANSI 50N/51N/67N)

Setting/characteristics (description/label)	Values
IN Pick-up value/IN>	
Setting range	For delay type DT: 0.020...20.000 pu[94] for IN measured with standard EF CT; 0.020...20.000 pu[94] for IN measured with standard EF CT(for CSH30 use); 0.050...20.000 pu[94] for IN measured with CSH; 0.050...40.000 pu[94] for IN calculated;

94. Inom for IN.calc; IN.nom for IN.meas; IN.sens.nom for IN.sens.meas; IN.CSH.nom for IN.CSH

Table 94 - Setting and characteristics of the non-directional/directional earth/ground fault overcurrent protection function (ANSI 50N/51N/67N) (Continued)

Setting/characteristics (description/label)	Values
	0.002...1.000 pu[95] for IN measured with sensitive EF CT. For delay type IDMT: 0.020...5.000 pu[95] for IN measured with standard EF CT; 0.020...5.000 pu[95] for IN measured with standard EF CT (for CSH30 use); 0.050...5.000 pu[95] for IN measured with CSH; 0.050...5.000 pu[95] for IN calculated; 0.002...1.000 pu[95] for IN measured with sensitive EF CT.
Resolution	0.001 pu[95]
Accuracy	±2% or ±0.002 pu[95] for IN measured with standard EF CT; ±2% or ±0.002 pu[95] for IN measured with standard EF CT (for CSH30 use); ±2% or ±0.005 pu[95] for IN measured with CSH; ±2% or ±0.005 pu[95] for IN calculated; ±2% or ±0.0005 pu[95] for IN.sens measured with sensitive EF CT.
Reset ratio	95% ±2% or ±2mA
Transient overreach	< 5% for X/R up to 120
EFCT input selection[96]	
Setting range	EFCT-1, EFCT-2
VN Pick-up value/	
Setting range	0.01...1.00 pu[97]
Resolution	0.01 pu[97]
IN input/Input	
Options	IN.calc, IN, IN.sens, IN.CSH
VN input mode	
Options	Measured, Calculated
Operating Curve	
Options	DT; IEC: SI, VI, EI, LTI, UTI; IEEE: MI, VI, EI ANSI: NI, STI, LTI Others: UK_Rectifier, FR_STI, RI, STI_CO2, LTI_CO5, MI_CO7, NI_CO8, VI_CO9, EI_CO11, BPN Prg1-3
Accuracy	±5% or ±20 ms
Operate delay/Operate delay	
Setting range	0.00...300.00 s
Resolution	0.01
Accuracy	±1% or ±10 ms
TMS/TMS	
Setting range	0.020...20.000
Resolution	0.001
DT adder/DT adder	
Setting range	0.00...1.00 s
Resolution	0.01 s
Minimum operate delay/Min operate delay	

95. Inom for IN.calc; IN.nom for IN.meas; IN.sens.nom for IN.sens.meas; IN.CSH.nom for IN.CSH
96. Available for P5T30 only.
97. √3 x Vnom

Table 94 - Setting and characteristics of the non-directional/directional earth/ground fault overcurrent protection function (ANSI 50N/51N/67N) (Continued)

Setting/characteristics (description/label)	Values
Setting range	0.00...10.00 s
Resolution	0.01 s
Direction mode/Direction mode	
Options	ResCap, Sector, Non_Dir
Char ctrl. in ResCap mode/ChCtrl	
Options	Res, Cap, DI, VI
Angle offset/Offset	
Setting range	-180°...+179°
Resolution	1°
Accuracy	±2°
Reset ratio (angle)	2°
Pick up sector size	
Sector size	10°...170°
VTS blocking	
Options	Blocked, Non-directional
Reset curve/Reset curve	
Options	DT; IDMT; Prg1-3
Reset delay/Reset delay	
Setting range	0.00...100.00 s
Resolution	0.01 s
Accuracy	±1% or ±30 ms
SOL use by INDir>	
Options	Off; SOL1; SOL2
SOL operate delay/SOL operate delay	
Setting range	0.00...300.0 s
Resolution	0.1s
Accuracy	±1% or ±10 ms
SOL TMS/SOL TMS	
Setting range	0.020...20.000
Resolution	0.001
Dynamic mode/Dynamic mode	
Options	Off/On
Dynamic threshold/Dyn pick-up value	
Setting range	For delay type DT: 0.020...20.000 pu[98] measured with standard EF CT; 0.020...20.000 pu[98] measured with standard EF CT (for CSH30 use); 0.050...20.000 pu[98] measured with CSH; 0.050...40.000 pu[98] calculated; 0.002...10.000 pu[98] for IN measured with sensitive EF CT. For delay type IDMT: 0.020...5.000 pu[98] for IN measured with standard EF CT;

98. Inom for IN.calc; IN.nom for IN.meas; IN.sens.nom for IN.sens.meas; IN.CSH.nom for IN.CSH

Table 94 - Setting and characteristics of the non-directional/directional earth/ground fault overcurrent protection function (ANSI 50N/51N/67N) (Continued)

Setting/characteristics (description/label)	Values
	0.020...5.000 pu[99] for IN measured with standard EF CT (for CSH30 use); 0.020...5.000 pu[99] for IN measured with CSH; 0.050...5.000 pu[99] for IN calculated; 0.002...1.000 pu[99] for IN measured with sensitive EF CT.
Resolution	0.001 pu[99]
Accuracy	±2% or ±0.002 pu[99] for IN measured with standard EF CT; ±2% or ±0.002 pu[99] for IN measured with standard EF CT (for CSH30 use); ±2% or ±0.005 pu[99] for IN measured with CSH; ±2% or ±0.005 pu[99] for IN calculated; ±2% or ±0.0005 pu[99] for IN.sens measured with sensitive EF CT.
Dynamic operate delay/Dynamic op delay	
Setting range	0.00...300.00 s
Resolution	0.01 s
Accuracy	±1% or ±10 ms
Dynamic TMS/Dynamic TMS	
Setting range	0.020...20.000
Resolution	0.001
Characteristic times	
Start time	< 30 ms (25 ms with high speed) for currents at 2 x Is pick-up value (non-directional) < 40 ms (35 ms with high speed) for currents at 1,2 x Is pick-up value (non-directional)
	< 45 ms (40 ms with high speed) for currents at 2 x Is pick-up value (directional) < 50 ms (45 ms with high speed) for currents at 1,2 x Is pick-up value (directional)
Disengaging time	< 65 ms (80 ms, only for high speed high break digital outputs)
Overshoot time	< 30 ms for currents at 2 x Is
Setting group	
Number	4

NOTE: The timer accuracy is only for the pure timer accuracy, not including the start time.

99. Inom for IN.calc; IN.nom for IN.meas; IN.sens.nom for IN.sens.meas; IN.CSH.nom for IN.CSH

Restricted earth fault protection (ANSI 64REF)

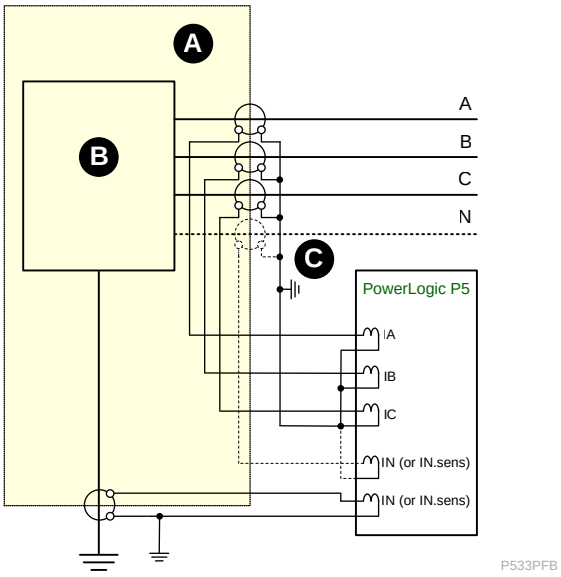
Description

Earth faults occurring on a transformer winding or terminal may be of limited magnitude, either due to the impedance present in the earth path or by the percentage of transformer winding that is involved in the fault. It is common to apply standby earth fault protection fed from a single CT in the transformer earth connection, this provides time-delayed protection for a transformer winding or terminal fault. In general, particularly as the size of the transformer increases, it becomes unacceptable to rely on time-delayed protection to clear winding or terminal faults as this would lead to an increased amount of damage to the transformer. A common requirement is therefore to provide instantaneous phase and earth fault protection. Applying differential protection across the transformer may fulfill these requirements. However, an earth fault occurring on the LV winding, particularly if it is of a limited level, may not be detected by the differential relay, as it is only measuring the corresponding HV current. Therefore, instantaneous protection that is restricted to operating for transformer earth faults only is applied. This is referred to as Restricted Earth Fault (REF) protection.

When applying differential protection such as REF, some suitable means must be employed to give the protection stability under external fault conditions, thus ensuring that relay operation occurs for faults inside the protected zone only. For this, two methods are commonly used:

- The low impedance REF (biased REF) technique operates by measuring the level of current flowing through the protected object (through phase, neutral and ground connections) and altering the relay sensitivity according to the level of currents. The dedicated 64REF protection function is such a biased differential function.
- The high impedance REF technique ensures that the relay circuit is of sufficiently high impedance such that the differential voltage that may occur under external fault conditions is less than that required to drive set current through the relay. Such protection scheme can be set up with P5 neutral overcurrent elements, as detailed in related application note.

Figure 277 - Basic biased REF scheme



A Zone of protection B Protected object C Optional (5CT application)

The Restricted Earth Fault (REF) protection principle has several advantages. It is very selective because the protection zone is limited between the current transformers that are used for the Restricted Earth Fault (REF) protection. Because of its selectivity, the Restricted Earth Fault (REF) protection requires no

additional time delay for protection coordination. Therefore, the Restricted Earth Fault (REF) protection is especially suitable for the protection of transformers and rotating machines against internal ground faults. Because of the differential protection principle, it is also very sensitive which makes it suitable for detecting faults located near the neutral point of transformers and rotating machines.

The low-impedance Restricted Earth Fault (REF) protection function is sensitive to the fundamental frequency component of the measured currents.

With transformer differential protection P5T30 two REF elements are available with a fix link to the measured currents of one end (REF-1 to end 1, REF-2 to end 2).

Wording

REF is also referred to as Balanced Earth Fault (BEF) Protection, where this terminology is usually used when the protection is applied to a delta winding. Also in some areas the use of "Ground" instead of "Earth" is preferred.

5CT Application

For protection of 4 wire systems (including the dashed connections in Basic biased REF scheme, page 410) the "5CT application" feature in REF has to be enabled. In all other REF applications this feature shall remain disabled.

This feature is not available with P5T30.

CT polarity

Low impedance Restricted Earth Fault (REF) protection function measures phase and neutral currents, as sketched in Basic biased REF scheme, page 410. When calculating differential and bias currents, the sign of the measured currents must be considered. Accordingly, settings are provided to adjust actual wiring to the function needs. These settings can be found in the **GENERAL** menu/**Scaling** sub-menu.

- Phase CT polarity: Standard/Opposite
- IN CT polarity: Standard/Opposite
- IN.sens CT polarity: Standard/Opposite

  Standard polarity is given with CT star point outside the zone of protection.

  NOTE: Configuration of the polarity of both neutral current CTs is only required in case of “5CT application”. In 4 CT applications, just polarity of that neutral CT must be set which is selected as IG input.

Amplitude matching

Neutral CTs can have smaller current ratio than phase CTs, reflecting different expected fault currents for phase and ground faults as a result from power system grounding impedances. In order to calculate correct differential and bias currents, such differences in CT ratio must be considered.

For this purpose, Restricted Earth Fault (REF) protection function automatically scales all currents to a common reference, which is the phase CT primary current. This scaling uses matching factors which are calculated from the ratio of the neutral and phase CTs.

- Standard earth fault current amplitude matching factor:

  IN CT scaling factor = Neutral CT ratio / Phase CT ratio

- Sensitive earth fault current amplitude matching factor:

  IN.sens scaling CT factor = Sensitive neutral CT ratio / Phase CT ratio

  Where:

  - Phase CT ratio = IP CT primary / IP CT secondary
  - Neutral CT ratio = IN CT primary / IN CT secondary
  - Sensitive neutral CT ratio = IN.sens CT prim. / IN.sens CT sec.

Permissible ranges of the matching factors are within 0.1 and 32. If this condition is not satisfied, the low impedance Restricted Earth Fault (REF) protection will be blocked.

Example: Phase CT ratio is 1000A: 1A; Neutral CT ratio is 500A: 5A; Then reference current is 1000A = phase CT primary nominal current and IN scaling factor is 500:5 / 1000:1 = 0.1.

Measurements

Protection function calculates differential and bias currents. The continuously updated values of these measurements are displayed on device HMI and are available for communication both to local operating tool as well as to remote SCADA systems for monitoring during normal operation or check during commissioning.

The differential current is always calculated as vectorial sum of all currents, for example:

- In 4 CT application: Id = | IA + IB + IC + I'G |
- In 5 CT application: Id = | IA + IB + IC + I'G + I'N |

Where:

- IA, IB, IC are the phase currents.
- I'G is the amplitude matched current flowing through the star point to ground (measured through standard or sensitive neutral CT acc. to selected IG input).
- I'N is the amplitude matched current from the neutral wire CT in "5CT application" (measured through remaining neutral CT, not set as IG input).

The bias current calculation depends on selected operating mode.

Operating modes

There are two operating modes selectable:

- Sum(IP) bias = Biased by sum of phase currents
- Max(IP) bias = Biased by maximum phase current

The difference between both is the definition of the restraining current and their tripping characteristic.

Biased by sum of phase currents

In this operating mode, bias current is calculated as follows:

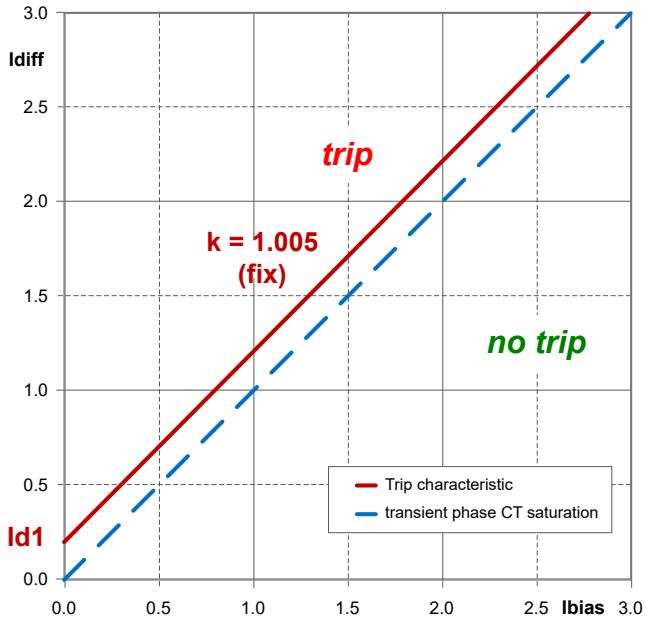
- In 4 CT application: Ib = | IA + IB + IC | = | Σ(IP) |
- In 5 CT application: Ib = | IA + IB + IC |

Where:

- IA, IB, IC are the phase currents.

The related differential characteristic is shown in REF tripping characteristic in operating mode "Sum(IP) bias", page 413 as the solid red line.

Figure 278 - REF tripping characteristic in operating mode "Sum(IP) bias"



The characteristic has a fixed slope of 1.005, beginning at the "Low set Id1". The characteristics equation is: Id = Id1 + 1.005 x Ib.

The dashed blue line indicates the values of apparent differential and bias currents (Id, Ib) in case of transient saturation of a phase CT during an external phase fault. As per definition above for calculating differential and bias currents, this characteristic is always below the tripping characteristic, hence in stable region.

The slope provides slight increase of stability margin (slight increase of required differential current for tripping) with increasing sum of phase currents.

> **NOTE:** Low impedance REF biased by sum of phase currents is only applicable where the protected object (e.g. transformer winding) has a neutral point earthing which is fitted with a CT, because it needs measured ground current to operate. So this mode cannot be applied for balanced earth fault protection or delta windings. Its main advantage is an inherent stability against transient phase CT saturation.

Biased by maximum phase current

In this operating mode, bias current is calculated as follows:

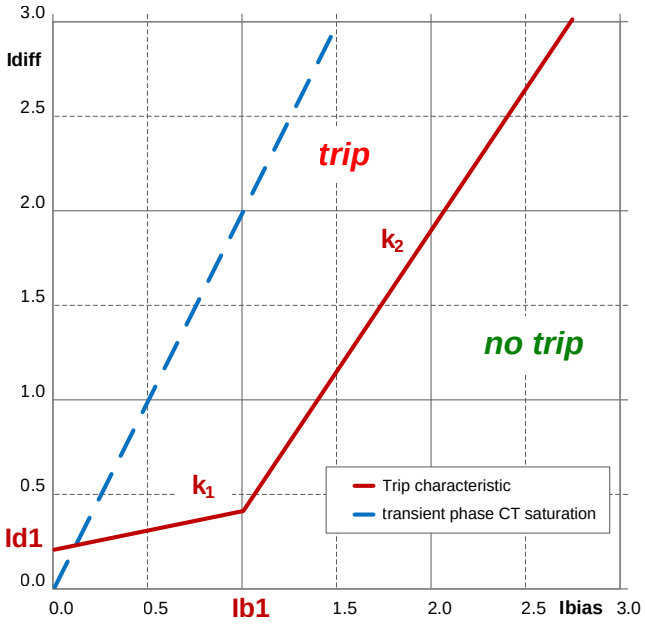
- In 4 CT application: Ib = 0.5 x (Max{| IA |, | IB |, | IC | } + | I'G |)
- In 5 CT application: Ib = 0.5 x (Max{| IA |, | IB |, | IC | } + | I'N |+ | I'G |)

Where:

- IA, IB, IC are the phase currents.
- I'G is the amplitude matched current flowing through the star point to ground (measured through standard or sensitive neutral CT acc. to selected "IG input").
- I'N is the amplitude matched current from the neutral wire CT in "5CT application" (measured through standard or sensitive neutral CT not selected as "IG input").

A dual slope characteristic is required with this operating mode, as shown in REF Tripping characteristic in operating mode "Max(IP) bias", page 414 as solid red line.

Figure 279 - REF Tripping characteristic in operating mode "Max(IP) bias"



Also this characteristic starts at "Low set Id1", has a first section with "slope k1" for bias currents up to "Bias current Ib1" setting and then a second section with higher "slope k2" for increased stability at high bias current levels.

The characteristics equations for the two ranges are:

- For Ib ≤ Ib1: Id = Id1 + k1 x Ib
- For Ib > Ib1: Id = Id1 + k1 x Ib + (k2 - k1) x (Ib – Ib1)

The dashed blue line in the figure indicates the values of apparent differential and bias currents (Id, Ib) in case of transient saturation of a phase CT (or likewise a single phase current infeed test).

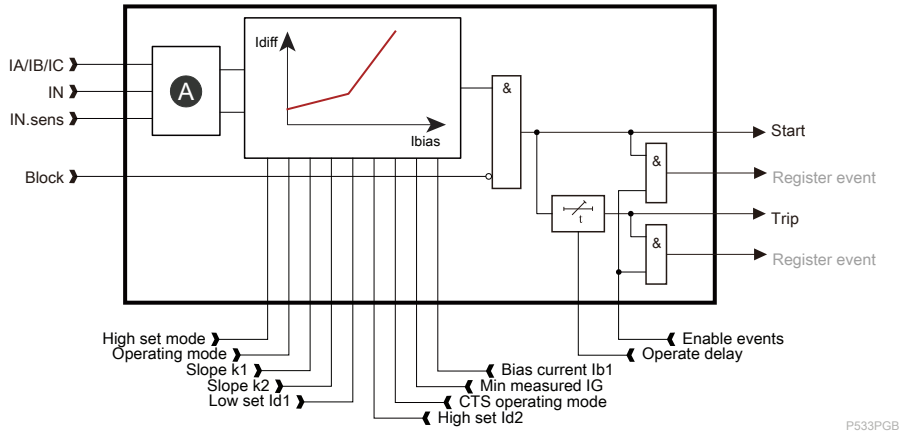
In order to reduce the risk of false tripping caused from phase CT saturation only, this operating mode is accomplished with a check for minimum ground current. A trip is released only if the measured current exceeds the set threshold “Min measured IG”.

NOTE:

- It is recommended that this threshold is set below Id1, otherwise it introduces a further restriction in the tripping characteristic. If this constraint is intentionally not required, it could be disabled by setting the threshold to 0 pu.
- This mode has the advantage of being universally applicable to all kinds of protected objects with or without neutral point earthing, i.e. including balanced earth fault protection for unearthed star or delta windings. Unless minimum star point current constraint is set up, this bias definition also allows the user to apply tripping test simply by shorting a phase current (for simulation of neutral current) without the need of current injection equipment.

Block diagram

Figure 280 - Low impedance REF function structure overview



A REF calculation

High-set unrestrained differential operation

Within low impedance REF protection function an unrestrained operation can be enabled by selecting "High set mode". If this feature is enabled and the differential current exceeds the “High set Id2”, REF will trip regardless the actual bias current.

Current Transformer Supervision (CTS)

REF operation in presence of a CTS alarm is settable as follows:

- Indication: CTS alarm has no impact on REF operation. It is an indication only.
- Blocking: REF is blocked while the CTS alarm is present, to avoid any maloperation.
- Restraining: REF trip characteristic is shifted vertically while the CTS alarm is present, by activating the dedicated setting "CTS low set Id1" instead of normal "Low set Id1". That way bias is increased, yet REF remains operational for faults with high current level.

Characteristics

Table 95 - Settings and characteristics of the low impedance restricted earth fault protection function (ANSI 64REF)

Settings/characteristics (description/label)	Values
IG input/IG input	
Option	IN.meas/IN.sens
5 CT application/5 CT application	
Option	Enable/Disable
Phase CT polarity/Phase CT polarity[100]	
Option	Standard/Opposite
Neutral CT polarity/Neutral CT polarity[100]	
Option	Standard/Opposite
Sensitive neutral CT polarity/Sensitive neutral CT polarity[100]	
Option	Standard/Opposite
Operating mode/Operating mode	
Option	Sum(IP) bias/Max(IP) bias
Low set Id1/Low set Id1	
Setting range	0.10...1.00 pu[101]
Resolution	0.01 pu[101]
Min measured IG/Min measured IG	
Setting range	0.00...1.00 pu[101]
Resolution	0.01 pu[101]
Slope k1/Slope k1	
Setting range	0...100%
Resolution	1%
Slope k2/Slope k2	
Setting range	10...200%
Resolution	1%
Bias current Ib1/Bias current Ib1	
Setting range	0.10...1.50 pu[101]
Resolution	0.01 pu[101]
High set mode/High set mode	
Option	Enable/Disable
High set Id2/High set Id2	
Setting range	2.00...30.00 pu[101]
Resolution	0.01 pu[101]
Operate delay/Operate delay	
Setting range	0.00...1.00 s
Resolution	0.01 s
CTS operating mode/CTS operating mode	
Option	Indication/Blocking/Restraining

100. These settings can be found in the GENERAL menu/Scaling sub-menu.
101. Inom

Table 95 - Settings and characteristics of the low impedance restricted earth fault protection function (ANSI 64REF) (Continued)

Settings/characteristics (description/label)	Values
CTS low set Id1/CTS low set Id1	
Setting range	0.00...1.00 pu[102]
Resolution	0.01 pu[102]
Phase current input selection[103]	
Stage 1	Fixed to CT-1
Stage 2	Fixed to CT-2
Inhibit REF/Inhibit REF	
Option	DI/VI/Function key
Characteristic times	
Start time	< 40 ms (35 ms with high speed) for currents at 2 x pick-up value
Setting group	
Number	4

102. Inom
103. Available for P5T30 only.

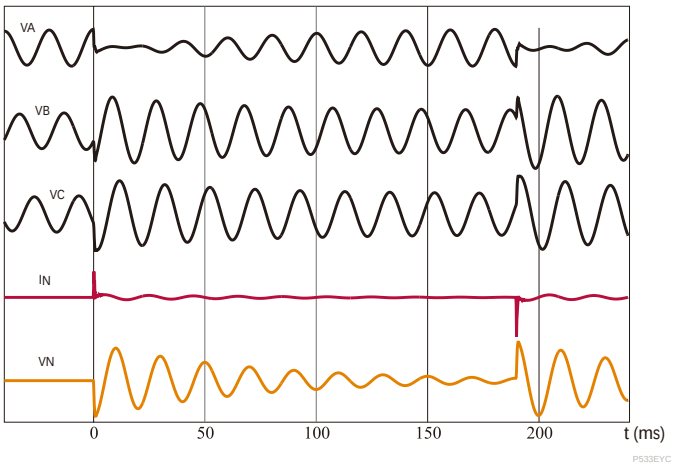
Transient intermittent earth/ground fault (ANSI 67NI)

Description

The directional transient intermittent earth/ground fault protection function (ANSI code 67NI) is used to detect short transient intermittent faults in compensated cable networks. The transient faults are self-extinguished at the zero crossing of the transient part of the fault current I_{Fault} and the fault duration is typically just 0.1 - 1 ms. Such short intermittent faults cannot be correctly recognised by conventional directional earth/ground fault function using the fundamental frequency components of IN and VN only.

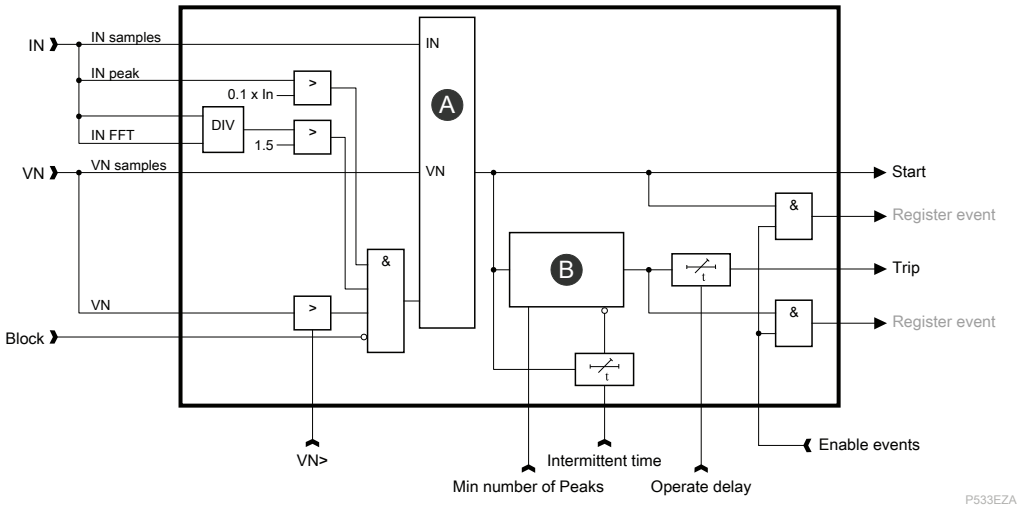
Although a single transient fault usually self extinguishes within less than 1 ms, in most cases a new fault happens when the line to neutral voltage of the faulty phase has recovered.

Figure 281 - Typical line to neutral voltages, earth/ground fault current of the faulty feeder and the neutral displacement voltage during two transient earth/ground faults in phase A (the network is compensated)



Block diagram

Figure 282 - Block diagram of the directional transient intermittent earth/ground fault stage IN.int>



A	Transient algorithm	B	Counter

Operation

Direction calculation

The function is sensitive to the instantaneous sampled values of the earth/ground fault overcurrent and neutral voltage displacement voltage. The sample of the neutral voltage can be from a direct VN measurement with a voltage transformer, or can be calculated from the three phase voltages.

NOTE: Connect the VN signal according to the connection diagram to achieve correct polarisation.

Co-ordination with the conventional directional earth/ground fault protection based on fundamental frequency signals

The transient intermittent earth/ground fault current stage IN.int> should always be used together with the conventional directional earth/ground fault overcurrent protection stages IN>1, IN>2. The transient stage IN.int> may in worst case detect the start of a steady earth/ground fault in wrong direction but does not trip because the peak value of a steady state sine wave IN signal must also exceed the corresponding base frequency component's peak value to allow IN.int> to trip. The operate time of the transient stage IN.int> should be lower than the settings of any directional earth/ground fault overcurrent stage to avoid any unnecessary trip from the IN>1 and IN>2 stages .The start signal of the IN.int> stage can be also used to block IN>1, IN>2 stages of all parallel feeders.

Auto reclosing

The start signal of any IN>1 stage initiating auto reclosing (AR) can be used to block the IN.int> stage to avoid the IN.int> stage with a long intermittent setting to interfere with the AR cycle.

Usually the IN.int> stage itself is not used to initiate any AR. For transient faults, the AR does not help because the fault phenomena itself already includes a repetitive unsuccessful self-extinguishing.

Operate time, peak amount counter and intermittent time coordination

The protection function has three independently settable parameters: operation delay, required number of peaks and intermittent time. All characteristics need to be satisfied before the stage issues a trip signal. There is also a settable reset delay so that the stage does not release before the circuit breaker has operated. If, for example, the number of peaks is set to 2, the operation delay is set to 160 ms and the intermittent time to 200 ms, then the function starts the operation delay from the first peak. If the second peak occurs after 80 ms, the peak amount criteria is satisfied. After 160 ms the delay time elapses, all operate criteria are satisfied and the stage trips.

If the second peak does not occur before the operational delay elapses, the stage is released after the intermittent time has elapsed. But if the second peak occurs after the operate time has elapsed but still within the intermittent time, then a trip is issued instantly.

If the intermittent time elapses before the operation delay elapses, the stage is reset.

There are a couple of limitations to avoid completely incorrect settings. Peaks cannot occur more often than twice per period, so there are about 10 ms in between (at 50 Hz nominal frequency). Therefore if the peak amount is set to 10, then the operation delay setting does not accept a value smaller than 100 ms. Vice versa, if the operation delay is set to 40 ms, then it is not possible to set a peak amount greater than 4. This prohibits settings that can be never satisfied.

Figure 283 - Peak amount condition is satisfied and operate time elapses within intermittent time setting. Stage issues a trip.

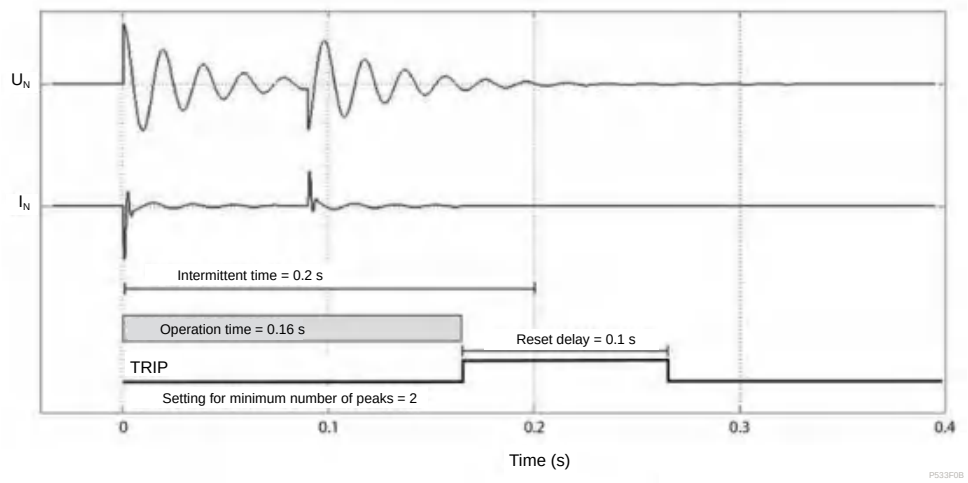


Figure 284 - Peak amount condition is not satisfied when operation delay elapses but last required peak occurs during intermittent time. Stage then issues instant trip.

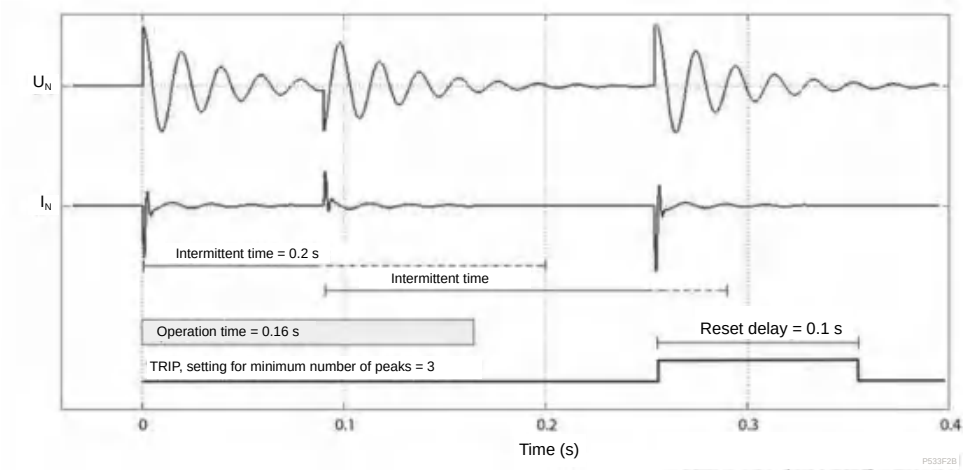
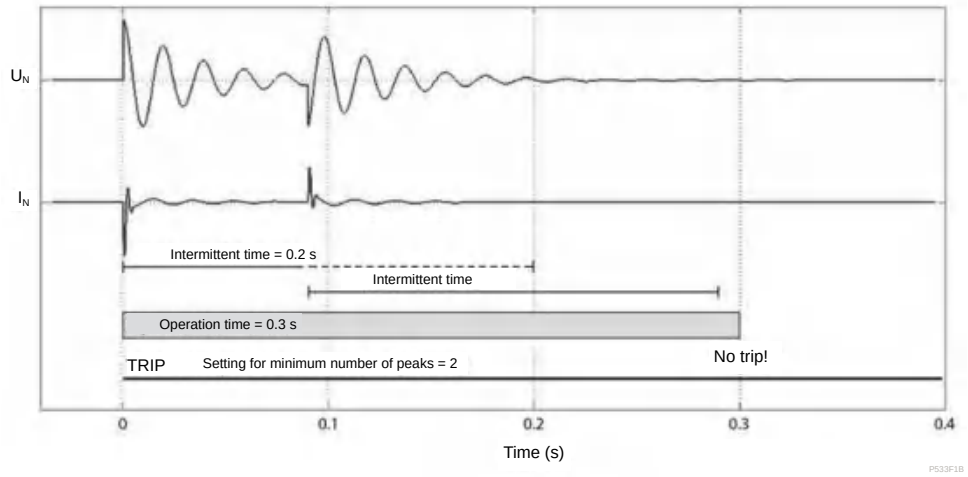


Figure 285 - Peak amount condition is satisfied but intermittent time elapses before operate time. Stage is reset.



Characteristics

Table 96 - Settings and characteristics of the transient intermittent earth/ ground fault protection stage IN.int>

Settings/characteristics (description/label)	Values
IN input	
Options	IN peak, IN.CSH peak , IN.sens peak
Direction mode/Mode	
Options	Forward; Reverse
IN peak value/INPeak	
Value	0.1 pu[104] (fixed)
VN Pick-up/VN>	
Setting range	0.01...0.60 pu[105]
Resolution	1% pu[105]
Accuracy	±3%
Reset ratio	97% ± 2%
Min number of peaks/MinPeaks	
Setting range	1...20
Resolution	1
Operate delay/t>	
Setting range	0.00...300.00 s
Resolution	0.02 s
Accuracy	±1% or ±20 ms
Reset delay/Rst delay	
Setting range	0.06...300.00 s
Resolution	0.01 s
Intermittent time/Intmt time[106]	
Setting range	0.01...300.00 s
Resolution	0.01 s
Characteristic times	
Start time	< 50 ms (45 ms with high speed) maximum
Disengaging time	< 65 ms
Setting group	
Number	4

104. Inom for IN.calc; IN.nom for IN.meas; IN.sens.nom for IN.sens.meas; IN.CSH.nom for IN.CSH
105. √3 x VT primary nominal (PN)
106. Common setting for setting group 1, 2, 3, 4.

5th harmonic (H5) detection (ANSI 68H5)

Description

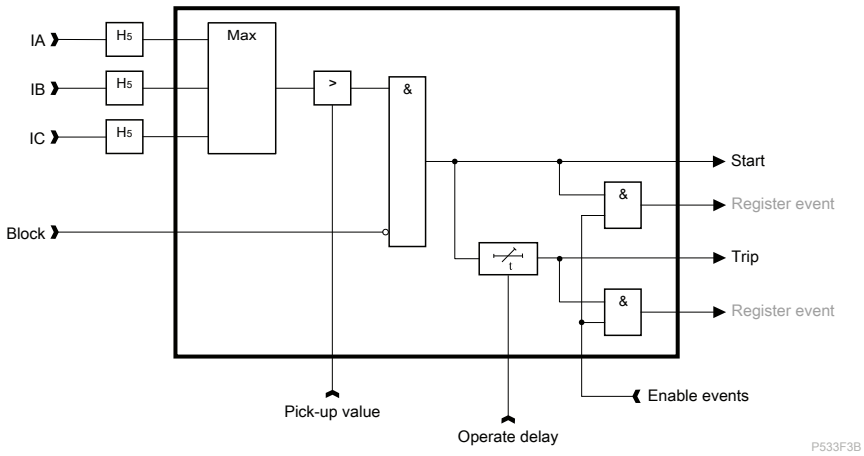
Overexciting a transformer creates odd harmonics. The fifth harmonic component can be used to detect overexcitation. This stage can also be used to block some other function stages.

The ratio between the fifth harmonic component and the fundamental frequency component is measured on all the phase currents. When the ratio in any phase exceeds the setting value, the stage activates a start signal. After a settable delay, the stage operates and activates a trip signal.

It is recommended to set the trip delay to longer than 60 ms, to block properly the protection stages.

Block diagram

Figure 286 - Block diagram of the 5th harmonic detection stage Ih5>



Characteristics

Table 97 - Setting and characteristics of the 5th harmonic detection stage Ih5>

Setting/characteristics (description/label)	Values
Pick-up value/Pick-up value	
Setting range	10%...100%
Resolution	1%
Accuracy	±1% or ±0.005 Inom
Reset ratio	97% ± 1%
Operate delay/Operate delay	
Setting range	0.03...300.00 s
Resolution	0.01 s
Accuracy	±1% or 30 ms
Characteristic times	
Start time	< 55 ms (50 ms with high speed)
Disengaging time	< 70 ms (85 ms with high speed)

Table 97 - Setting and characteristics of the 5th harmonic detection stage Ih5> (Continued)

Setting/characteristics (description/label)	Values
Setting group	
Number	1

Auto-recloser function (ANSI 79)

Description

The auto-recloser (AR) function (ANSI code 79) can be used in feeder protection relays to help protect an overhead line.

The function uses the object control function to control the CB open/close sequence. All other object control methods are in simultaneous use, including object failure monitoring. If the circuit breaker (CB) control fails or another function controls the CB, the AR sequence stops.

Purpose

Typically protection functions detect the fault and trigger the AR function. After tripping the circuit breaker, the AR function can reclose the CB. Normally, the first reclose (or shot) is so short in time that users cannot notice anything. However, the fault is cleared and the feeder will continue in normal service.

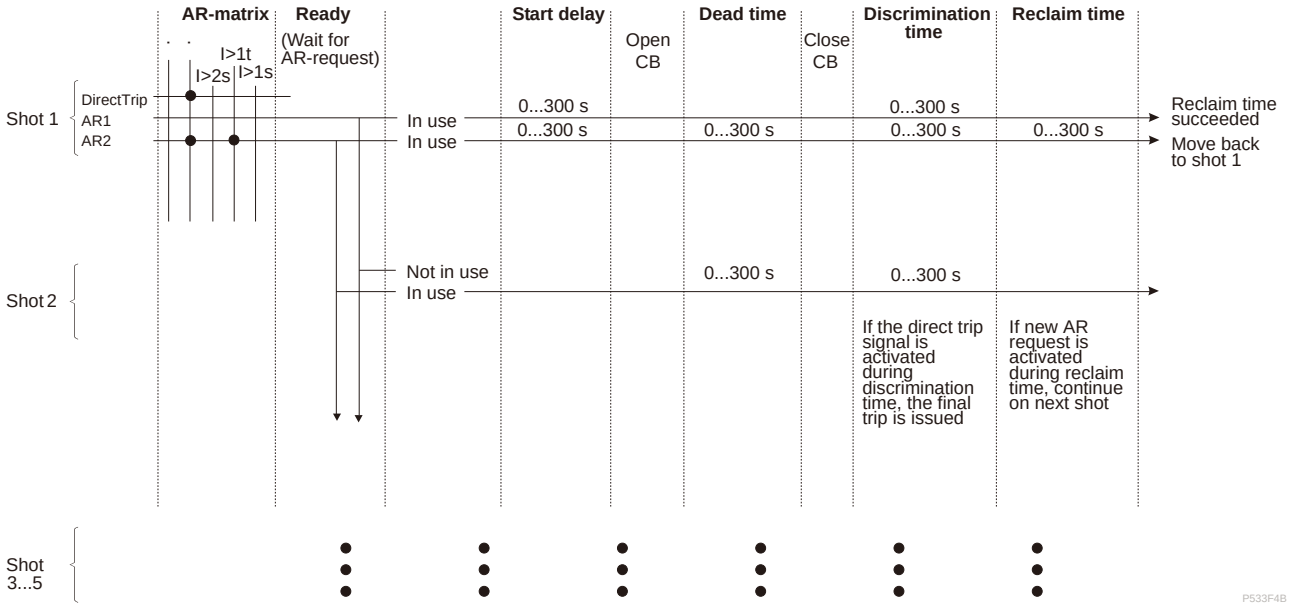
Auto-recloser principle

Even though the basic principle of AR is very simple, there are a lot of different timers and parameters that have to be set.

The PowerLogic P5 protection relays provide auto-reclosing with up to five shots. A shot consists of open time (so called “dead” time) and closed time (so called “burning” time or discrimination time). A high-speed shot means that the dead time is less than one second. The time-delayed shot means longer dead times up to two to three minutes.

There are four AR lines. A line means an initialisation signal for AR. Normally, start or trip signals of protection functions are used to initiate an AR sequence. Each AR line has a priority. AR1 has the highest and AR4 has the lowest priority. This means that if two lines are initiated at the same time, AR follows only the highest priority line. A very typical configuration of the lines is that the instantaneous overcurrent stage initiates the AR1 line, time-delayed overcurrent stage the AR2 line and earth/ground fault protection will use lines AR3 and AR4.

Figure 287 - Auto-reclose matrix



The AR matrix above defines which signals (the start and trip signals from protection stages or digital input) are forwarded to the AR function. In the AR function, the AR signals can be configured to initiate the reclose sequence. Each shot from 1 to 5 has its own enabled/disabled flag. If more than one AR signal activates at the same time, AR1 has highest priority and AR5 the lowest. Each AR signal has an independent start delay for the shot 1. If a higher priority AR signal activates during the start delay, the start delay setting will be changed to that of the highest priority AR signal.

After the start delay, the CB is opened if it is still closed (i.e. if no trip has been issued from another protection function in the mean time). When the CB opens, a dead time timer is started. Each shot from 1 to 5 has its own dead time setting. When dead time elapses, the reclose command is sent to the breaker and the reclaim time is started. If the reclaim time elapses with no further starting or tripping, the AR sequence is successfully executed and the AR function moves to ready state and waits for a new AR request in shot 1.

It is recommended to configure the protection stage start signal to initiate the AR function. A trip signal from the protection stage can be used as a backup. If AR does not issue the open command, the protection trip signal still operates the CB. The delay setting of the protection stage should be longer than the AR start delay, CB operation time and protection reset time.

Operation

Manual closing

When CB is closed manually with the local panel, by remote, or with digital inputs, the reclaim state is activated. Within the reclaim time, all AR requests are rejected. The protection stages take care of tripping when they are connected to a trip relay in the output matrix.

Manual opening

Manual CB open command during AR sequence stops the sequence and leaves the CB open.

Reclaim time setting

- Use shot-specific reclaim time: No

  This reclaim time setting defines reclaim time between different shots during a sequence and also the reclaim time after manual closing.

- Use shot-specific reclaim time: Yes

  This Reclaim time setting defines the reclaim time only for manual control. The reclaim time between different shots is defined by shot-specific reclaim time settings.

Support for two circuit breakers

The AR function can be configured to handle two controllable objects. Object 1 – 6 can be configured to CB1 and any other controllable object can be used as CB2. The object selection for CB2 is made with the **Breaker 2 object setting**. Switching between the two objects is done with a digital input, virtual input, virtual output or by choosing **Auto CB selection**. AR controls CB2 when the input defined by the **Input for selecting CB2** setting is active (except when using auto CB selection when operated CB 1 or 2 is that which was last in closed state). Control is changed to another object only if the current object is not closed.

AR shots blocking

Each AR shot can be blocked with a digital input, virtual input or virtual output. The blocking input is selected with the Block setting. When the selected input is active, the shot is blocked. A blocked shot is treated like it does not exist and AR sequence skips it. If the last shot in use is blocked, any AR request during reclaiming of the previous shot causes the final tripping.

Starting AR sequence

Each AR request line has its own start delay timer. That AR line that is selected depends on which starting delay elapses first. If more than one delay elapses at the same time, the AR request of the highest priority is selected. AR1 has the highest priority and AR5 has the lowest priority. First shot is selected according to the AR request. Next AR opens the CB and starts counting dead time.

AR shot 2-5 starting or skipping

Each AR request line can be enabled to any combination of the five shots. For example, making a sequence of Shot 2 and Shot 4 for AR request 1 is done by enabling AR1 only for those two shots.

NOTE: If AR sequence is started at shot 2 - 5, the starting delay is taken from the discrimination time setting of the previous shot. For example, if Shot 3 is the first shot for AR2, the starting delay for this sequence is defined by discrimination time of Shot 2 for AR2.

Direct trip AR request

A direct trip AR request stops the AR sequence and causes final tripping. The direct trip request is ignored when the AR sequence is not running. The direct trip request is accepted during dead time and discrimination time.

Shot active matrix signals

When a start delay has elapsed, an active signal is set for the first shot. If successful reclosing is executed at the end of the shot, the active signal is reset after the reclaim time. If the reclosing was not successful or a new fault appears during the reclaim time, the active signal is reset for the current shot and an active signal is set for the next shot (if there are any shots left before the final trip).

AR running matrix signal

This signal indicates dead time. The signal is set after CB is opened. When dead time ends, the signal is reset and CB is closed.

Final trip matrix signals

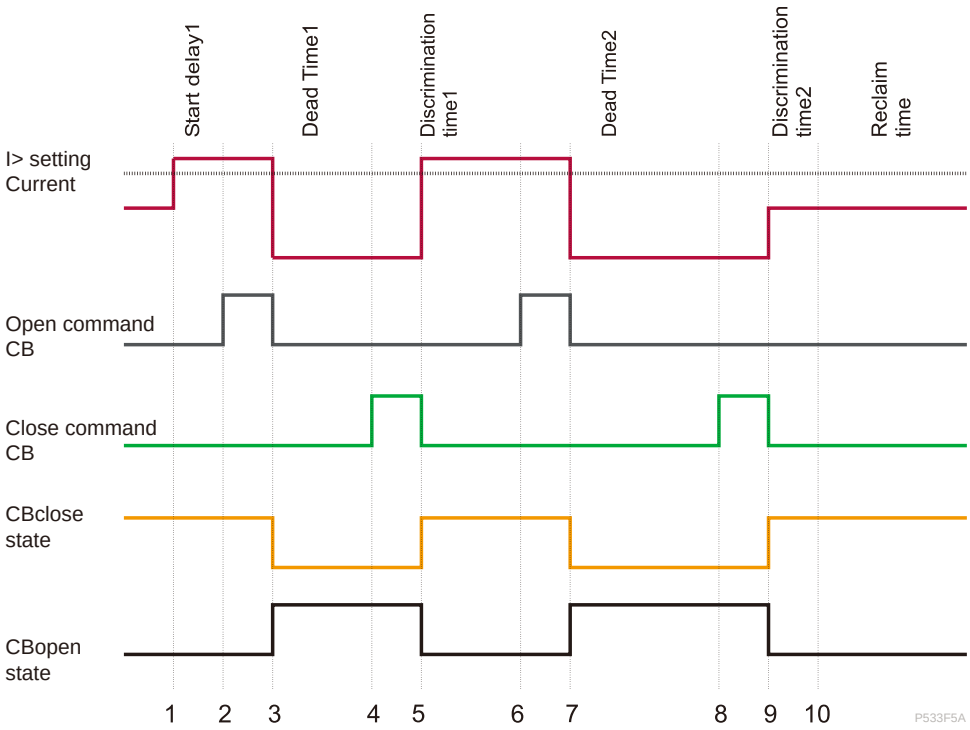
There are five final trip signals in the matrix, one for each AR request (1 to 4 and 1 direct trip). When a final trip is generated, one of these signals is set according to the AR request which caused the final tripping. The final trip signal stays active for 0.5 seconds and then resets automatically.

DI to block AR setting

This setting is useful with an external synchro-check device. This setting only affects re-closing the CB. Re-closing can be blocked with a digital input, virtual

input or virtual output. When the blocking input is active, CB is not closed until the blocking input becomes inactive again. When blocking becomes inactive, the CB is immediately closed providing the close command is still active.

Figure 288 - Example sequence of two shots (after shot 2 the fault is cleared)



1. The current exceeds the I> setting; the start delay from shot 1 starts.
2. After the start delay, an OpenCB relay output is operated.
3. The CB opens. The dead time from shot 1 starts, and the OpenCB relay output resets.
4. The dead time from shot 1 elapses; a CloseCB output is operated.
5. The CB closes. The CloseCB output resets, and the discrimination time from shot 1 starts. The current is again above the I> setting.
6. The discrimination time from the shot 1 elapses; the OpenCB relay output is operated.
7. The CB opens. The dead time from shot 2 starts, and the OpenCB relay output resets.
8. The dead time from shot 2 runs out; the CloseCB output is operated.
9. The CB closes. The CloseCB output resets, and the discrimination time from shot 2 starts. The current is now below I> setting.
10. Reclaim time starts. After the reclaim time elapsed the AR sequence is successfully executed. The AR function moves to wait for a new AR request in shot 1.

Characteristics

Table 98 - Setting and characteristics of the auto-recloser protection function (ANSI 79)

Setting/characteristics (description/label)	Values
Enable auto reclosing/Enable auto reclosing	
Options	On; Off
DI for AR on/off/DI for AR on/off	
Options	Selection of one digital input (DI), one virtual input (VI), one virtual output (VO), or one function key.
CB1 object/CB1 object	
Options	Obj1; Obj2; Obj3; Obj4; Obj5; Obj6
CB2 object/CB2 object	
Options	Obj1; Obj2; Obj3; Obj4; Obj5; Obj6
Auto CB selection/Auto CB selection	
Options	Disable; Enable
DI to select CB2/DI to select CB2	
Options	Selection of one digital input (DI), one virtual input (VI), one virtual output (VO), or one function key.
Dead time/Dead time	
Setting range	0.01...1,200.00 s
Resolution	0.01 s
Discrimination time/Discrimination time	
Setting range	0.02...300.00 s
Resolution	0.01 s
Reclaim time/Reclaim time	
Setting range	0.02...3,000.00 s
Resolution	0.01 s
DI to block sync check/DI to block sync check	
Options	Selection of one digital input (DI), one virtual input (VI), one virtual output (VO), or one function key.
Shot reclaim time/Shot reclaim time	
Options	On; Off
AR info for mimic display/ShowInfo	
Options	On; Off

Overfrequency (ANSI 81O)

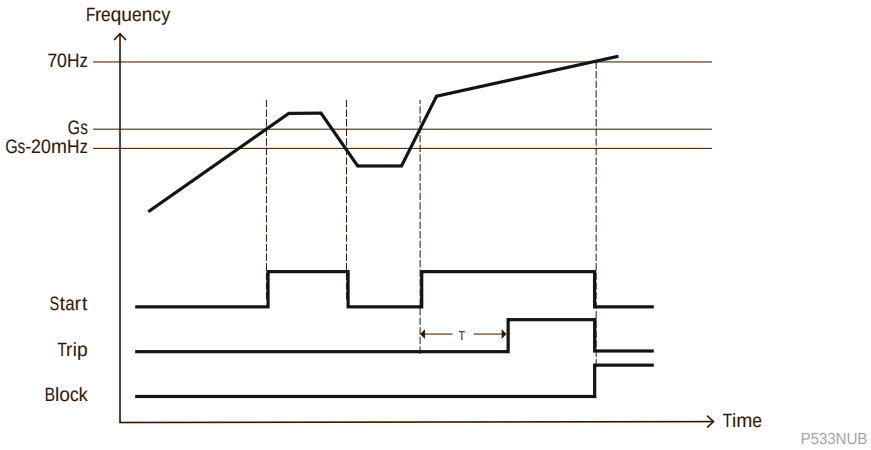
Description

Frequency deviations result from an imbalance between power generation and power loads. An over frequency condition happens when the power generation exceeds the power loads, which maybe is due to a sudden removal of load due to tripping of an outgoing feeder. The sustained over frequency condition may damage the power generators. Normally the governor system would respond quickly and restore normal frequency. Over frequency protection is required as a back-up for generator overspeed. Also, over frequency protection is also applied in load restoration schemes to detect that the power system frequency has recovered sufficiently to allow load which had previously been shed to be reconnected.

So, the over frequency protection function (ANSI code 81O) is used for load restoration, and as a backup protection for overspeeding.

Whenever the frequency reaches the pick-up value of a particular stage, this stage starts, and a start signal is issued. If the fault remains on longer than the operating delay setting, a trip signal is issued.

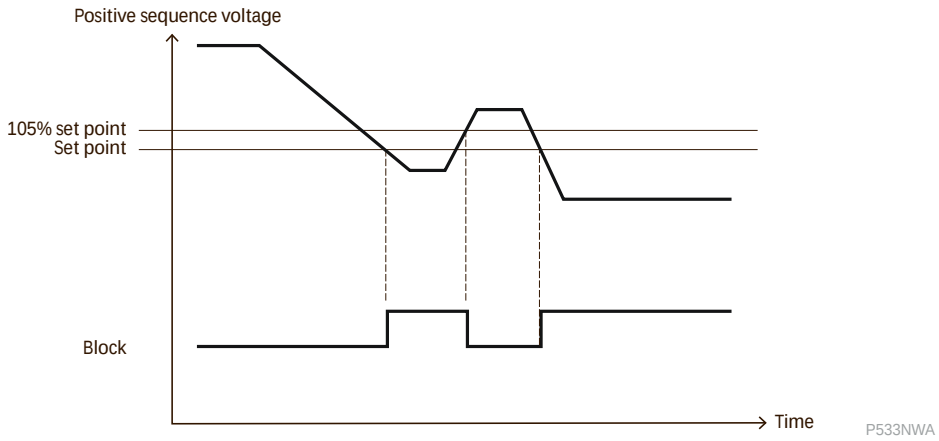
Figure 289 - Status change of overfrequency protection (Gs: frequency setting)



Self blocking at low voltage

The protection is blocked when the positive sequence voltage is lower than the setting threshold. This feature is common to all the groups and stages of ANSI 81O, ANSI 81U and ANSI 81R functions, yet with individual threshold settings.

Figure 290 - Low voltage block logic

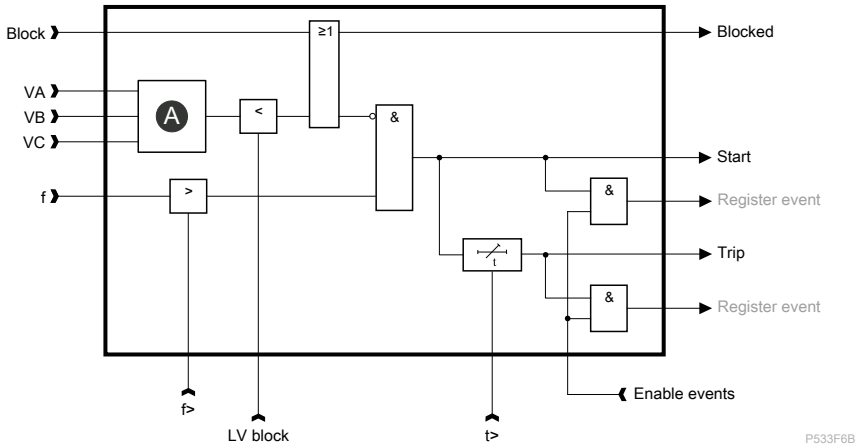


Two independent stages

There are two separately adjustable stages: f>1 and f>2. All the stages have definite operate time (DT).

Block diagram

Figure 291 - Block diagram of the overfrequency protection (ANSI 81O)



A Positive Sequency voltage

Characteristics

Table 99 - Setting and characteristics of the overfrequency protection stages f>1 and f>2

Setting/characteristics (description/label)	Values
Pick-up value/f>	
Frequency protection operation range	35...70 Hz
Setting range	40.00...65.00 Hz
Reset ratio	20 mHz ± 5 mHz
Resolution	0.01 Hz

Table 99 - Setting and characteristics of the overfrequency protection stages f>1 and f>2 (Continued)

Setting/characteristics (description/label)	Values
Accuracy	±0.01 Hz
Operate delay/t>	
Setting range	0.00...7200.00 s
Resolution	0.01 s
Accuracy	±1% or ±10 ms
Low voltage blocking/LV block	
Setting range	0.10...1.00 pu[107]
Reset ratio	105%
Resolution	1%
Accuracy	±5% or ±0.5V (secondary)
Characteristic times	
Start time	< 110 ms (105 ms with high speed), typically 80 ms
Disengaging time	< 120 ms (135 ms with high speed)
Overshoot time	< 70 ms
The voltage measured range	
Minimum value	Umin = 30 V
Maximum value	Umax = 220 V
Setting group	
Number	4

107. Vnom/√3 = VT primary nominal (PN)

Underfrequency (ANSI 81U)

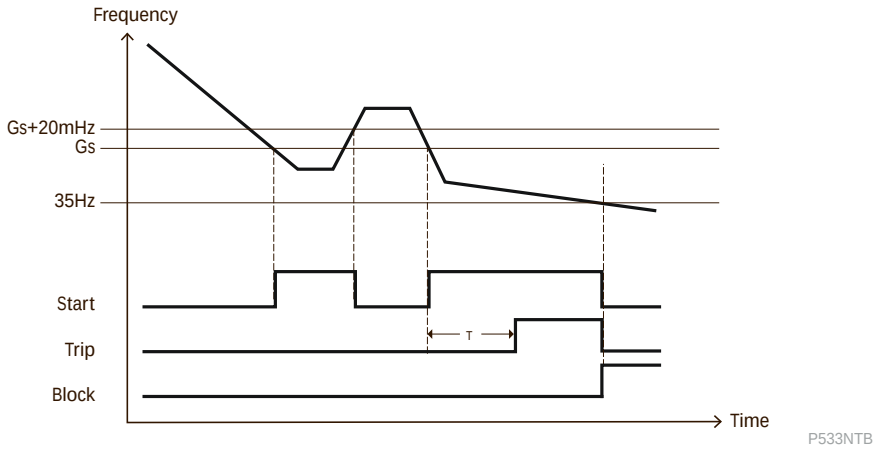
Description

Frequency deviations result from an imbalance between power generation and power loads. An under frequency condition happens when the power load exceeds the available power generation. This happens when an interconnected system splits, and the load left connected to one of the subsystems is in excess of the capacity of the generators. Sustained under frequency has implications on the stability of the power system, whereby any subsequent disturbance may damage equipment and even lead to blackouts. It is therefore usual to provide protection for under frequency conditions and the related load-shedding scheme shall be deployed to restore the normal frequency.

So, the under frequency protection function (ANSI code 81U) is used for detection of an abnormally low frequency compared to the rated frequency to monitor power supply quality. The protection may be used for overall tripping or load shedding.

Whenever the frequency reaches the pick-up value of a particular stage, this stage starts, and a start signal is issued. If the fault remains on longer than the operating delay setting, a trip signal is issued.

Figure 292 - Status change of underfrequency protection (Gs: frequency setting)



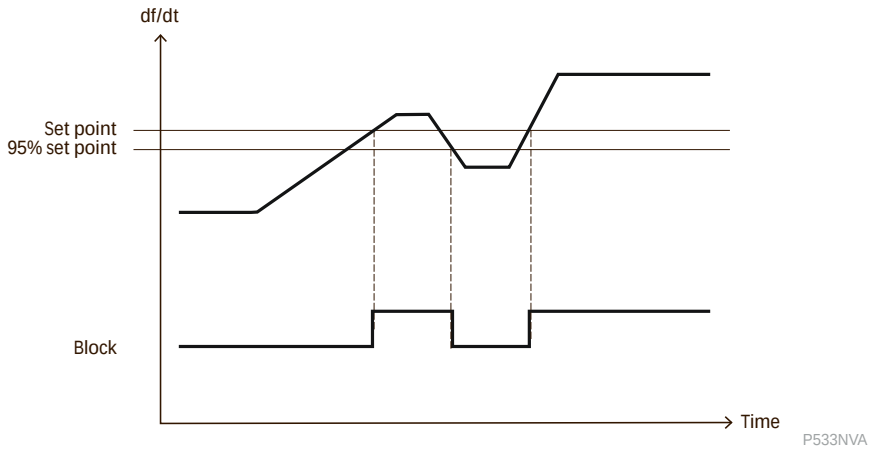
Self blocking at low voltage

The protection is blocked when the positive sequence voltage is lower than the setting threshold. This feature is common to all the groups and stages of ANSI 81O, ANSI 81U and ANSI 81R functions, yet with individual threshold settings. See Low voltage block logic.

Large df/dt block

The protection is blocked when the rate of change of frequency df/dt is larger than the setting threshold. The measured df/dt here shall not depend on any setting in ROCOF protection function.

Figure 293 - Large df/dt block logic

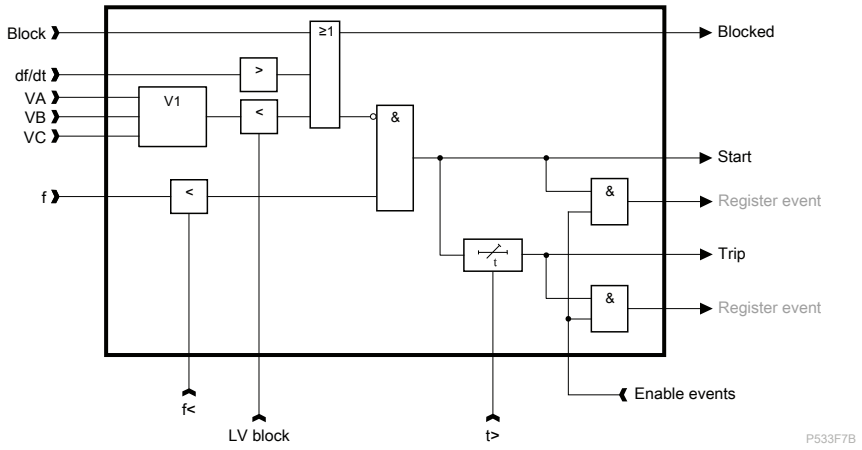


Eight independent stages

There are eight separately adjustable stages: f<1, f<2...f<8. All the stages have definite operate time (DT).

Block diagram

Figure 294 - Block diagram of the underfrequency protection function (ANSI 81U)



Characteristics

Table 100 - Setting and characteristics of the underfrequency protection stages f<1, f<2...f<8

Setting/characteristics (description/label)	Values
Pick-up value/f<	
Frequency protection operation range	35...70 Hz
Setting range	40.00...65.00 Hz
Hysteresis	20 mHz ± 5 mHz
Resolution	0.01 Hz
Accuracy	±0.01 Hz

Table 100 - Setting and characteristics of the underfrequency protection stages f<1, f<2...f<8 (Continued)

Setting/characteristics (description/label)	Values
Operate delay/Operate delay	
Setting range	0.00...7200.00 s
Resolution	0.01 s
Accuracy	±1% or ±10 ms
df/dt blocking	
Setting range	0.10...20.00 Hz/s
Hysteresis	5% or 0.05 Hz/s
Resolution	0.01 s
Accuracy	±5% or 50 mHz/s
Low voltage blocking/LV block	
Setting range	0.10...1.00 pu[108]
Reset ratio	105%
Resolution	1%
Accuracy	±5% or ±0.5V (secondary)
Characteristic times	
Start time	< 110 ms (105 ms with high speed), typically 80 ms
Disengaging time	< 100 ms (115 ms with high speed)
Overshoot time	< 70 ms
The voltage measured range	
Minimum value	Umin = 30 V
Maximum value	Umax = 220 V
Setting group	
Number	4

108. Vnom/√3 = VT primary nominal (PN)

Rate of change of frequency (ANSI 81R/81FR)

Description

Frequency deviations result from the imbalance between the power generation and power loads. The Rate of Change of Frequency (RoCoF) is depending on the system inertia, severity of electric power unbalance, system damping constant and various other parameters. Sometimes the significant electric power deficiency in the separated subsystem (islanding condition) could cause a large frequency decay in a short time. If corrective measures (such as load shedding) are not taken quickly, the frequency may drop below the minimum system operating level and cause a widespread network collapse.

Compared with the underfrequency protection (ANSI 81U), the protection based on RoCoF can forecast a severe frequency decay and trigger fast corrective measures before the frequency drops to below the minimum system operating level.

So, the RoCoF protection function is normally used along with underfrequency protection in order to trigger load shedding where the frequency drops too fast. It can also be used to detect loss of mains where local generation is suddenly disconnected from the power system. The calculation of the rate of change of frequency is based on the positive sequence voltage.

The RoCoF protection in PowerLogic P5 can operate as independent rate of change of frequency protection, as frequency supervised rate of change of frequency protection or as regular under/over frequency protection. The selection is made with Operating mode and Direction mode settings which are independent for each one of 9 stages.

- If Direction mode is “Negative” and Operating mode is "f+RoCoF", it is underfrequency supervised RoCoF protection
- If Direction mode is “Positive” and Operating mode is "f+RoCoF", it is overfrequency supervised RoCoF protection
- If Direction mode is “Either”, it is RoCoF protection
- If Direction mode is “Negative” and Operating mode is "Frequency", it is underfrequency protection
- If Direction mode is “Positive” and Operating mode is "Frequency", it is overfrequency protection

RoCoF stage can be used as underfrequency protection by applying "Frequency" mode.

NOTE: If set direction mode to “Either”, please set operating mode to “f +RoCof” firstly, to avoid dependency confusion.

Self blocking at low voltage

The protection is blocked when the positive sequence voltage is lower than the set undervoltage blocking threshold.

Self blocking at frequency out of range

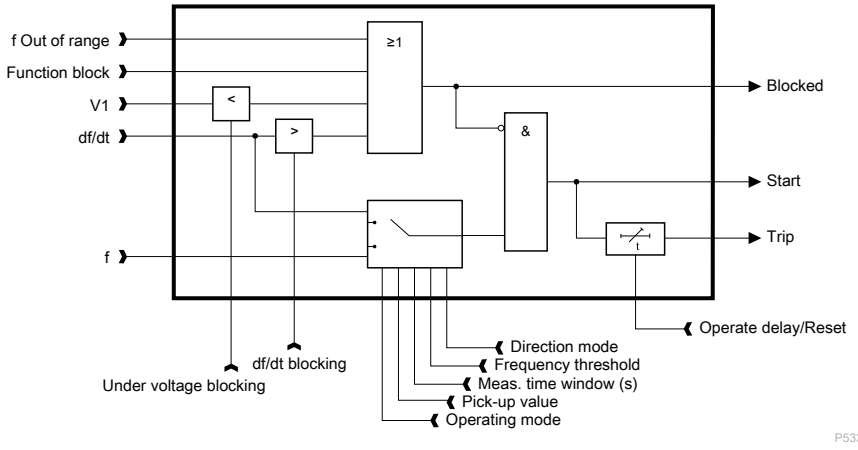
The protection is blocked when the measured frequency is out of the range 35...70 Hz.

df/dt blocking

The protection is blocked when the measured rate of change of frequency df/dt is bigger than the set df/dt blocking limit. To ensure the RoCoF is safely blocked, a short time delay such as 50 ms is suggested.

Block diagram

Figure 295 - RoCoF function structure overview



Characteristics

Table 101 - Setting and characteristics of the rate of change of frequency protection stages

Settings/characteristics (description/label)	Values
Direction mode/Direction mode	
Options	Negative; Positive; Either
Operating mode/OpMod	
Options	f+RoCoF; Frequency
Pick-up value/Pick-up value	
Setting range	0.1...10.0 Hz/s
Resolution	0.1 Hz/s
Settable df/dt window ΔT	0.05...1.00 s, default 50 ms, step 5 ms
Accuracy	< 0.05 Hz/s if df/dt < 5 Hz/s; ±2% for the upper range;
Hysteresis	5% or 0.05 Hz/s
Undervoltage blocking/LV block [109]	
Setting range	0.10...1.00 pu[110]
Reset ratio	105%
Resolution	1%
Accuracy	Static voltage ±5% or ± 0.5 V (secondary)
df/dt blocking/BlkVal_dfdt	
Setting range	0.10...20.00 Hz/s
Resolution	0.01 Hz/s
Accuracy	±5% or 50 mHz/s for ΔT = 50 ms and up to 10 Hz/s
Reset hysteresis	5% or 0.05 Hz/s
Operate delay/Operate delay	
Setting range	0.00...100.00 s

109. Common setting for setting group 1, 2, 3, 4.
110. Vnom/√3 = VT primary nominal (PN)

Table 101 - Setting and characteristics of the rate of change of frequency protection stages (Continued)

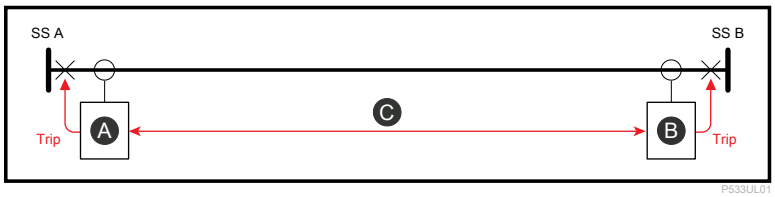
Settings/characteristics (description/label)	Values
Resolution	0.01 s
Accuracy	±1% or ±10 ms
Frequency threshold	
Setting range	40.00...65.00 Hz, Step 0.01 Hz
Accuracy	± 10 mHz
Reset hysteresis	Gs + 20 mHz[111]
Characteristic times	
Start time	< 135 ms at 2 Gs[111] for df/dt > 0.1 Hz/s for ΔT = 50 ms < 170 ms at 2 Gs[111] for df/dt = 0.1 Hz/s for ΔT = 50 ms
Disengaging time	< 180 ms for 2 Gs[111] to 0 and ΔT = 50 ms
Setting group	
Number	4

Inter-relay (ANSI 85)

Introduction

The inter-relay application is an effective replacement to the traditional hardwired exchange of digital information between 2 protection relays by using a serial communication link. It allows optimisation of the communication related requirements of speed, security and dependability, while minimising the amount of wiring between relays and providing comprehensive monitoring and status reporting of the communication link.

Figure 296 - The inter-relay between 2 protection relays



A	Protection relay A	B	Protection relay B
C	Protection communication, transfer of digital data (start, trip, direction,...)		

The inter-relay application is available for not only P5L, P5F, P5M and P5T. The typical use cases are inter-substation communications for inter tripping or permissive tripping, distance signaling, remote CB status indication, CBF backtrip, DEF signalling, load shedding and restoration.

In some case, the inter-relay signals may also be used in interlocking.

NOTE: the maximum length of FO (Fibre Optic) cable is 40 km.

111. Gs: frequency setting

Features of Inter-relay

Mode

The setting of mode is made in **eSetup Easergy Pro**/**PROTECTION**/**InterRelay communication**, in the section **Receive signal,** column **Signal type**. The mode of IRInx (x=1 ... 16) is fixed to *Direct*.

The digital signals are initiated in a transmitting relay but, according to the application, the receiving relay may condition the signal according to the scheme requirements:

Direct

In direct mode, the command is not supervised at the receiving end by any protection relay and its receipt causes direct circuit breaker operation. Since no checking of the received signal by another protection element is performed, it is essential that any noise on the signaling channel is not interpreted as being a valid signal when the command isn't being transmitted. For a direct mode, therefore, the primary requirement of the signaling channel is security.

Alarms

Communication between the two relays is continuously monitored. Different type of alarms will be raised if no message is received within due time or if too many faulty messages are received within a defined time window.

Link failure alarm

This alarm will be raised if no valid message is received within a user set **Comm link fail time**.

Depending on user setting the alarm will be either automatically reset when the internal communication flag is reset, or only upon acknowledgement by user.

Communication failure alarm

This alarm means any of the set frame sync timers elapses and hence for any received signal the fallback mode gets active. It will be active if for any signal the fallback mode is active.

When receiving a next fully valid message, it will reset automatically, hence when all received signals were successfully updated with the information received from such valid message frame.

Communication error alarm

This alarm will be issued if too many faulty messages are received either within a given time window or based on a given number of received telegrams. If the percentage of received erroneous telegrams (based on the total number of telegrams received) exceeds a user set **Comm error alarm level**, the related Communication error alarm will be raised.

Communication error statistics

To aid the bit error evaluation of the communication link, communication error statistics are kept by the relay. The statistics records the number of Errored messages detected and the number of Valid Messages received for the communications channel. The number of errored messages detected complies with ITU-T G.821.

The stored error statistics are:

- Valid messages: number of messages received which were OK/accepted.
- Errored messages: number of messages received but rejected.

- Errored seconds: number of seconds containing 1 or more errored messages. This is not updated for severely errored seconds.
- Severely errored seconds: number of seconds containing ≥ 30% errored messages.
- Elapsed time since reset: the number of seconds since the communications error statistics were last reset.

The error statistics are stored in non-volatile memory and automatically cleared on power-up. They can be cleared by eSetup Easergy Pro in **GENERAL**/**Optical fiber communication**:

- In **Statistics** section, after clicking the **Clear** button or buttons, the settings shall be written to the relay by clicking the **Write** button.
- In **Configuration** section, by clicking the **Reset** button besides the **Statistics reset command**, the settings will be written automatically.

Configurations

Address

The setting of address is made by eSetup Easergy Pro in **GENERAL**/**Optical fiber communication**, in section **Configuration**, selection of **Address**.

For two relays to communicate with one another their addresses must be in the same address group. One relay shall be assigned with address A and the other with address B. For example, if the group 1 addresses are to be used, then one relay shall be set to address *1A* and the other relay shall be set to address *1B*.

A relay with address *1A* will only accept messages from a relay with address *1B*, and vice versa.

Baud rate

The baud rate for communication between two relays is settable by eSetup Easergy Pro in **GENERAL**/**Optical fiber communication**, in section **Configuration**, selection of **Baud rate**. There are three selectable values: 56/64/115.2 kBit/s.

Inter-relay communication

The inter-relay communication is enabled/disabled and configured by eSetup Easergy Pro in **PROTECTION**/**InterRelay communication**, 8 or 16 digital signals are transmitted within the message frame.

The meaning of these signals is freely user configurable, in the same way as for example output or LED configurations, it means user will provide matrix style for this configuration. As typical examples, any start/trip/status signal of protection functions, switchgear open/close condition, or (timed) logic outputs is available through the configuration list.

In the column **Fallback mode**, two types of fallback modes are selectable in case of detected communication failure with either keeping last valid value (*Latching*) or forcing default value (*Default*). This fallback mode gets active if the set of column **Frame sync time** elapses. This timer is re-triggered upon receiving a valid message. Because of different types of signals and related application needs, this timer is individually settable for each signal.

Matrix

The inter-relay signals can be programmed in different matrix of PowerLogic P5:

- Output matrix: for direct mode

- Blocking matrix: for permissive mode and blocking mode
- LED matrix: for the use of the Alarm LED, the trip LED, and the configurable LEDs on the local panel of PowerLogic P5
- Object block matrix: for the controllable objects, they can be blocked by inter-relay

For the detail of matrix, please refer to Matrix, page 493.

Functional test

The inter-relay function provides test features for simple and efficient testing of signal transmission. The test features can be found in eSetup Easergy Pro in **DEVICE/TEST/InterRelay test**. The section **InterRelay test** lists the selectable test types, and the section **Send signal** is for the setting of test signals.

There are 2 test types for selection.

Loopback

This function allows to set a loopback mode. When this mode is active, the alarm LED will be turned on to orange to have proper user awareness.

In this mode, a user-settable bit pattern will be sent and the function checks that the received pattern is equal to the sent pattern. Only if the received signal pattern is equal to the sent pattern, a “Loopback test OK” signal will be raised, otherwise a “Loopback test NOK” signal.

NOTE: in loopback mode, the tested relay shall be in test mode, and its address shall be set to *00*.

Manual

By this type of test, user can select any single of the digital sent signals and force sending it with a user defined value (0 or 1) for a user set definite time. All other digital signals in the frame are not affected. When user checked the box of **Execute manual test** of a signal, the test will be triggered and lasts for a user set duration, the value of received signal at the remote device can be read from local HMI or by eSetup Easergy Pro.

Characteristics

Table 102 - Settings and characteristics of inter-relay function (ANSI 85)

Settings/characteristics (description/label)	Values
Address	00, 00, 1A, 1B … 20A, 20B
Baud rate	56 kbit/s, 64 kbit/s, 115.2 kbit/s, default 115.2 kbit/s
Comm link fail time	0.1 … 10.0 … 600.0 s, default 10.0; increment 0.1
Message alarm level	0.1 … 25.0 … 100.0, default 25.0; increment 0.1
Comm fail self-reset	Yes / No, default "Yes"
Message alarm self-reset	Yes / No, default "No"
InterMiCOM compatible[112]	Yes / No, default "No"

112. Impacts frame size and content definition. In compatible mode, PowerLogic P5 applys the InterMiCOM frame definition for sending and receiving data.

Table 102 - Settings and characteristics of inter-relay function (ANSI 85) (Continued)

Settings/characteristics (description/label)	Values
Inter-relay digital signals transmission	
Number of signals	8 / 16, default 8
Received signals related features	
IR1 type	Direct / Permissive / Blocking, default "Blocking"
IR1 frame sync time	0.01 … 1.00 s, step 0.01 s
IR1 fallback mode	Default / Latched, default "Default"
IR1 default value	0 / 1, default "0"
Inter-relay test settings	
Loopback test mode	Yes / No, default "No"
Test Pattern	Any pattern of 8 (or 16 Bit) digital values with values 0 or 1.
Send signal for test	None / Send 1 / … send n, default “None”
Send signal value	0 / 1, default “0”
Duration of single signal test	1 … 600 s/ default "1"
Execute single signal test	Yes / No, default "No"

Lockout relay (ANSI 86)

Description

The ANSI 86 function traditionally performed by lockout relays may be ensured by PowerLogic P5 protection relay using programmable logic, with latching of Global trip signal, which is used to inhibit any close order, until the cause of tripping disappears and is acknowledged by the user.

By default, the changeover contact DO2 on slot B is configured for this lockout feature. Accordingly, it's NC contacts (terminals 12-13) have to be rooted into the close command circuit (to interrupt it, as long as DO2 is energised).

Latch function

This feature can be programmed for outputs in the **MATRIX** menu/**Output matrix** sub-menu of the eSetup Easergy Pro. Any protection stage start or trip, digital input, logic output, alarm and GOOSE signal connected to the following outputs can be latched when required:

- Output contacts DOs
- LEDs on the local panel
- Virtual outputs VO1- VO20

NOTE: The latched signal is identified with a dot and circle in the matrix signal line crossing.

The lockout can be released through the local panel with the  key, or through the eSetup Easergy Pro. See Releasing latches, page 499.

Transformer differential protection (ANSI 87T)

Description

General

The PowerLogic P5T30 transformer differential protection is a high-speed, two-ended, phase segregated, transformer differential protection for distribution applications in the industry and utility segments, with absolute selectivity for power transformers, motors, generators, shunt reactors and similar equipment. For full application flexibility of this protection function, CT arrangement uses generic naming "CT-1" and "CT-2". In a standard transformer differential application CT-1 end is the high voltage (HV) end, and CT-2 end is the low voltage (LV) end.

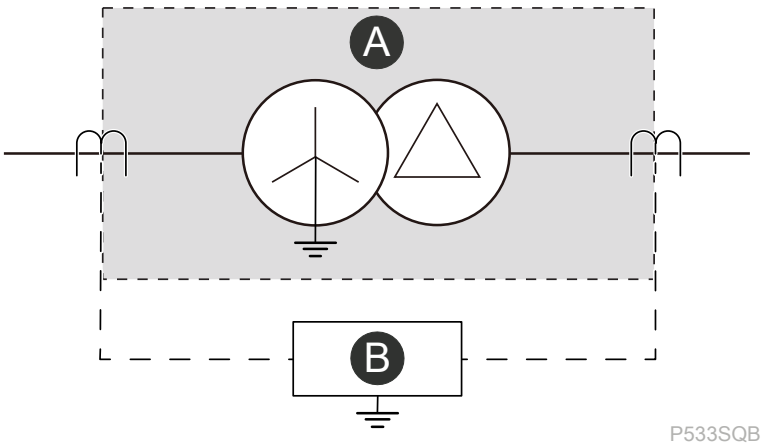
Based on the primary current comparison principle, the current values from both ends are continuously compared. In normal operation conditions or during external faults without CT saturation, the primary currents at both ends are practically the same, so the comparison result is practically zero (actually, the magnetizing current and thermal copper losses take less than 1% of transformer nominal current). For faults inside the protected transformer (inside the protected object) the comparison will result in values higher than the operation value, so the protection will trip. The zone of protection is precisely defined by the location of current transformers in the substations.

As the differential protection function measures the currents through the CTs, errors introduced from the CTs (namely transformation error and transient saturation) are considered. Same with uncertainties regarding the transformation ratio of the primary transformer.

This is basically done by calculating differential and restraining current and comparing these values against a triple-slope tripping characteristic.

The trip is usually instantaneous, or with a time delay for more complex protection schemes where other protection functions are embedded in the differential protection zone.

Figure 297 - Protected zone of current differential protection



A	Protected zone	B	Differential relay

Current measurement and preprocessing

CT connection

Differential protection function measures phase currents through different sets of CTs, which could be connected in standard way (common point toward protected

object side) or in opposite way. This affects the sign of the measured current. Accordingly, settings are provided to adjust actual wiring to the function needs.

- Phase CT-1 polarity (HV) = *Standard/Opposite*, by default: *Standard*
- Phase CT-2 polarity (LV) = *Standard/Opposite*, by default: *Standard*

For the CT orientation and polarity, please refer to CT and LPCT typical application, page 66.

Phase swapping

Hydro pump storage applications use motor/generators, where reversing the operating mode is done by swapping 2 phases either on HV or LV side. If such a reversing switch is inside the protected zone, the protection scheme is able to get aligned.

Accordingly, the settings of phase swapping are provided:

- CT-1 phase swap = *“No Swap”/A-B/B-C/C-A*, by default: *“No Swap”*
- CT-2 phase swap = *“No Swap”/A-B/B-C/C-A*, by default: *“No Swap”*

Activation of phase swapping is controlled through a dedicated digital input signal (Phase swap activation input = DI1 – DIx, Fx, VI1 – VIx).

Amplitude matching

Protection is based on comparison of the primary phase currents. In a transformer protection application, these will be naturally different with a ratio inverse to the nominal voltages of the windings.

These currents are measured through CTs with a different transformation ratio, more or less according to the nominal currents of the power transformer.

For example, a 110kV/22kV power transformer with 60 MVA rated power has a nominal current on HV side of 315 A and on LV side of 1575 A. Accordingly CTs on HV side could be 400:1 A and on LV side 2000:1 A.
PowerLogic P5 takes into account such different nominal currents and ratios in the data processing and provides amplitude matching settings to adjust the function accordingly: all currents are scaled to reference currents, calculated based on a common reference power S_{ref} and the nominal voltages of each end. For protection of transformers, motors, shunt reactors etc., this reference power is usually the rated or nominal power of the protected object.

The reference currents are calculated from the set reference power S_{ref},

- End-1 (HV) reference current: $I_{ref\text{-}1} = S_{ref} / \sqrt{3} \cdot V_{rated,end\text{-}1}$
- End-2 (LV) reference current: $I_{ref\text{-}2} = S_{ref} / \sqrt{3} \cdot V_{rated,end\text{-}2}$

With these reference currents and the primary nominal currents of the CTs the amplitude matching factors are calculated:

- CT-1 amplitude matching factor: $k_{amp,1} = I_{CT\text{-}1,primary} / I_{ref\text{-}1}$
- CT-2 amplitude matching factor: $k_{amp,2} = I_{CT\text{-}2,primary} / I_{ref\text{-}2}$

These matching factors are displayed at the P5.

If the value of a factor is outside the range from 0.1 to 32.0, the differential protection function is blocked.

The measured phase currents from each end are scaled with these factors per following equations:

- HV end phase currents: $\underline{I}_{amp,p,2} = k_{amp,1} \cdot I_{p,CT\text{-}1}$
- LV end phase currents: $\underline{I}_{amp,p,2} = k_{amp,2} \cdot I_{p,CT\text{-}2}$

where:

- amp = amplitude-matched
- p = phase A, B or C

Vector group correction

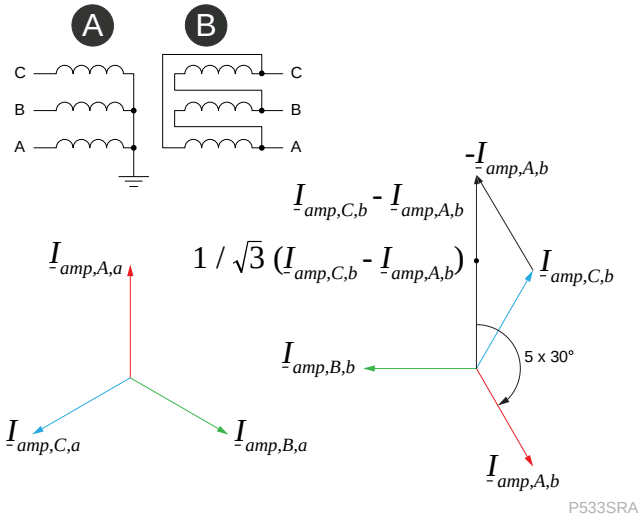
The transformer HV windings are indicated by capital letters and the LV windings by lower case letters. The numbers refer to positions on a clock face and indicate the phase displacement of balanced 3-phase LV line currents with respect to balanced 3-phase HV line currents. The HV side is taken as reference and it is the 12 o'clock position.

Therefore, each hour represents a 30° shift; for example, 1 represents a 30° lag and 11 represents a 30° lead (LV with respect to HV). An additional N, YNd1 (lower case for LV, d) indicates a neutral to earth connection on the high voltage winding of the power transformer.

By studying the relative phase shifts that can be obtained, it can be seen that star-star windings allow even vector group configurations and star-delta/delta-star windings allow odd group configurations.

According to the set vector group the LV side currents for differential comparison are calculated from different phases to align with the primary connection, as sketched in the following figure.

Figure 298 - Example of phase shift for a YNd5 transformer



A	Winding a	B	Winding b

Zero-sequence current filtering

The figure below shows the need for zero-sequence current filtering for differential protection across a transformer. It mimics the distribution of primary zero-sequence current in the protection scheme. The power transformer delta winding acts as a "trap" to zero-sequence current. This current is therefore only seen on the star connection side of the power transformer and hence as differential current by the protection scheme.

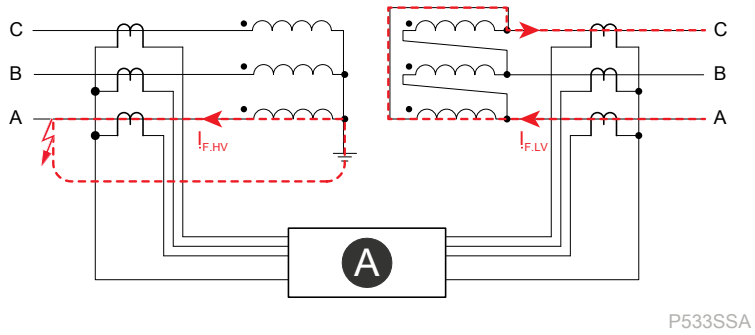
If the zero-sequence current filtering is enabled, one third of measured zero-sequence current is subtracted from each phase current. Otherwise, if disabled, one third of measured zero-sequence current is added to each phase current to increase the differential protection sensitivity for internal earth/ground faults on non-earthed/grounded ends.

Accordingly, the following calculations are executed per end:

1. Determination of zero-sequence current:
   - $\underline{I}_{zero,x} = (\underline{I}_{A,x} + \underline{I}_{B,x} + \underline{I}_{C,x}) / 3$
2. Determination of filtered phase currents:
   - If zero-sequence current filtering is enabled:
     - $\underline{I}_{p,zero.x} = \underline{I}_{p,x} - \underline{I}_{zero,x}$
   - Otherwise:
     - $\underline{I}_{p,zero.x} = \underline{I}_{p,x} + \underline{I}_{zero,x}$

where x = end 1 (HV) or 2 (LV), p = A, B, C

Figure 299 - Need for zero-sequence current filtering



A DIFF

	HV end (CT-1)	LV end (CT-2)
Setting	Zero-sequence current filtering CT-1 = Yes	Zero-sequence current filtering CT-2 = No
Calculated currents per end and measuring system:		
	$\underline{I}_{zero,HV} = (\underline{I}_{A,HV} + \underline{I}_{B,HV} + \underline{I}_{C,HV}) / 3 = \underline{I}_{F,HV} / 3$	$\underline{I}_{zero,LV} = (\underline{I}_{A,LV} + \underline{I}_{B,LV} + \underline{I}_{C,LV}) / 3 = 0$
ms1 (A)	$\underline{I}_{ms1,zero,HV} = \underline{I}_{A,HV} - \underline{I}_{zero,HV} = 2/3 \cdot \underline{I}_{F,HV}$	$\underline{I}_{ms1,zero,LV} = \underline{I}_{C,LV} - \underline{I}_{A,LV} + \underline{I}_{zero,LV} = 2 \cdot \underline{I}_{F,LV}$
ms2 (B)	$\underline{I}_{ms2,zero,HV} = \underline{I}_{B,HV} - \underline{I}_{zero,HV} = - 1/3 \cdot \underline{I}_{F,HV}$	$\underline{I}_{ms2,zero,LV} = \underline{I}_{B,LV} - \underline{I}_{C,LV} + \underline{I}_{zero,LV} = - 1 \cdot \underline{I}_{F,LV}$
ms3 (C)	$\underline{I}_{ms3,zero,HV} = \underline{I}_{C,HV} - \underline{I}_{zero,HV} = - 1/3 \cdot \underline{I}_{F,HV}$	$\underline{I}_{ms3,zero,LV} = \underline{I}_{A,LV} - \underline{I}_{B,LV} + \underline{I}_{zero,LV} = - 1 \cdot \underline{I}_{F,LV}$

The following table lists all the mathematical phasor operations. It shows that for all odd-numbered vector group characteristics the zero-sequence current on the low-voltage side is basically always filtered out, whereas for even-numbered vector group characteristics the zero-sequence current on the low-voltage side is basically never filtered out automatically. The latter is also true for the high-voltage side since in that case no mathematical phasor operations are performed. Vector group matching and zero-sequence current filtering must therefore always be viewed in combination.

Table 103 - Numerical processing depending on vector group and zero-sequence current filtering

Vector group	With zero-sequence current filtering	Without zero-sequence current filtering
Mathematical operations on the HV side		
	$\underline{I}_{vec,ms,z} = \underline{I}_{amp,p,z} - \underline{I}_{amp,zero.z}$	$\underline{I}_{vec,ms,z} = \underline{I}_{amp,p,z}$
Mathematical operations on the LV side for even-numbered vector group characteristics		
0	$\underline{I}_{vec,ms,z} = \underline{I}_{amp,p,z} - \underline{I}_{amp,zero.z}$	$\underline{I}_{vec,ms,z} = \underline{I}_{amp,p,z}$
2	$\underline{I}_{vec,ms,z} = -(\underline{I}_{amp,p+1,z} - \underline{I}_{amp,zero.z})$	$\underline{I}_{vec,ms,z} = -\underline{I}_{amp,p+1,z}$
4	$\underline{I}_{vec,ms,z} = \underline{I}_{amp,p-1,z} - \underline{I}_{amp,zero.z}$	$\underline{I}_{vec,ms,z} = \underline{I}_{amp,p-1,z}$
6	$\underline{I}_{vec,ms,z} = -(\underline{I}_{amp,p,z} - \underline{I}_{amp,zero.z})$	$\underline{I}_{vec,ms,z} = -\underline{I}_{amp,p,z}$
8	$\underline{I}_{vec,ms,z} = \underline{I}_{amp,p+1,z} - \underline{I}_{amp,zero.z}$	$\underline{I}_{vec,ms,z} = \underline{I}_{amp,p+1,z}$
10	$\underline{I}_{vec,ms,z} = -(\underline{I}_{amp,p-1,z} - \underline{I}_{amp,zero.z})$	$\underline{I}_{vec,ms,z} = -\underline{I}_{amp,p-1,z}$
Mathematical operations on the LV side for odd-numbered vector group characteristics		
1	$\underline{I}_{vec,ms,z} = (\underline{I}_{amp,p,z} - \underline{I}_{amp,p+1,z}) / \sqrt{3}$	$\underline{I}_{vec,ms,z} = [(\underline{I}_{amp,p,z} - \underline{I}_{amp,p+1,z}) / \sqrt{3}] + \underline{I}_{amp,zero.z}$
3	$\underline{I}_{vec,ms,z} = (\underline{I}_{amp,p-1,z} - \underline{I}_{amp,p+1,z}) / \sqrt{3}$	$\underline{I}_{vec,ms,z} = [(\underline{I}_{amp,p-1,z} - \underline{I}_{amp,p+1,z}) / \sqrt{3}] + \underline{I}_{amp,zero.z}$
5	$\underline{I}_{vec,ms,z} = (\underline{I}_{amp,p-1,z} - \underline{I}_{amp,p,z}) / \sqrt{3}$	$\underline{I}_{vec,ms,z} = [(\underline{I}_{amp,p-1,z} - \underline{I}_{amp,p,z}) / \sqrt{3}] + \underline{I}_{amp,zero.z}$
7	$\underline{I}_{vec,ms,z} = (\underline{I}_{amp,p+1,z} - \underline{I}_{amp,x,z}) / \sqrt{3}$	$\underline{I}_{vec,ms,z} = [(\underline{I}_{amp,p+1,z} - \underline{I}_{amp,p,z}) / \sqrt{3}] + \underline{I}_{amp,zero.z}$
9	$\underline{I}_{vec,ms,z} = (\underline{I}_{amp,p+1,z} - \underline{I}_{amp,p-1,z}) / \sqrt{3}$	$\underline{I}_{vec,ms,z} = [(\underline{I}_{amp,p+1,z} - \underline{I}_{amp,p-1,z}) / \sqrt{3}] + \underline{I}_{amp,zero.z}$
11	$\underline{I}_{vec,ms,z} = (\underline{I}_{amp,p,z} - \underline{I}_{amp,p-1,z}) / \sqrt{3}$	$\underline{I}_{vec,ms,z} = [(\underline{I}_{amp,p,z} - \underline{I}_{amp,p-1,z}) / \sqrt{3}] + \underline{I}_{amp,zero.z}$

Where the indices in the equations have the following meanings:

- amp: amplitude-matched
- vec: amplitude- and vector group-matched
- p: phase A, B or C
- p+1: cyclically trailing phase
- p-1: cyclically leading phase
- ms: measuring system 1, 2 or 3
- z: end 1(HV) or 2(LV)

A reverse phase rotation (A-C-B) setting and phase swapping condition are taken automatically into account in the calculation of these amplitude- and vector group-matched phase currents from both ends.

Differential protection

Differential protection calculations

The differential protection is based on calculation of differential and restraint (or bias) current, both calculated from amplitude matched, vector group compensated and zero-sequence current filtered currents as detailed in Numerical processing depending on vector group and zero-sequence current filtering, page 447.

The differential current is sum of HV and LV side current values (per phase), it is calculated with:

$I_d = | \underline{I}_{vec,end1} + \underline{I}_{vec,end2} |$

The bias current is the difference of HV and LV side current values (per phase), scaled to be comparable with the load current in normal operation.

It is calculated in one of the following ways according to the selected method:

- Sum of absolute values divided by 2:

  $I_R = (| \underline{I}_{vec,end1} | + | \underline{I}_{vec,end2} |) / 2$

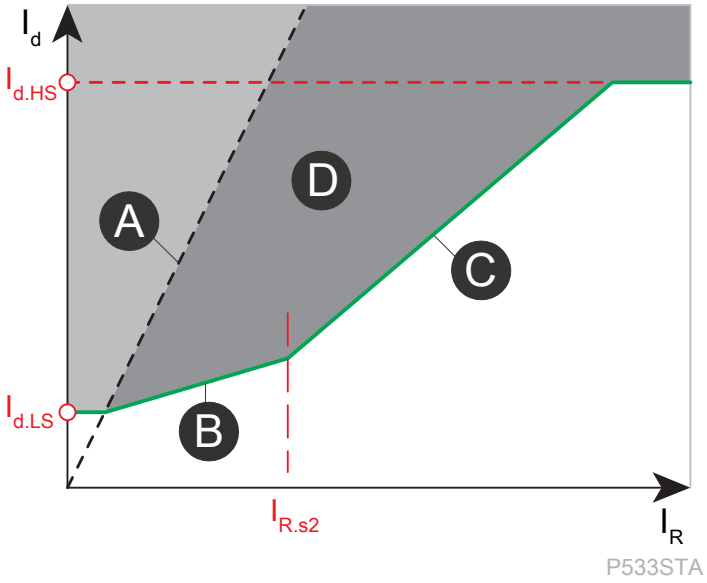
- Absolute value of phasor difference divided by 2:

  $I_R = | \underline{I}_{vec,end1} - \underline{I}_{vec,end2} | / 2$

Differential characteristic

With high current flowing through the protected object, for example during external fault conditions, a differential current might be apparent. The reason can be due to different ratio errors and/or magnetizing/saturation characteristics of the CTs. Therefore, the current differential protection gets provided with a biased tripping characteristic, as shown in following figure:

Figure 300 - Biased tripping characteristic



A	Characteristic for single side fed fault = 200% slope	B	Slope 1
C	Slope 2	D	Trip area

Whatever method is used, the calculated value pair of differential and restraining current (I_d and I_R) is compared against this characteristic with three sections (green characteristic in above figure). The first section is a horizontal line at set pick-up threshold $I_{d.LS}$ up to the intersection with the line for single side infeed, with value considering basic inaccuracies (transformer magnetizing current, …). The first slope (slope 1) ensures sensitivity to internal faults, while providing increasing restraint to for example compensate effect of false amplitude matching due to non-compensated tap changer. The second slope provides stability against measuring errors like CT saturation.

The high set unrestrained differential current level $I_{d.HS}$ defines the characteristic boundary. Differential currents which are higher than this value indicate internal faults (external faults are limited for example by transformer reactance) and require the fastest fault clearance. Therefore, differential protection will operate without consideration of the restraint current.

The differential operating current is calculated using the following characteristic equations:

For $I_R < I_{d.LS} / 2$	$I_d > I_{d.LS}$
For $I_{d.LS} / 2 \leq I_R \leq I_{R.S2}$	$I_d >$ Slope 1 x ($I_R - I_{d.LS} / 2$) + $I_{d.LS}$
For $I_R > I_{R.S2}$	$I_d >$ Slope 2 x ($I_R - I_{R.S2}$) + Slope 1 x ($I_{R.S2} - I_{d.LS} / 2$) + $I_{d.LS}$

High-set differential operation

The transformer differential function provides a setting “EnableHS” for unrestrained operation.

When the setting “EnableHS” is set to *On*, the start and trip decision is made regardless of the amount of measured restraining current if the measured differential current exceeds the high-set threshold $I_{d.HS}$.

When the setting “EnableHS” is set to *Off*, the high-set (unrestrained) differential operation is disabled.

Operate time delay

The transformer differential function provides a setting for time delayed trip, to allow time grading of overlapping differential protection zones. The default setting is instantaneous, meaning with no intentional time delay. In that case, start and trip signals are issued at the same time.

Supplementary features

Inrush detection

Any sudden change of magnetizing voltage will cause a magnetizing inrush. This most commonly occurs when energising a transformer (initial inrush), but it occurs also upon voltage recovery after primary system failure (recovery inrush) or voltage drop when energising a parallel transformer (sympathetic inrush).

This magnetising inrush current usually flows into one transformer winding only and is not represented at the other transformer end, hence is seen as differential current from the protection. Therefore, inrush current detection and prevention from false tripping is an inherent part of the differential protection function.

Inrush condition is determined by evaluating the ratio of the 2^{nd} harmonic to fundamental current component, based on the phase segregated differential currents. This signal analysis is executed only if the differential current is within reasonable limits:

- the fundamental of the differential current is higher than a fixed minimum current of 0.1 I_{ref}
- the differential current is smaller than a set threshold, set above the expected maximum inrush current

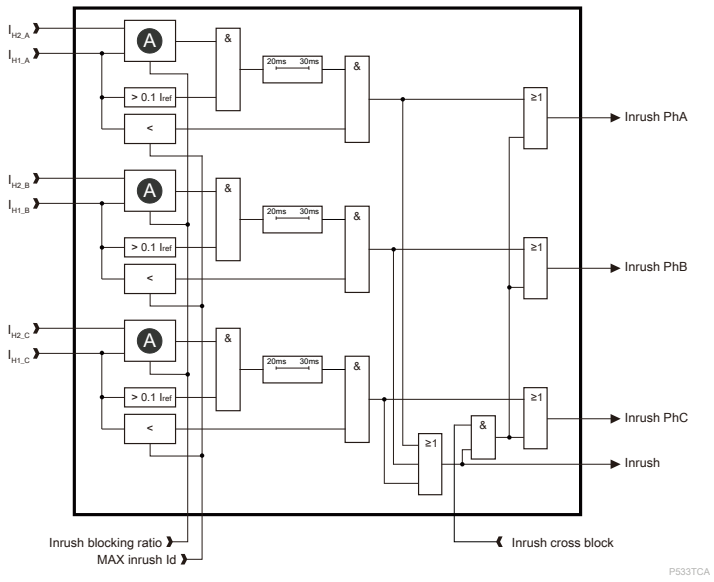
Further complementary conditions are checked prior to accepting an inrush condition:

- the differential current waveform must show gaps (namely, periods of few milliseconds with no current flow, as they are present with real inrush currents)
- the inrush waveform has to be detected in at least 2 phases (there is no three-phase transformer energisation condition, where only one phase shows an inrush waveform).

If inrush detection is enabled and an inrush condition is determined, then differential protection will be blocked.

The differential protection blocking is settable to be either phase-selective or cross-blocking.

Figure 301 - Inrush detection structure overview



A H2 / H1 > pick-up H2

Transformer overfluxing detection

If the transformer is energised with a voltage in excess of its nominal voltage, saturation effects occur which in turn cause higher magnetising currents. Without stabilisation, these could lead to differential protection tripping. The fact that the current of the protected object under saturation conditions has a high proportion of 5^{th} harmonic serves as the basis of stabilisation.

Overfluxing detection is provided as an option, based on the phase segregated differential currents. The ratio of the 5th harmonic to fundamental component of the differential current is evaluated, while the fundamental current is within a range of 0.1…4.0 I_{ref}. If this ratio is bigger than the set threshold, overflux blocking gets activated and blocks the differential protection function. As per setting, this is either phase selective or cross-blocking.

The structure overview is much similar to the figure above.

CT saturation detection

During external faults CTs may saturate, either because of very high fault currents, or because of slowly decaying DC offset of primary current. Appropriate measures are implemented to detect such conditions to prevent false differential tripping. Yet vice versa, a fast reset of this blocking feature is also provided for fast differential protection tripping in case of consecutive faults inside the protection zone.

CT supervision (differential CTS)

Generally, current transformer supervision is used to detect failure of the phase current inputs to protection relay of one or more phases. Failure of a phase CT or an open circuit of the interconnecting wiring can result in incorrect operation of any current operated element. Additionally, interruption in the AC current circuits risks dangerous CT secondary voltages being generated.

Differential CTS will operate if the following 3 conditions are simultaneously present:

- the ratio of negative to positive sequence current I_2/I_1 on one end exceeds a high set threshold (I_2/I_1 high)
- the ratio I_2/I_1 on the other end remains below a low set threshold (I_2/I_1 low)
- the positive sequence currents I_1 on both ends exceed a set threshold I_1>

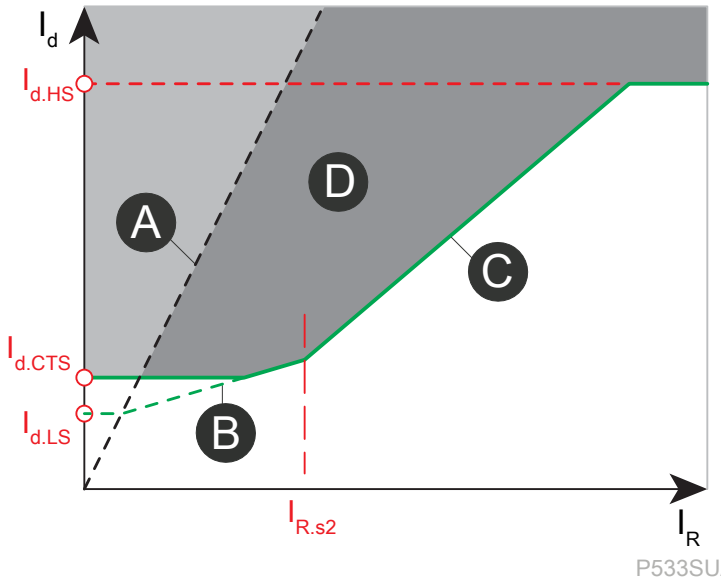
When CTS operates, it will raise its fast CTS alarm output instantaneously, while a latched CTS alarm output is issued after a set delay has expired.

As a mutual constraint, differential CTS gets blocked and its output reset if (and as long as) any inrush or overflux blocking signal is present.

Differential CTS is provided with three modes of interaction with differential protection function:

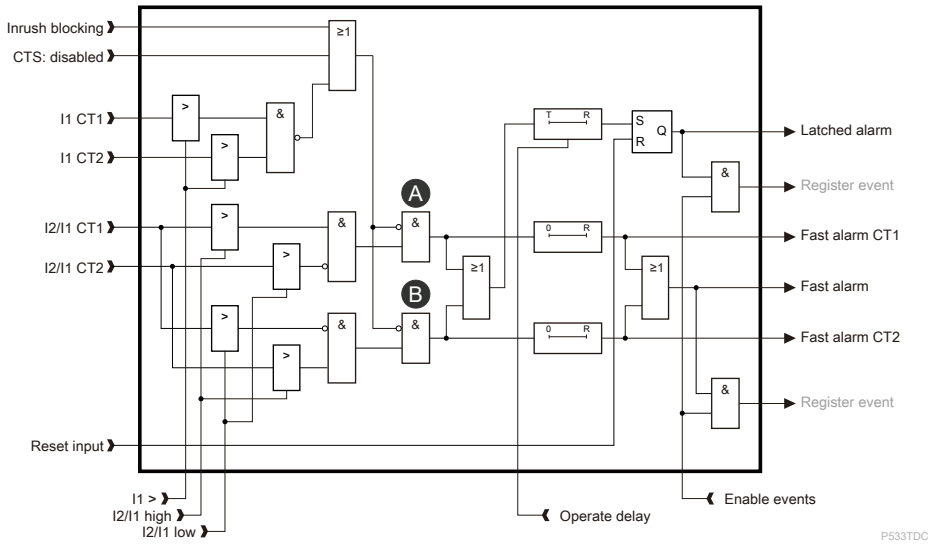
- **Indication only:** no impact of CTS alarm on differential protection operation.
- **Restraining:** the minimum differential protection pick-up value is “shifted” vertically to a set $I_{d.CTS}$ while CTS alarm is present, as shown below.
- **Blocking:** differential protection is blocked while CTS alarm is present.

Figure 302 - Biased tripping characteristic with CTS restraint



A	Characteristic for single side fed fault = 200% slope	B	Slope 1
C	Slope 2	D	Trip area

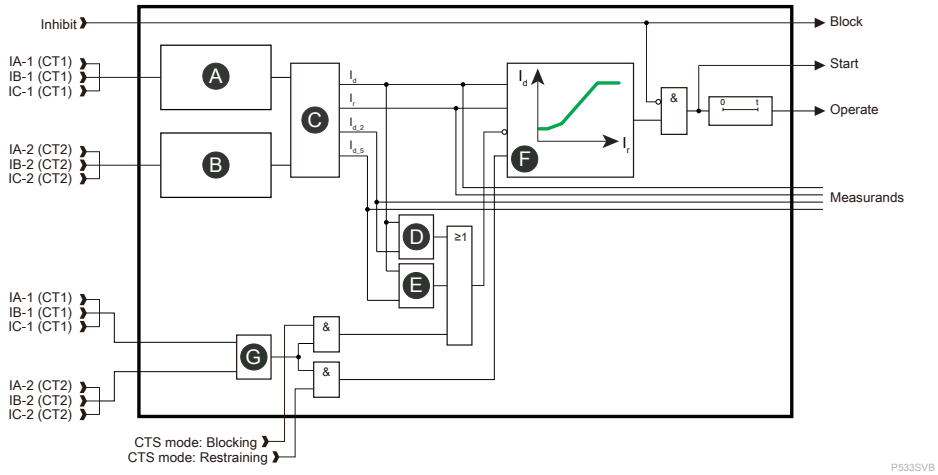
Figure 303 - CTS operate logic



A	CT1 failure	B	CT2 failure

Block diagram

Figure 304 - Transformer differential protection function structure overview



A	End 1 (CT-1) current: • Polarity adjustment • Phase swapping • Ratio correction • Zero-sequence current filtering	B	End 2 (CT-2) current: • Polarity adjustment • Phase swapping • Ratio correction • Vector group correction • Zero-sequence current filtering
C	DIFF calculation	D	Inrush detection
E	Overfluxing detection	F	Biased characteristic
G	Differential CTS		

Characteristics

Table 104 - Settings and characteristics of transformer differential protection function (ANSI 87T)

Settings/characteristics (description/label)	Values
Reference power	
Setting range	0.1...1000.0 MVA
CT-1 end rated voltage	
Setting range	0.1...500.0 kV
CT-2 end rated voltage	
Setting range	0.1...500.0 kV
Phase CT-1 polarity	
Setting range	Standard/Opposite
Phase CT-2 polarity	
Setting range	Standard/Opposite
CT-1 Phase swap	
Setting range	No swap; A-B; B-C; C-A
CT-2 Phase swap	
Setting range	No swap; A-B; B-C; C-A
Enable for T-Diff	

Table 104 - Settings and characteristics of transformer differential protection function (ANSI 87T) (Continued)

Settings/characteristics (description/label)	Values
Enable T-Diff	On/Off
Vector group	
Setting range	0…11[113]
Zero-seq. current filtering CT-1, Zero-seq. current filtering CT-2	
Enable Zero-seq. current filtering CT-1 Enable Zero-seq. current filtering CT-2	On/Off
Low set I_d	
Setting range	0.10… 3.00 I_{ref}
Resolution	0.01 I_{ref}
Accuracy	±3% or ± 0.005 I_{ref}
Reset ratio	95% ± 2%
Slope 1	
Setting range	10%…150%
Resolution	1%
I_b for start of slope 2	
Setting range	1.00…30.00 I_{ref}
Resolution	0.01 I_{ref}
Slope 2	
Setting range	30%…150%
Resolution	1%
High set mode	
Enable High set mode	On/Off
High set I_d	
Setting range	1.00…30.00 I_{ref}
Resolution	0.01 I_{ref}
Accuracy	±3% or ± 0.005 I_{ref}
Reset ratio	95% ± 2%
Bias calculation mode	
Setting range	Diff. of phasors; Sum of abs. val.
Operate delay	
Setting range	0.00…100.00 s
Resolution	0.01 s
Accuracy	±1% or ± 20 ms
Inrush blocking	
Enable Inrush blocking	On/Off
Inrush blocking ratio	
Setting range	5%…50%
Resolution	1%
Inrush cross block	
Enable Inrush cross block	On/Off

113. Phase shifting angle of an in-zone power transformer (= vector group x 30°)

Table 104 - Settings and characteristics of transformer differential protection function (ANSI 87T) (Continued)

Settings/characteristics (description/label)	Values
Max inrush current	
Setting range	2.50…30.00 I_{ref}
Resolution	0.01 I_{ref}
Overflux blocking	
Enable Overflux blocking	On/Off
Overflux blocking ratio	
Setting range	5%…100%
Resolution	1%
Overflux cross block	
Enable Overflux cross block	On/Off
CTS operating mode	
Setting range	Indication; Blocking; Restraining
CTS low set I_d	
Setting range	0.10…3.00 I_{ref}
Resolution	0.01 I_{ref}
Accuracy	±3% or ± 0.005 I_{ref}
Reset ratio	95% ± 2%
Characteristics	
Start time	< 35 ms
Disengaging time	< 50 ms
Setting group/SetGrp	
Number	4

Programmable stages (ANSI 99)

Description

For special applications dedicated protection and monitoring stages can be set up by selecting the signal to be supervised and the comparison mode. This is not to be confused with programmable IDMT curves. Programmable stages trigger an event from a selection of signals and select the type, level and timing to suit the application.

The following parameters are available:

Priority:

If operate times less than 80 ms are needed, select 10 ms. For operate times shorter than 1 s, 20 ms is recommended. For longer operation times and THD signals, 100 ms is recommended.

Input value A:

The selected supervised signal in compare conditions ">" and "<". The available signals are shown in Available signals to be supervised by the programmable stages, page 456

Input value B:

The selected supervised signal in "Diff" and "AbsDiff" mode. This selection becomes available once "Diff" or "AbsDiff" is chosen as compare condition. Available signals for selection depends on the selected input value A.

Timebase for input value A (B):

The timebase of the selected supervised signal can be set to "Instant", "200 ms", "1 min", or "demand". When the timebase "demand" is selected, the demand time window is set in the **Demand values** view of the **Measurements** menu.

Compare condition:

- > ('over...')

  Comparison of input A against exceeding the set pick-up value.
- < ('under...')

  Comparison of input A against dropping below the set pick-up value.
- Diff

  Calculated value of input A minus input B is compared against exceeding the set pick-up value, if the sign of the difference value is positive.
- AbsDiff

  Calculated absolute value of input A minus input B is compared against exceeding the set pick-up value.

Pick-up value :

Limit of the stage. The available setting range and the unit depend on the selected signal.

Operate delay:

Definite time operate delay.

Hysteresis:

Hysteresis (dead band) of the comparator function as percentage of the set threshold.

No Compare limit for mode < :

Only used in compare condition under (‘<’). This is the minimum limit to start the comparison. Signal values below this limit are disregarded. This feature prevents the programmable stage to operate on small values that could be caused by noise or signal interferences.

NOTE: The 'No Compare limit for mode <' value can only be set successfully when it is smaller than the start values in all 4 setting groups. An attempt to set it higher than the start value in any setting group is rejected, even if the setting group is not active.

Available signals

Table 105 - Available signals to be supervised by the programmable stages

Signals	Description
IA, IB, IC	Phase currents
IN	Neutral current
IN.sens	Sensitive neutral current
IN.CSH	Neutral current measured with CSH
VAB, VBC, VCA	Phase to phase voltages
VA, VB, VC	Phase to neutral voltages
VN.meas	Measured neutral voltage
VN.calc	Neutral voltage calculated from 3 phase voltages
f	Frequency
IN.calc	Neutral current calculated from 3 phase currents
I_1	Positive sequence current
I_2	Negative sequence current
I_2/I_1	Ratio of negative to positive sequence current
V_1	Positive sequence voltage
V_2	Negative sequence voltage
V_2/V_1	Ratio of negative to positive sequence voltage
VPN average	Average phase to neutral voltage
VPP average	Average phase to phase voltage
IA THD	Total harmonic distortion of current IA
IB THD	Total harmonic distortion of current IB
IC THD	Total harmonic distortion of current IC
VA THD	Total harmonic distortion of voltage VA
VB THD	Total harmonic distortion of voltage VB
VC THD	Total harmonic distortion of voltage VC
IA_{RMS}	RMS value of current IA
IB_{RMS}	RMS value of current IB
IC_{RMS}	RMS value of current IC
IN_{rms}	RMS value of earth/ground current
$IN.sens_{rms}$	RMS value of sensitive earth/ground current
$IN.CSH_{rms}$	RMS value of CSH earth/ground current

Eight independent stages

The PowerLogic P5 protection relay has eight independent programmable stages. Each programmable stage can be enabled or disabled according to the application.

Measurement functions

Primary, secondary and per unit scaling

All measurement values are shown as primary values although the PowerLogic P5 protection relay is connected with its analogue voltage and current inputs to secondary signals. Some measurement values are shown as relative values in per unit or percent. Almost all pick-up setting values are using relative scaling.

The scaling is done using the rated values of VTs and CTs, or LPVTs and LPCTs depending on the selected model order option.

Scaling settings

The scaling settings define the characteristics of measurement transformers connected to the PowerLogic P5 protection relay and determine the correct adaptation and performance of the metering and protection functions.

They are accessed via:

- eSetup Easergy Pro or web HMI **Scaling** view in **General** menu
- on local panel in the **CT- VT** view of the **General** menu

The scaling parameters are listed in List of scaling parameters, page 457.

Table 106 - List of scaling parameters

Scaling parameters	Description	Selection[114]	Value
Iprim.nom	Rated primary phase current of CT	CT	10 A to 20 kA
	Nominal current	LPCT	K x I_{pr} (automatically calculated)
Isec.nom	Rated secondary phase current of CT	CT	1 A or 5 A
Ipr	LPCT rated current corresponding to 22.5 mV at the secondary	LPCT	10 A to 5 kA
K	Current factor	LPCT	0.25 - 0.50 - 1.00 - 1.25 - 1.33 - 2.00 - 2.50 - 3.20 - 4.00 - 5.00 - 6.30 - 6.66 - 10 - 16 - 20 - 25 - 31.5
Number of connected phase CT	Number of CT	CT	IA/IB/IC, or IA/IC
IN.prim.nom	Rated primary neutral current of CT	Calculated	10 A to 20 kA (see $I_{prim.nom}$)
		CSH core balance CT according to the input selected	2 A or 20 A
		Standard earth/ground fault CT	1 A to 20 kA
IN.sec.nom	Rated secondary neutral current of CT	Calculated	1 A or 5 A (see $I_{sec.nom}$)
		CSH core balance CT	-
		Standard earth/ground fault CT	1 A, 2 A, 5A
IN.sens.prim.nom'	Rated primary neutral current of CT	Sensitive earth/ground CT primary	1 A to 20 kA
IN.sens.sec.nom	Rated secondary neutral current of CT	Sensitive earth/ground CT secondary	1 A fixed

114. Depending on the model number option.

Table 106 - List of scaling parameters (Continued)

Scaling parameters	Description	Selection[115]	Value
VT type[116]	VT type		LPVT (fixed)
Vprim.nom	Rated primary voltage of transformer	VT	100 V to 500 kV
	Nominal voltage	LPVT	75 V to 500 kV
Vsec.nom	Rated secondary voltage of transformer	VT	25 V to 250 V
Vpr	LPVT rated voltage corresponding to 3,25/√3 mV at the secondary	LPVT	50 to 500,000 V
K	Voltage factor	LPVT	0.25 to 1.5
VAMagCor[117]	VA magnitude correction	LPVT	0.9000 to 1.1000
VAAngCor[117]	VA Angle correction	LPVT	-5.0000 to 5.0000
VBMagCor[117]	VB magnitude correction	LPVT	0.9000 to 1.1000
VBAngCor[117]	VB Angle correction	LPVT	-5.0000 to 5.0000
VCMagCor[117]	VC magnitude correction	LPVT	0.9000 to 1.1000
VCAngCor[117]	VC Angle correction	LPVT	-5.0000 to 5.0000
VAyMagCor[117]	VAy magnitude correction	LPVT	0.9000 to 1.1000
VAyAngCor[117]	VAy Angle correction	LPVT	-5.0000 to 5.0000
VByMagCor[117]	VBy magnitude correction	LPVT	0.9000 to 1.1000
VByAngCor[117]	VBy Angle correction	LPVT	-5.0000 to 5.0000
VN.prim.nom	Rated primary neutral voltage of transformer	VT	Same setting as the rated primary voltage of transformer
		LPVT	Same setting as the rated primary voltage of transformer
VN.sec.nom	Rated secondary neutral voltage of transformer	VT	25 V to 240 V
Phase rotation	Phase sequence selection		A - B - C or A - C - B
Voltage measurement mode	Usage of voltage inputs for phase voltage, neutral voltage or other additional voltage	VT	3VP, 3VP+VN, 3VP/VPy, 3VP/VPPy, 2VPP +VN+VPPy, 2VPP + VN, VPP/VPPy
		LPVT	3VP, 3VP+VN, 3VP/VPy, 3VP/VPPy
fn	Nominal frequency of power system		50 Hz or 60 Hz
Power direction	Direction of the power flow		Outgoing or Incoming

NOTE: Phase and neutral CT polarity settings affect only differential protection functions (REF, DIFF).

115. Depending on the model number option.
116. Only available for LPVT board
117. When LPVT is installed in the system, a magnitude correction factor and an angle correction factor will be used to compensate the accuracy. If the LPVT is a resistor divided type, it is recommended to set magnitude to 1 and angle correction factors to 0, but if it is a capacitor divided type, then these correction factor settings should be configured according to the nameplate of the LPVT sensor.

Current values

Primary and secondary values

Table 107 - Primary and secondary scaling

	Current (CT) Neutral current calculated	Neutral current (CT)	Current (LPCT) Neutral current calculated (LPCT)
Secondary -> Primary	$I_{prim} = I_{sec} \cdot \frac{I_{prim.nom}}{I_{sec.nom}}$	$IN_{.prim} = IN_{.sec} \cdot \frac{IN_{.prim.nom}}{IN_{.sec.nom}}$	$I_{prim} = \frac{V_{sec}}{k \times 22.5\ mV} \times I_{pr}$
Primary -> Secondary	$I_{sec} = I_{prim} \cdot \frac{I_{sec.nom}}{I_{prim.nom}}$	$IN_{.sec} = IN_{.prim} \cdot \frac{IN_{.sec.nom}}{IN_{.prim.nom}}$	$V_{sec} = \frac{I_{prim}}{I_{pr}} \times k \times 22.5\ mV$

For neutral current measured by CSH core balance CTs, only primary values are considered. CTprim is equal at 2A or 20A according to the connection on the protection relay.

Examples

1. **Secondary to primary (CT)**

   CT = 500 A / 5 A

   If the current on PowerLogic P5 input is 4 A, then the corresponding primary current is Iprim = 4 x 500 / 5 = 400 A.

2. **Secondary to primary (LPCT)**

   LPCT = 100 A / 22.5 mV

   If the voltage on the LPCT input is 30 mV, then the corresponding primary current is Iprim = 30 / 22.5 x 100 = 136 A, whatever is K.

   With K = 0.25, V_{sec} corresponds to 136 / (100 x 0.25) = 5.44 I_n.

3. **Primary to secondary (CT)**

   CT = 500 A / 5 A

   If PowerLogic P5 displays Iprim = 100 A, then the injected current is

   I_{sec} = 100 x 5 / 500 = 1 A.

4. **Primary to secondary (LPCT)**

   LPCT = 100 A / 22.5 mV

   If PowerLogic P5 displays Iprim = 640 A, then the injected current is

   V_{sec} = 640 / 100 x 22.5 = 144 mV, whatever is K.

   With K = 3.2, V_{sec} corresponds to 640 / (100 x 3.2) = 2 I_n.

Per unit [pu] values

Table 108 - Per unit [pu] scaling

	Phase current (CT) scaling	Phase current (LPCT) scaling	Neutral current scaling	Neutral current (CSH) scaling
Amp -> Per unit	$I_{pu} = \frac{I_{sec}}{I_{sec.nom}}$	$I_{pu} = V_{sec} / (k \times 22.5)$	$I_{pu} = \frac{I_{sec}}{I_{sec.nom}}$	-
	$I_{pu} = \frac{I_{prim}}{I_{prim.nom}}$	$I_{pu} = \frac{I_{prim}}{I_{pr} \cdot k}$	$I_{pu} = \frac{I_{prim}}{I_{prim.nom}}$	$I_{pu} = \frac{I_{prim}}{I_{prim.nom}}$
Per unit -> Amps	$I_{sec} = I_{pu} \cdot I_{sec.nom}$	$I_{sec} = I_{pu} \times k \times 22.5$	$I_{sec} = I_{pu} \cdot I_{sec.nom}$	-
	$I_{prim} = I_{pu} \cdot I_{prim.nom}$	$I_{prim} = I_{pu} \cdot k \cdot I_{pr}$	$I_{prim} = I_{pu} \cdot I_{prim.nom}$	$I_{prim} = I_{pu} \cdot I_{prim.nom}$

Examples

1. **Secondary to per unit for phase current (CT)**

   CT = 750 A / 5 A

   If the current injected is 7 A, then the per unit current is

   I_{pu} = 7 / 5 = 1.4 pu

2. **Per unit to secondary for phase current (CT)**

   CT = 750 A / 5 A

   If the protection setting is 2.0 pu, then the corresponding secondary current is I_{sec} = 2 x 5 = 10 A.

3. **Secondary to per unit for phase current (LPCT)**

   LPCT = 100 A / 22.5 mV with K = 3.2

   If the PowerLogic P5 protection relay displays Iprim = 640 A, then the injected voltage is

   V_{sec} corresponds to 640 / (100 x 3.2) = 2 I_n.

4. **Primary to per unit for phase current (LPCT)**

   LPCT rated current = 100 A with LPCT Current factor k = 2 (45 mV at the secondary)

   If the primary current is 150 A (33.75 mV at the secondary), then the per unit current (voltage) is I_{pu} = 150/200 = 33.75/45 = 0.75 I_n.

5. **Per unit to primary and secondary value (LPCT)**

   LPCT rated current = 100 A with LPCT Current factor = 10

   If protection setting is 1.5 I_n, the corresponding secondary voltage is

   V_{sec} = 1.5 x 10 x 22.5 = 337.5 mV,

   and the corresponding primary current is

   Iprim = 1.5 x 100 x 10 = 1.5 kA.

6. **Secondary to per unit for earth/ground fault current (CT)**

   EF CT = 750 A / 1 A

   If for standard and sensitive earth/ground fault inputs the current is 30 mA, then the per unit current is

   I_{pu} = 0.03 / 1 = 0.03.

7. **Per unit to secondary for earth/ground fault current (CT)**

   EF CT = 50 A / 1 A

   If for standard and sensitive earth/ground fault inputs the protection setting is 0.1 pu, then the corresponding I_{sec} = 0.1 x 1 = 100 mA.

Calculation scenarios for CSH30

Scenario 1: The second value of standard EF CT is 1 A and fixed to 2 A CSH channel and 2 turns in CSH CT primary.

Parameters: IN.prim = 1000 A, IN.sec = 1 A, Turns = 2, IN.CSH.nom = 2 A, standard CT is connected to 2 A CSH channel

Table 109 - Calculation scenario 1

Earth fault current in primary (A)	Standard EF CT second value (A)	Standard EF CT second value (pu)	CSH CT primary value (A)	CSH CT primary value (pu)
500	0.5	0.5	0.5	0.25
1000	1.0	1.0	1.0	0.5
2000	2.0	2.0	2.0	1.0

Scenario 2: The second value of standard EF CT is 5 A and fixed to 20 A CSH channel and 4 turns in CSH CT primary.

Parameters: IN.prim = 1000 A, IN.sec = 5 A, Turns = 4, IN.CSH.nom = 20 A, standard CT is connected to 20 A CSH channel

Table 110 - Calculation scenario 2

Earth fault current in primary (A)	Standard EF CT second value (A)	Standard EF CT second value (pu)	CSH CT primary value (A)	CSH CT primary value (pu)
500	2.5	0.5	2.5	0.125
1000	5.0	1.0	5.0	0.25
2000	10.0	2.0	10.0	0.5

Voltage values

Rated phase and neutral voltage inputs

Voltage transformer scaling is always based on the phase to phase voltages in all voltage measurements modes.

The rated phase and neutral voltage inputs are defined as below:

Table 111 - Voltage rating (VT)

VT connection	VT ratio		Value for 1 pu or 100%				
	primary	secondary	PP	PN	V1	V2	VN
3VP	Vprim. nom/√3	Vsec.nom/ √3	Vpri-m. nom	Vprim. nom/√3	Vprim. nom/√3	Vprim. nom/√3	√3 x Vprim. nom
1VPP	Vprim. nom	Vsec.nom	Vpri-m. nom	-	-	-	-
2VPP	Vprim. nom	Vsec.nom	Vpri-m. nom	Vprim. nom/√3	Vprim. nom/√3	Vprim. nom/√3	-

Table 111 - Voltage rating (VT) (Continued)

VT connection	VT ratio		Value for 1 pu or 100%				
Broken delta	VN.prim. nom/√3	VN.sec. nom/√3	-	-	-	-	√3 x Vprim. nom
VPy	Vprim. nom/√3	Vprim.nom/ √3	-	Vprim. nom/√3	-	-	-
VPPy	Vprim. nom	Vprim.nom	Vpri-m. nom	-	-	-	-

NOTE: V1 and V2 are respectively the positive and the negative sequence voltages. VN is the neutral voltage (zero-sequence voltage x3).

Table 112 - Voltage rating (LPVT)

Connection	LPVT primary	LPVT secon-dary	LPVT nomi-nal volt-age	Value for 1 pu or 100%				
				PP	PN	V1	V2	VN
3VP	Vprim. nom/√3	3.25V/ √3	Vprim. nom/ √3	Vprim. nom	Vprim. nom/√3	Vprim. nom/ √3	Vprim. nom/√3	Vprim. nom/√3
Broken delta[118]	VN.prim. nom/√3	VN.sec. nom/√3	-	-	-	-	-	√3 x Vprim. nom
VPPy	Vprim. nom.y	3.25V/ √3	Vprim. nom.y/ √3	Vprim. nom.y	-	-	-	-

118. possible only with VT + LPVT adapter

Primary and secondary scaling of phase to phase voltages

Table 113 - Primary and secondary scaling of phase to phase voltages

	Phase to phase voltage measurement (PP) with VT	Phase to neutral measurement (PN) with VT	Phase to neutral voltage measurement with LPVT
Secondary –> Primary	$V_{prim} = V_{sec} \cdot \frac{V_{prim.nom}}{V_{sec.nom}}$	$V_{prim} = \sqrt{3} \cdot V_{sec} \cdot \frac{V_{prim.nom}}{V_{sec.nom}}$	$V_{prim} = 3.25 \frac{V_{prim.nom}}{V_{sec.nom}}$
Primary –> Secondary	$V_{sec} = V_{prim} \cdot \frac{V_{sec.nom}}{V_{prim.nom}}$	$V_{sec} = \frac{V_{prim}}{\sqrt{3}} \cdot \frac{V_{sec.nom}}{V_{prim.nom}}$	$V_{sec} = \frac{V_{prim}}{V_{prim.nom}} \cdot \frac{3.25}{\sqrt{3}}$

Examples

1. **Secondary to primary**

   Phase to phase voltage measurement mode (VT)

   VT = 12000 V / 110 V

   If voltage connected to the PowerLogic P5 input V_A, V_B or V_C = 100 V, then primary voltage is Vprim = 100 x 12000 / 110 = 10909 V.

   Phase to neutral voltage measurement mode (VT)

   VT = 12000 V / 110 V

   If the three phase symmetric voltage magnitude is 60 V, then the primary voltage is Vprim = √3 x 60 x 12000 / 110 = 11336 V.

2. **Primary to secondary**

   Phase to phase voltage measurement mode (VT)

   VT = 12000 V / 110 V

   If the PowerLogic P5 protection relay displays Vprim = 10910 V, then the secondary voltage is Vsec = 10910 x 110 / 12000 = 100 V.

   Phase to neutral voltage measurement mode (VT)

   VT = 12000 V / 110 V

   If the PowerLogic P5 protection relay displays
   VAB = VBC = VCA = 10910 V for a symmetric voltage system, then the secondary voltages at V_A, V_B and V_C are

   Vsec = 10910 / √3 x 110 / 12000 = 57.7 V.

3. **Phase to neutral voltage measurement mode (LPVT)**

   LPVT = 20 kV / 3.25 V with k = 0.5

   If the PowerLogic P5 protection relay displays
   VAB = VBC = VCA = 11 kV for a symmetric voltage system, then the secondary voltages V_A, V_B, and V_C are

   Vsec = 11000 / 20000 x 3.25 / √3 = 1.032 V.

Per unit [pu] scaling of phase to phase voltages

One per unit = 1 pu = 1 x Vnom = 100%, where Vnom = rated voltage of the VT.

Table 114 - Per unit [pu] scaling of phase to phase voltages

	Phase to phase voltage measurement (PP) with VT	Phase to neutral voltage measurement (PN) with VT	Phase to neutral voltage measurement with LPVT
Voltage –> Per unit	$V_{pu} = \frac{V_{sec}}{V_{sec.nom}} = \frac{V_{prim}}{V_{prim.nom}}$	$V_{pu} = \sqrt{3} \cdot \frac{V_{sec}}{V_{sec.nom}} = \sqrt{3} \cdot \frac{V_{prim}}{V_{prim.nom}}$	$V_{pu} = \frac{V_{prim}}{k \times V_{pr}}$ $V_{pu} = \frac{V_{sec}}{k \times 3.25} \times \sqrt{3}$
Per unit –> Voltage	$V_{sec} = V_{pu} \cdot V_{sec.nom}$	$V_{sec} = V_{pu} \cdot \frac{V_{sec.nom}}{\sqrt{3}}$	$V_{sec} = \frac{V_{pu} \times k \times 3.25}{\sqrt{3}}$
	$V_{prim} = V_{pu} \cdot V_{prim.nom}$	$V_{prim} = V_{pu} \cdot \frac{V_{prim.nom}}{\sqrt{3}}$	$V_{prim} = V_{pu} \times k \times V_{pr}$

Examples

1. **Secondary to per unit**

   Phase to phase voltage measurement mode

   VT = 12000 V / 110 V

   If the voltage input of V_A or V_B is 100 V, then the per unit voltage is

   Vpu = 100 / 110 = 0.91 pu.

   Phase to neutral voltage measurement mode

   VT = 12000 V / 110 V

   If the three symmetric phase to neutral injected to the voltage inputs are 63.5 V, then the per unit voltage is pu = √3 x 63.5 / 110 = 1.00 pu.

2. **Per unit to secondary**

   Phase to phase voltage measurement mode

   VT = 12000 V /110 V

   If the PowerLogic P5 protection relay displays 1.00 pu, then the secondary voltage is Vsec = 1.00 x 110 = 110 V.

   Phase to neutral voltage measurement mode

   VT = 12000 V / 110 V

   If the PowerLogic P5 protection relay displays 0.8 pu, then the three symmetric phase to neutral voltages injected to the inputs are

   Vsec = 0.8 x 110 / √3 = 50.8 V.

3. **Per unit to secondary for voltage measurement with LPVT**

   LPVT = 20 kV / 3.25 V with k = 0.8

   If the phase to neutral voltage displayed is 0.5 x Vnom, the secondary value injected to the PowerLogic P5 protection relay is 0.5 x 0.8 x 3.25 / √3 = 0.75 V.

Per unit [pu] scaling of neutral voltage

Table 115 - Per unit [pu] scaling of neutral voltage

	Neutral voltage measured	Neutral voltage calculated with VT	Neutral voltage calculated with LPVT
Voltage -> per unit	$V_{pu} = \frac{V_{sec}}{V_{sec.nom}}$	$V_{pu} = \frac{1}{V_{sec.nom}} \left\| \bar{V}_A + \bar{V}_B + \bar{V}_C \right\|_{sec}$	$V_{pu} = \frac{1}{k \times 3.25} \left\| \bar{V}_A + \bar{V}_B + \bar{V}_C \right\|_{sec}$
	$V_{pu} = \frac{V_{prim}}{V_{prim.nom}}$		$V_{pu} = \frac{1}{k \times V_{pr}} \left\| V_A + V_B + V_C \right\|_{sec}$
Per unit -> voltage	$V_{sec} = V_{pu} \cdot V_{sec.nom}$	$\left\| \bar{V}_A + \bar{V}_B + \bar{V}_C \right\|_{sec} = V_{pu} \cdot V_{sec.nom}$	$\left\| \bar{V}_A + \bar{V}_B + \bar{V}_C \right\|_{sec} = V_{pr} \cdot k \cdot 3.25$
	$V_{prim} = V_{pu} \cdot V_{prim.nom}$	$\left\| \bar{V}_A + \bar{V}_B + \bar{V}_C \right\|_{prim} = V_{pu} \cdot V_{prim.nom}$	$\left\| V_A + V_B + V_C \right\|_{prim} = V_{pu} \cdot k \cdot V_{pr}$

Examples

1. **Secondary to per unit**

   Neutral voltage measurement (VT)

   VN.sec = 110 V (this is a configuration value corresponding to VN at full ground fault.)

   If the voltage connected to the device's input V_C is 22 V, then the per unit voltage is Vpu = 22 / 110 = 0.20 pu = 20%.

   Neutral voltage calculated (VT)

   VT = 12000 V / 110 V

   If the voltage connected to the relay's input V_A is 38.1 V, while $V_B = V_C = 0$, then the per unit voltage is

   Vpu = (38.1 + 0 + 0) / (√3 x 110) = 0.20 pu = 20%.

2. **Per unit to secondary**

   Voltage measurement mode is "2PP + VN" (VT)

   VN.sec = 110 V (this is a configuration value corresponding to VN at full earth/ ground fault.)

   If the relay displays VN = 20%, then the secondary voltage at input V_C is

   Vsec = 0.20 x 110 = 22 V.

3. **Per unit to secondary**

   Neutral voltage calculated (VT)

   VT = 20 kV /110 V

   If the PowerLogic P5 protection relay displays VN = 20% and if $V_B = V_C = 0$, then the secondary voltage at V_A is Vsec = √3 x 0.2 x 110 = 38.1 V.

   Neutral voltage calculated (LPVT)

   LPVT = 20 kV / √3 / 3.25 V / √3 with k = 1.5

   If PowerLogic P5 protection relay displays 30% and $V_A = V_C = 0$, then the secondary voltage of V_B is Vsec = 0.3 x 1.5 x 3.25 / 1.732 = 0.844 V.

Reading of measurements

All measurement values can be read out via:

- Local panel: Measurements menu ( ) and on the Mimic screen if they were configured with eSetup Easergy Pro
- eSetup Easergy Pro: **Measurements** menu
- Communication interface (if the used protocol provide this)
- EcoStruxure Power Device application

The refresh interval, on automatic cyclic updates, is less than 1 second typically.

Phase currents

PowerLogic P5 measures the fundamental and RMS values of phase current inputs using 1A CTs, 5A CTs, or LPCTs:

Table 116 - Measurements of fundamental and RMS values of phase current

Value	Description
Fundamental value	
IA	Fundamental value of phase 1 current IA
IB	Fundamental value of phase 2 current IB
IC	Fundamental value of phase 3 current IC
RMS value	
IA_{rms}	RMS value of phase 1 current IA
IB_{rms}	RMS value of phase 2 current IB
IC_{rms}	RMS value of phase 3 current IC

The RMS current measurement takes into account harmonics up to the 15th. The calculation is done as follows:

$$I_{RMS} = \sqrt{I_{f1}^2 + I_{f2}^2 + ... + I_{f15}^2}$$ P533Z1A

Table 117 - Characteristics for measuring phase current

Signal	Measurement range	Unit	Resolution	Accuracy
Magnitude				
CT	0.005...60.000 Inom	A	1 A	±1% for range 1.2...1.5 Inom ±0.5% for range 0.8...1.2 Inom ±1% for range 0.3...0.8 Inom ±2% for range 0.1...0.3 Inom
LPCT	0.05...45.00 Inom	A	1 A	±1% for range 1.2...1.5 Inom ±0.5% for range 0.8...1.2 Inom ±1% for range 0.3...0.8 Inom ±2% for range 0.1...0.3 Inom
Phase angle[119]				
	-180°...+180°		0.1°	0.5° with I > 0.1Inom[120]

119. Phase angle can only be detected when current is over 100 mA.
120. Nominal CT Rating

Neutral current

The neutral current is calculated by the vector sum of the 3 phase currents or directly measured with a conventional CT or CSH core balance CT. Where the neutral current is directly measured, the PowerLogic P5 protection relay uses either the connected standard earth/ground fault input (IN) or alternatively the sensitive earth/ground fault input (IN.sens).

Table 118 - Characteristics for measuring neutral current

Signal	Measurement range	Unit	Resolution	Accuracy
IN.calc (IN calculated from 3 phase currents)	0.005...60.000 Inom	A	0.01 A	
IN.meas (IN measured with standard 1 A/5 A CT)	0.005...30.000 IN.nom	A	0.01 A	±0.5% for In > 0.05 IN.nom ±1% for range 0.02...0.05 IN.nom ±2% for In < 0.02 IN.nom
IN.meas (CSH30) (IN measured with standard 1 A/5 A CT and CSH30 interposing ring CT)	0.01...30.000 IN.nom	A	0.01 A	±2% or 0.001 IN.nom
IN.sens (IN measured with sensitive 1 A CT)	0.002...4.000 IN.sens.nom	A	0.001 A	±2% for In < 0.002 IN.sens.nom ±1% for In > 0.002 IN.sens.nom
IN.CSH (IN measured with CSH core-balance CT)	0.005...42.000 IN.CSH.nom	A	0.01 A	±2% or 0.001 IN.nom

Frequency

PowerLogic P5 protection relay determines the frequency based on the samples of an available voltage or current signal. The frequency determination will be automatically adapted to the availability and quality of the related signal inputs:

- Based on positive sequence voltage V1 or
- Based on any single phase to phase voltage or phase to neutral voltage or
- Based on currents when the voltage is not measured or below 15%Vnom.

The frequency is not measured if:

- The maximum of three phase to phase or phase to neutral voltages or positive sequence voltage V1 is less than 15% Vnom
- The maximum of three currents or positive sequence current (I1) is less than 10%Inom.

The following table provides an overview of the characteristics for frequency measurement:

Table 119 - Characteristics for frequency measurement

Characteristics	Range
Measurement range	10...72 Hz
Units	Hz
Resolution	0.001 Hz
Accuracy	± 0.01 Hz

Voltages

The PowerLogic P5 measures the fundamental and RMS values of phase to phase voltages and phase to neutral voltages.

Table 120 - Measurements of phase to phase and phase to neutral voltages

Value	Description
VA	Fundamental value of the phase to neutral voltage on phase A
VB	Fundamental value of the phase to neutral voltage on phase B
VC	Fundamental value of the phase to neutral voltage on phase C
VAB	Fundamental value of the phase to phase voltage between phase A and phase B
VBC	Fundamental value of the phase to phase voltage between phase B and phase C
VCA	Fundamental value of the phase to phase voltage between phase C and phase A
VA_{rms}	RMS value of the phase to neutral voltage on phase A
VB_{rms}	RMS value of the phase to neutral voltage on phase B
VC_{rms}	RMS value of the phase to neutral voltage on phase C
VAB_{rms}	RMS value of the phase to phase voltage between phase A and phase B
VBC_{rms}	RMS value of the phase to phase voltage between phase B and phase C
VCA_{rms}	RMS value of the phase to phase voltage between phase C and phase A

These voltages are measured with the three analogue voltage inputs VA, VB and VC.

A 4th analogue voltage input V_4 is used to measure an additional phase to phase voltage or phase to neutral voltage, which is usually used as a reference voltage for the synchronisation checking function.

V_y : fundamental value of the additional phase to phase voltage

V_{yrms} : RMS value of the additional phase to phase voltage calculated as follows:

$$V_{RMS} = \sqrt{V_{f1}^2 + V_{f2}^2 + ... + V_{f15}^2}$$ P533Z2A

For phase to phase (2VPP) connections, which can be applied for cost reasons in isolated or compensated power systems, the three phase to phase voltages are directly measured and the phase to neutral voltages are calculated taking into account the neutral voltage measurement (VN) when it is measured. Otherwise, the calculation considers a balanced power system.

For phase to neutral (3VP) connections, the three phase to neutral voltages are directly measured and the three phase to phase voltages are calculated.

Table 121 - The voltage modes and the corresponding measurements and calculated values

Voltage mode	Sensors	Voltages measured	Voltages calculated	Additional voltages
3VP	VT, LPVT	VA, VB, VC	VAB, VBC, VCA	
3VP+VN	VT	VA, VB, VC	VAB, VBC, VCA	
3VP/VPy	VT, LPVT	VA, VB, VC, VA_y[121]	VAB, VBC, VCA, VAB_y	VA'
3VP/VPPy	VT, LPVT	VA, VB, VC, VAB_y[121]	VAB, VBC, VCA	VAB'
2VPP+VN	VT	VAB, VBC	VCA, VA, VB, VC	

121. Used for synchro-check function.

Table 121 - The voltage modes and the corresponding measurements and calculated values (Continued)

Voltage mode	Sensors	Voltages measured	Voltages calculated	Additional voltages
2VPP+VN+VPPy	VT	VAB, VBC, VAB_y[122]	VA, VB, VC	VAB'
VPP/VPPy	VT	VAB, VAB_y[122]	VA, VB, VC, VBC, VCA[123]	VAB'

Depending on the phase rotation, the phase to phase values are defined according to A-B-C network: phase to neutral and phase to phase voltages, page 469 and A-C-B network: phase to neutral and phase to phase voltages, page 469:

- For voltage between phases A and B:

$$\vec{V}_{AB} = \vec{V}_A - \vec{V}_B$$ P533Z3A

- For voltage between phases B and C:

$$\vec{V}_{BC} = \vec{V}_B - \vec{V}_C$$ P533Z4A

- For voltage between phases C and A:

$$\vec{V}_{CA} = \vec{V}_C - \vec{V}_A$$ P533Z5A

Figure 305 - A-B-C network: phase to neutral and phase to phase voltages

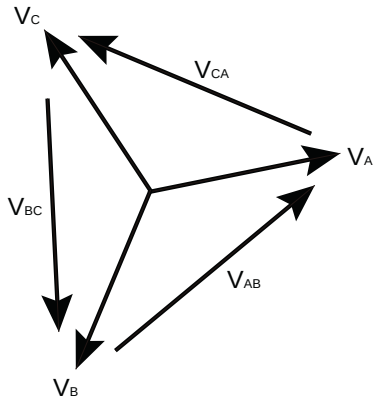


Figure 306 - A-C-B network: phase to neutral and phase to phase voltages

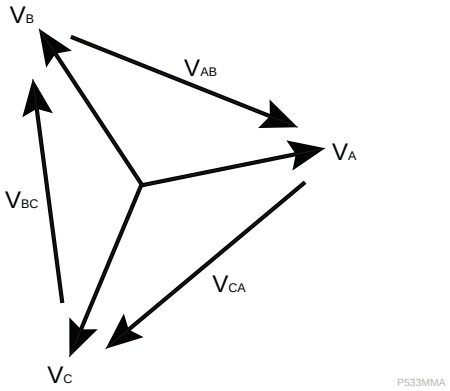


Table 122 - Characteristics for measuring voltage

Characteristics	Measurement range	Unit	Resolution	Accuracy
Magnitude	0.01...1.50 Vnom[124] 0...240 V secondary	V	1 V	± 5% from 1%...10% Vnom[124] ± 2% from 10%...20% Vnom[124] ± 1% from 20%...50% Vnom[124] ± 0.5% at 50% Vnom[124] and above
Phase angle	-180°...+180°		0.1°	0.5° with V > 0.1 Vnom[124] and I > 0.1 Inom

122. Used for synchro-check function.
123. Considering a balanced power system.
124. VT Primary nominal

Neutral voltage

The PowerLogic P5 protection relay measures the fundamental value of a neutral voltage VN by an open star/delta voltage transformer. If such a VT is not available, the protection relay is able to calculate VN by taking the internal sum of the three phase to neutral voltages:

$$\vec{V}_N = \vec{V}_A + \vec{V}_B + \vec{V}_C$$

If the calculation method is used, the measurement can only be considered as valid if the power system is balanced.

The following table provides an overview of the measuring options:

Table 123 - Neutral voltage measuring options

Voltage mode	Sensors	Measured/Calculated
3VP	VT, LPVT	VN.calc calculated[125]
3VP+VN	VT	VN.meas measured
3VP/VPPy	VT, LPVT	VN.calc calculated[125]
3VP/VPy	VT, LPVT	VN.calc calculated
2VPP+VN	VT	VN.meas measured
2VPP+VN+VPPy	VT	VN.meas measured
VPP/VPPy	VT	VN not available

The following table lists the characteristics for measuring neutral voltage:

Table 124 - Characteristics for measuring neutral voltage

Measurement range	Unit	Resolution	Accuracy
1...240 V secondary	V	1 V	1...10 V secondary: ± 5%; 10...20 V secondary: ± 2%; 20...50 V secondary: ± 1%; > 50 V secondary: ± 0.5%

125. Considering a balanced power system

Power and power factor

Active, reactive, apparent power

The PowerLogic P5 protection relay calculates the active, reactive and apparent power values of the power system based on the fundamental or RMS values of the primary three phase currents and voltages.

All power values are determined separately for each phase based on the fundamental or RMS values of related phase current and voltage signal depending on the availability.

Three phase power values can be calculated using phase to neutral voltages and phase currents as follows :

- Active power = 3·V·I·cosφ
- Reactive power = 3·V·I·sinφ
- Apparent power = 3·V·I

According to the transformers used, power calculations are based on the 2 or 3 wattmeter method.

The 2 wattmeter method is only accurate when there is no neutral current (i.e. balanced power system is), but it is not applicable if the neutral is distributed.

The 3 wattmeter method gives an accurate calculation of 3-phase as well as per phase powers in all cases, regardless of whether or not the neutral is distributed.

Table 125 - Power calculation

Voltage measurement mode	Voltage transformer	Voltages used	Currents used (acc. to connected phase CTs)	P, Q, S calculation method	Power per phase (Px, Qx, Sx with x = A,B, C)
3VP 3VP/ VPy 3VP/VPPy 3VP+VN	VT, LPVT	VA, VB, VC	IA, IB, IC	3 wattmeter	Available
			IA, IC	2 wattmeter	Not available
2VPP+ VN 2VPP+ VN + VPPy	VT	VAB,VCB,VN	IA, IB, IC	3 wattmeter	Available
			IA, IC	2 wattmeter	Not available
VPP/VPPy	VT	VAB	IA, IB, IC	3 wattmeter	Available
			IA, IC	2 wattmeter	Not available

Power calculation

The power values are calculated in detail as follows:

- By 3 wattmeter method:

$$P = \vec{V}_A \cdot \vec{I}_A \cdot cos\,(\vec{V}_A \cdot \vec{I}_A) + \vec{V}_B \cdot \vec{I}_B \cdot cos\,(\vec{V}_B \cdot \vec{I}_B) + \vec{V}_C \cdot \vec{I}_C \cdot cos\,(\vec{V}_C \cdot \vec{I}_C)$$ P533Z6B

$$Q = \vec{V}_A \cdot \vec{I}_A \cdot sin\,(\vec{V}_A \cdot \vec{I}_A) + \vec{V}_B \cdot \vec{I}_B \cdot sin\,(\vec{V}_B \cdot \vec{I}_B) + \vec{V}_C \cdot \vec{I}_C \cdot sin\,(\vec{V}_C \cdot \vec{I}_C)$$ P533Z7B

- By 2 wattmeter method:

$$P = \vec{V}_{AB} \cdot \vec{I}_A \cdot cos\,(\vec{V}_{AB} \cdot \vec{I}_A) + \vec{V}_{CB} \cdot \vec{I}_C \cdot cos\,(\vec{V}_{CB} \cdot \vec{I}_C)$$ P533Z8B

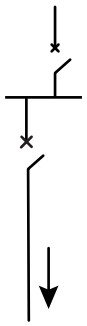
$$Q = \vec{V}_{AB} \cdot \vec{I}_A \cdot sin\,(\vec{V}_{AB} \cdot \vec{I}_A) + \vec{V}_{CB} \cdot \vec{I}_C \cdot sin\,(\vec{V}_{CB} \cdot \vec{I}_C)$$ P533Z9B

NOTE: If just one phase to phase voltage is measured (voltage measurement mode “VPP/VPPy”), then a symmetric 3-phase voltage system is assumed to calculate the non-measured voltages.

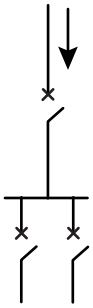
- $$S = \sqrt{P^2 + Q^2}$$ P533ZAA

According to standard practice, it is considered that[126]:

- For the outgoing circuit:
  - Power supplied by the busbars is positive
  - Power supplied to the busbars is negative


P533MOB

- For the incoming circuit:
  - Power supplied to the busbars is positive
  - Power supplied by the busbars is negative


P533MNB

Cosφ and power factor

PowerLogic P5 protection relay calculates:

- cosφ, tanφ, the angle φ and power factor values of the power system.
- cosφ and power factor values of the phase, depending on their availability of phase current and voltages.

cosφ, tanφ and the angle φ express the phase displacement between the phase currents and phase to neutral voltages.

The power factor is defined by:

$$Cos\varphi = P \Big/ \sqrt{P^2 + Q^2}$$ P533ZBA

The + and - signs of cosφ give the direction of power flow.

The IND (inductive) and CAP (capacitive) indications of the power factor give type of load.

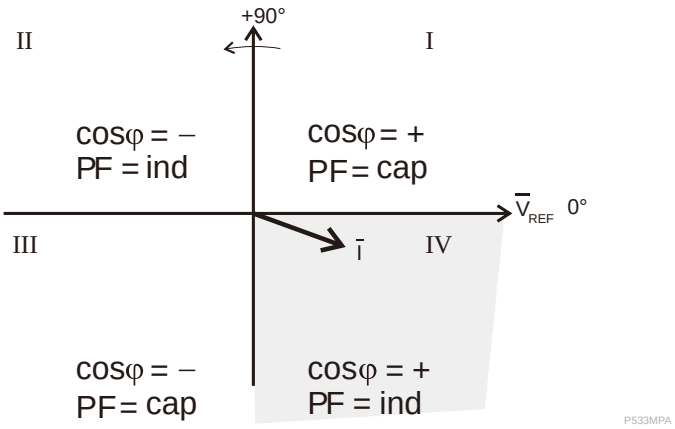
Power and current direction

This figure shows the concept of three-phase current direction and sign of cosφ and power factor PF (the absolute value is equal to cosφ, and the indication 'IND'

126. Choice to be set in the Scaling view of the General menu.

means inductive i.e. lagging current and 'CAP' means capacitive i.e. leading current).

Figure 307 - Quadrants of voltage/current phasor plane



I: Forward capacitive power current is leading

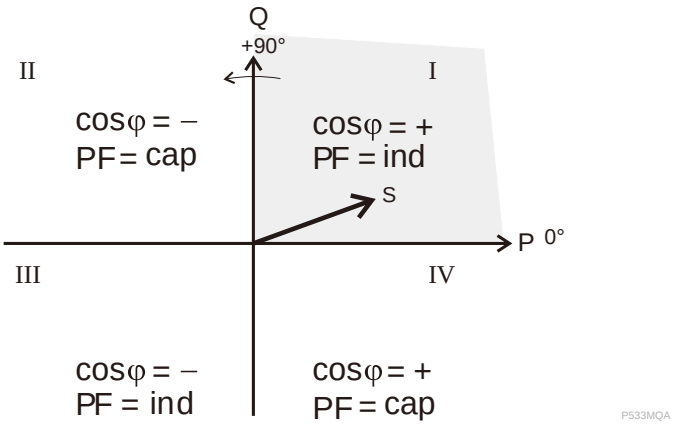
II: Reverse inductive power current is leading

III: Reverse capacitive power current is lagging

IV: Forward inductive power current is lagging

This figure below shows the same concepts on a PQ-power plane.

Figure 308 - Quadrants of power plane



I: Forward inductive power current is lagging

II: Reverse capacitive power current is lagging

III: Reverse inductive power current is leading

IV: Forward capacitive power current is leading

Table 126 - Power quadrants

Power quadrant	Current related to voltage	Power direction	Cosφ	Power factor PF
+ inductive	Lagging	Forward	+	IND
+ capacitive	Leading	Forward	+	CAP
- inductive	Leading	Reverse	-	IND
- capacitive	Lagging	Reverse	-	CAP

Characteristics

The following tables summarise the characteristics for power measuring:

Table 127 - Characteristics for power measuring (part 1)

Characteristics	Active power	Reactive power	Apparent power
Units	kW	kvar	kVA
Resolution	0.1 kW	0.1 kvar	0.1 kVA
Accuracy	±1% Snom typically[127]	±1% Snom typically[127]	±1% Snom typically[127]

Table 128 - Characteristics for power measuring (part 2)

Characteristics	Power factor	Cosφ	Tanφ	Angle φ
Measurement range	0 to 1 IND/CAP	-1 to +1		
Resolution	0.01	0.01	0.01	0.01
Accuracy	0.01[128]	0.01[128]		

127. Snom= √3 Vprim.nom Iprim.nom
128. For measurements at Inom, Vnom, cosφ > 0.8.

Active and reactive energy

The PowerLogic P5 protection relay measures the following active and reactive energy values, calculated on basis of the first three voltages and phase currents IA, IB and IC measured according to the related current flow for an outgoing feeder:

- E+: the accumulated active energy exported
- E-: the accumulated active energy imported
- Eq+: the accumulated reactive energy exported
- Eq-: the accumulated reactive energy imported

It is based on fundamental values or RMS values. The choice is done with the **Energy calculation mode** parameter.

The resolution of each energy counter can be defined by setting from 1 K unit to 1 M unit, by setting the number of decimal places of the value calculated.

When the apparent energy counter reaches 1 TVAh, the active and reactive energy counters reset to zero. To monitor the energy consumption on a feeder, a dedicated energy counter can be set up over a defined time window of between 10 minutes and 24 hours.

All the energy counter settings can be done:

- with eSetup Easergy Pro in the **Energy** view of the **Measurements** menu
- on local panel in the **Measurement** menu

The accumulated energy values are maintained when the PowerLogic P5 protection relay is powered off.

Table 129 - Characteristics of active and reactive energy measuring

Characteristics	Active power	Reactive power
Measurement range	999999.999 MWh	999999.999 MVArh
Units	MWh	MVArh
Resolution (self-adaptable)	0.001...1 MWh	0.001...1 MVArh
Accuracy	± 1% typical[129]	

129. At In, Vnp, cosφ > 0.8

Harmonics and Total Harmonic Distortion (THD)

The total harmonic distortion (THD) is calculated as a percentage of all the currents and voltages measured in relation to the base value of the fundamental frequency.

The device calculates the value from the 2nd to the 15th harmonic of each phase current and voltage signal separately and as total value.

The harmonic distortion is calculated as follows:

$$THD = \frac{\sqrt{\sum_{i=2}^{15} h_i^{\,2}}}{h_1}$$

P533ZCA

where

h_1 = Fundamental value

h_2 - h_{15} = Harmonics

Example

h_1 = 100A, h_3 = 10 A, h_7 = 3 A, h_{11} = 8 A

$$THD = \frac{\sqrt{10^2 + 3^2 + 8^2}}{100} = 13.15\%$$

P533ZDA

For reference, the RMS value is

$$RMS = \sqrt{100^2 + 10^2 + 3^2 + 8^2} = 100.9\ A$$

P533ZEA

Demand values

The PowerLogic P5 protection relay calculates average demand values of phase currents IA, IB, IC and power values S, P and Q. They are calculated over an adjustable demand time in a range from 10 to 60 minutes.

The parameters used to configure or control the demand values in the **MEASUREMENTS** menu/**Demand values** sub-menu of eSetup Easergy Pro are the following:

Table 130 - Demand value parameters

Parameter	Unit	Description
Demand time	min	Demand time (averaging time)
Fundamental frequency values		
IAda	A	Demand of phase current IA
IBda	A	Demand of phase current IB
ICda	A	Demand of phase current IC
Pda	kW	Demand of active power P
PFda	-	Demand of power factor PF
Qda	kvar	Demand of reactive power Q
Sda	kVA	Demand of apparent power S
RMS values		
IARMSda	A	Demand of RMS phase current IA
IBRMSda	A	Demand of RMS phase current IB
ICRMSda	A	Demand of RMS phase current IC
Prmsda	kW	Demand of RMS active power P
Qrmsda	kvar	Demand of RMS reactive power Q
Srmsda	kVA	Demand of RMS apparent power S

Table 131 - Resetting to zero

Characteristics	Range
Demand time	10...60 min
Currents	see Phase currents, page 466
Powers	see Power and power factor, page 471

Minimum and maximum values

Minimum and maximum values for many measurements are available through the user interfaces (HMI, eSetup Easergy Pro, Web HMI or communications protocols). Each record of minimum or maximum value includes a time stamp. This time stamp is reset either when a clear command (ClrMax) is applied or by a product restart.

The available values are listed in the following table:

Table 132 - Available minimum and maximum values

Min & Max measurement	Description
IA, IB, IC	Phase current, fundamental frequency value
IA_{RMS}, IB_{RMS}, IC_{RMS}	Phase current, RMS value

Table 132 - Available minimum and maximum values (Continued)

Min & Max measurement	Description
IN, IN'	Earth/ground fault overcurrent, fundamental value
VA, VB, VC	Voltages, fundamental frequency values
VA_{RMS}, VB_{RMS}, VC_{RMS}	Phase to neutral voltages, RMS value
VAB, VBC, VCA	Phase to phase voltage
VAB_{RMS}, VBC_{RMS}, VCA_{RMS}	Phase to phase voltage, RMS value
VN	Neutral voltage
f	Frequency
P, Q, S	Active, reactive, apparent power
PF	Power factor

The clearing parameter "ClrMax" is a common reset for all min. and max. values.

Table 133 - Parameters

Parameter	Value	Description	Note
ClrMax	-; Clear	Reset all minimum and maximum values	Settable[130]

A ClrMax command can be initiated as below:

- with "Clear min & max" parameter in the **Measurements** menu in eSetup Easergy Pro
- with "Clear min & max" parameter in the **Measurements** menu in the Web HMI
- from the local panel with the "Clr Max" parameter
- With a suitably configured DI
- with virtual inputs / outputs according to the setting of the "DI to clear min & max" parameter

In addition any action that results in a restart of the PowerLogic P5 protection relay will also clear the min/max values. This includes power cycling and certain configuration updates.

130. An editable parameter (password needed).

Average current

The PowerLogic P5 protection relay calculates the average of the three phase currents IA + IB + IC over a period of time defined by the “Average current window” setting, in the **3_Phase Average current** view of the **Measurements** menu in eSetup Easergy Pro.

Table 134 - 3_Phase Average current

Parameter	Value	Description
Average current window	1 s; 1 min; Demand Time	Time for calculating the average current

If the “Average current window” is set to “Demand Time”, the setting value will depend on the “Demand time” setting, which is configured in the **Demand values** view of the **Measurements** menu.

Table 135 - Demand values

Parameter	Range	Description
Demand time	10...60 min	Demand time (averaging time)

The average current is refreshed each second when the “ Average current window” is set to “1 s”, and it is refreshed each minute when the “Average current window” is set to “1 min” or “Demand Time”.

The average current is available in eSetup Easergy Pro and all communication interfaces.

Voltage sags and swells

The PowerLogic P5 protection platform provides many power quality functions that can be used to evaluate, monitor and alarm on the current power system quality. Two of the most important power quality functions are the voltage sag and swell monitoring.

The PowerLogic P5 protection relay provides separate monitoring logs for sags and swells. The voltage log is triggered if any voltage input either goes under the sag limit (V<) or exceeds the swell limit (V>). There are four registers for both sags and swells in the fault log. Each register will have start time, phase information, duration, minimum, average and maximum voltage values of each sag and swell event. Furthermore, there are total number of sags and swells counters as well as total timers for sags and swells.

The voltage sags and swells monitoring function can be read and set:

- on local panel, through **Measures** menu, under **"Voltages"** sub-menu, in the view of **Voltage sag & swell**
- with eSetup Easergy Pro, under the **Measurements** menu, in the view of **Voltage sag & swell**

Measurement mode

There are 3 selections in drop menu: *Ph-Ph*, *Ph-G* and *Default*, stand for different types of measured voltage.

- Ph-Ph: phase to phase voltage
- Ph-G: phase to ground voltage
- Default: use the setting of “Voltage mode” from system setting.

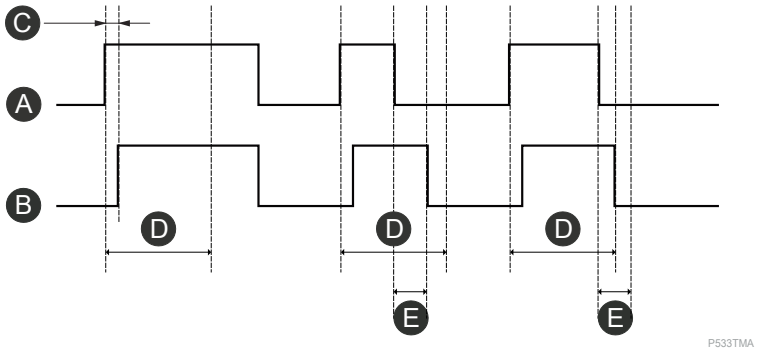
SSW maximum time and SSW gap time

These 2 settings define how to end the Voltage swell signal.

As shown in following chart:

- When Voltage > “Voltage swell limit” is fulfilled, Voltage swell signal will be activated after a delay time. SSW maximum timer starts.
- In case of Voltage > “Voltage swell limit” is continued, Voltage swell signal will also be activated in continue.
- When Voltage > “Voltage swell limit” ends, SSW gap timer starts. Voltage swell signal will be ended either SSW maximum timer or SSW gap timer reaches the set value.

Figure 309 - Example of SSW maximum time and SSW gap time



A	Voltage > “Voltage swell limit”	B	Voltage swell signal
C	Delay time	D	SSW maximum time
E	SSW gap time		

Table 136 - Setting and characteristics of voltage sags and swells monitoring

Setting/characteristics	Values
Measurement mode	
Options	Default (same as the scaling setting); Ph-Ph; Ph-G
Voltage sag limit	
Setting range	10%...120% U_n[131]
Resolution	1% U_n[131]
Accuracy	±0.5 V or 3% of the set value
Reset ratio	103%
Voltage swell limit	
Setting range	10%...150% U_n[131]
Resolution	1% U_n[131]
Accuracy	±0.5 V or 3% of the set value
Reset ratio	97%
DT delay time	
Setting range	0.06...1.00 s
Resolution	0.02 s
Accuracy	±1% or ±30 ms
Low voltage blocking	
Setting range	0...50% U_n[131]
Resolution	1% U_n[131]
Accuracy	±5% of the set value
Maximum time	
Setting range	10...1000 s
Resolution	1 s
Gap time	
Setting range	0.00...5.00 s
Resolution	0.01 s
Characteristic time	
Disengaging time	< 60 ms

131. VT Primary nominal

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 the IEC 60751 and DIN 43760 standards
- Nickel 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).

In the event of a fault, the display of the value is inhibited.

The associated monitoring function generates a maintenance alarm.

Readout

The measurements may be accessed via:

- **RTD** view of the **Measures** menu on the local panel of the PowerLogic P5 protection relay
- **Temperature** view of the **MEASUREMENTS** menu in eSetup Easergy Pro
- The communication link

Characteristics

Table 137 - Characteristics of temperature measuring

Characteristics	Values
Range	-30...+200°C (-22...+392°F)
Resolution	1°C (1°F)
Accuracy	±1°C for +20...+140°C (±1.8°F for +68...+284°F); ±2°C for -30...+20°C (±3.6°F for -22...+68°F); ±2°C for +140...+200°C (±3.6°F for +284...+392°F)
Refresh interval	5 seconds (typical)

Accuracy derating according to wiring (connection in 3-wire mode)

The deviation Δt is proportional to the length of the connector and inversely proportional to the connector cross-section:

$$\Delta t\,(^{\circ}\mathrm{C}) = 2 \times \frac{L\,(km)}{S\,(mm^2)}$$

P533ZFA

- ±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)

Control functions

Digital outputs

Description

Digital outputs are available for control and signalling purposes.

The number of available outputs depends on the number and type of board options ordered.

The following digital output contact relays are available:

- **Slot B**

  The digital output DO1 is normally opened (NO) contact (and high speed high break contact for P5x30 only) used for control. The digital output DO2 (Change Over contact) is usually used for control.

  The digital output DO3 (Normal Open) is usually used for control.

  The digital output DO4 (change over contact) is dedicated to the watchdog (signalling).

  Both the tripping DO2 relay and the watchdog relay have normally open (NO) or normally closed (NC) contacts. Refer to Selecting the trip command and examples of use, page 520.

- **Slot C, D, E (6I4O option)**

  The digital outputs DO1 to DO4 (Normal Open single pole single throw) are for signalling only.

  Slot C, D, E (5I5O option)

  The digital outputs DO1 and DO2 (Change Over contact single pole double throw) are usually used for control.

  The digital outputs DO3 (Normal Open single pole single throw) are for control.

  The digital outputs DO4 and DO5 are normally opened (NO) contact and high speed high break contact used for control.

  Slot C, D, E (12I4O option)

  The digital outputs DO1 to DO4 are independently controlled normally open signalling contacts with DO1 & DO2 and DO3 & DO4 having a common connection point.

- **Slot D, E (Arc-flash option)**

  The digital output DO1 (Normal Open) is usually used for control.

  The digital output DO2 (Change Over contact single pole double throw) is usually used for control.

  The digital output DO3 (Normal Open single pole single throw) is usually used for signalling.

  The contacts are (SPST) normal open (NO) type, except signal relay DO2 and DO4 (watchdog) which has a changeover contact (SPDT).

  The digital outputs can be set in Normal Open or Normal Close position with eSetup Easergy Pro and Web HMI in the **Relays polarity** view of the **Control** menu.

The status of the digital outputs can be read:

- with eSetup Easergy Pro in the **Relays** view of the **Device/Test** menu
- by the local panel in the **digital output Slot x** view under the menu option **DO** of the **Device/Test** sub-menu
- EcoStruxure Power Device application
- Web HMI

Label and description texts can be edited with eSetup Easergy Pro or the Web HMI in **Names for output relays** view according to the demand. Labels are the short parameter names used on the local panel display and descriptions are the longer names used by eSetup Easergy Pro (the **Names of the output relays** view in the **Control** menu).

Any internal signal can be connected to the output relays using the output matrix. An output relay can be configured as latched or non-latched. (see **Output Matrix** view in the **Matrix** menu of eSetup Easergy Pro and Web HMI).

Forced control of digital outputs

For tests purposes, first set the **IED Mode** to **Test:**

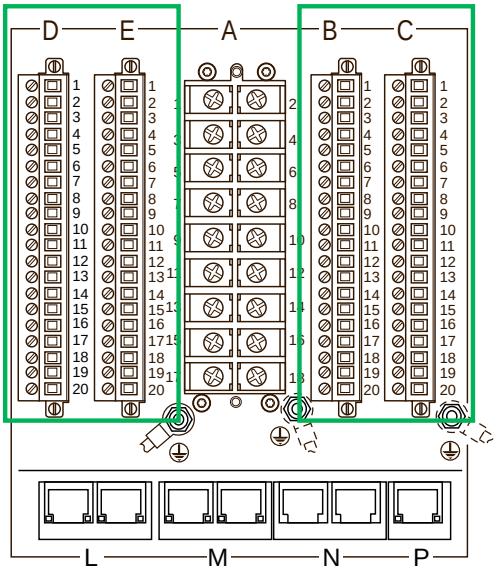
- with eSetup Easergy Pro in the **System info** setting view of the **General** menu
- by local panel in the **Device/Test** menu under the **Test** menu option

See Mode of use for testing purposes, page 258 for more information.

Default numbering of digital outputs

Every option card and slot has default numbering. Below is an example of PowerLogic P5x30 showing default numbering of DOs.

Figure 310 - Default numbering of digital outputs for PowerLogic P5x30



P533NCA

Table 138 - Example of digital outputs numbering

Option boards	Slot B	Slot C	Slot D[132]	Slot E[132]
No option	DO1...DO3 + WD			
1 x 6I/4O	DO1...DO3 + WD	DO1...DO4		
2 x 6I/4O	DO1...DO3 + WD	DO1...DO4	DO1...DO4	
3 x 6I/4O	DO1...DO3 + WD	DO1...DO4	DO1...DO4	DO1...DO4

132. For PowerLogic P5x30 only

Table 138 - Example of digital outputs numbering (Continued)

Option boards	Slot B	Slot C	Slot D[133]	Slot E[133]
1 x 6I/4O +1 x Arc-flash	DO1...DO3 + WD	DO1...DO4	DO1...DO3	
2 x 6I/4O +1 x Arc-flash	DO1...DO3 + WD	DO1...DO4	DO1...DO3	DO1...DO4
1 x 6I/4O +2 x Arc-flash	DO1...DO3 + WD	DO1...DO4	DO1...DO3	DO1...DO3

Characteristics

Table 139 - Characteristics of the digital outputs

Parameter	Value	Description	Note
DO1...DOn	0; 1	Status of the digital outputs: • 0 = Digital output not energised • 1 = Digital output is set active The available parameter list depends on the number and type of the I/O cards.	Editable when IED mode is set to "Test".
Mode	NO NC	Normal open Normal close	Editable when IED mode is set to "Test".
IED mode	Normal Test Test-block	In **Test** mode, digital output forcing is enabled for test purposes.	Editable parameter (password needed)
Name of output relays			
Label	String of max. 16 characters	Short name for digital outputs on the local display. Default is "DO1...DOx". x is the maximum number of the digital outputs.	Editable parameter (password needed)
Description	String of max. 32 characters	Long name for digital outputs. Default is "Digital output 1...Digital output x". x is the maximum number of the digital outputs.	Editable parameter (password needed)

133. For PowerLogic P5x30 only

Digital inputs

⚠WARNING

FIRE

Do not connect power greater than 0.5 W to each digital input for ambient temperature lower than 70°C (158°F), or 0.8 W for lower than 45°C (113°F).

Failure to follow these instructions can result in death, serious injury, or equipment damage.

Digital inputs are available for control purposes. For example, the digital inputs can provide the position of the circuit breaker and make it possible to change setting group, block/enable/disable functions, program logic, and indicate object status.

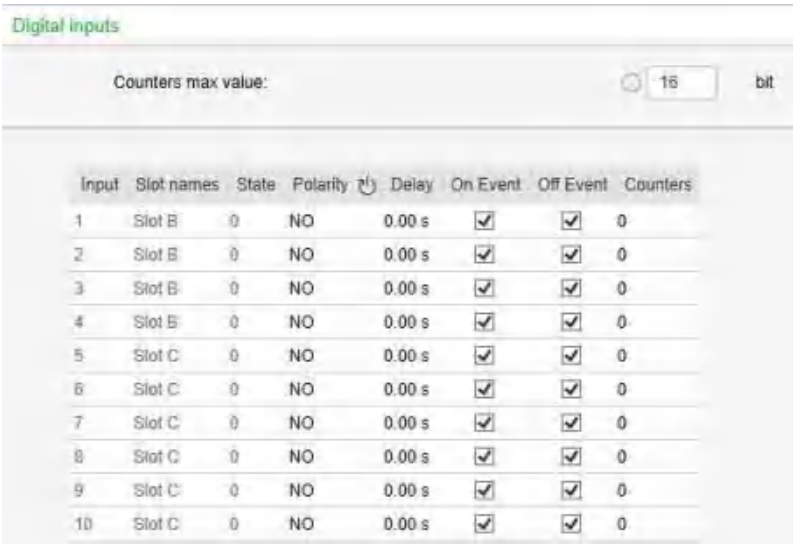
The number of available inputs depends on the number and type of option boards.

The digital inputs require an external control voltage (AC or DC) and are activated after the voltage exceeds the pick-up threshold. Deactivation follows when the voltage drops below the drop-off threshold limit.

Configuring the digital inputs

The digital inputs are set with eSetup Easergy Pro and Web HMI in the **Digital Inputs** view of the **Control** menu. They are not settable on the local panel.

Figure 311 - The Digital inputs setting section in the Digital inputs view

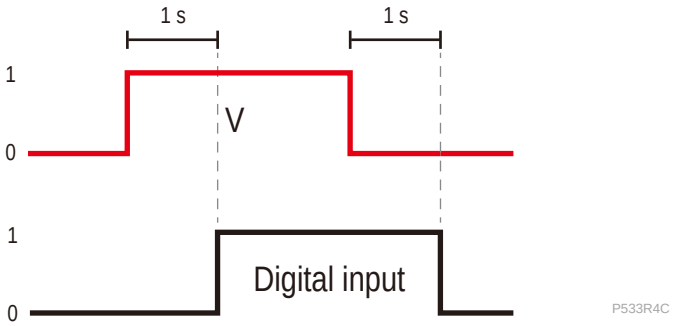


The settable items includes:

- Polarity
- Delay
- On event
- Off event
- Counter

Digital input delay determines the activation and de-activation delay for the digital input. It is used for both On and Off transitions. Digital inputs behaviour when delay is set to 1 second, page 487 shows how the digital input behaves when the delay is set to 1 second.

Figure 312 - Digital inputs behaviour when delay is set to 1 second



Digital inputs on/off events and alarm pop-up message display can be enabled and disabled in **Digital inputs** setting view of eSetup Easergy Pro or Web HMI.

Individual operation counters are located in the same view as well. The maximum value of the counters is settable and is the same for all counters.

The status of the digital inputs can be read:

- with eSetup Easergy Pro and Web HMI in the **Digital inputs** view of the **CONTROL** menu
- by local panel in the **Digital inputs** view of the **DI** menu option in the **Control** menu
- EcoStruxure Power Device application
- Communication according to the protocol

The configuration of the digital inputs in eSetup Easergy Pro is common for all digital inputs on the same board.

Figure 313 - The DI Configuration section in the Digital inputs view

DI configuration

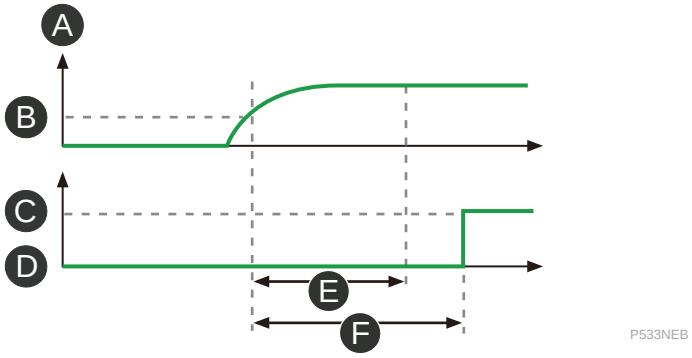
Slot Names	Mode	Nominal voltage	Pick up	Drop off	Debounce
Slot B	Universal	220.0 V	9 %	6 %	10 ms
Slot C	Universal	220.0 V	9 %	6 %	10 ms

The digital inputs can be set for the following voltage values with pre-defined setting values or settable values:

- Universal (by default)
- Standard AC or DC voltages (24 V DC, 48 V DC, 110 V DC, 220 V DC and 220 V AC)
- Customisable AC (settable from 90 V AC to 230 V AC), customisable DC (settable from 24 V DC to 220 V DC)

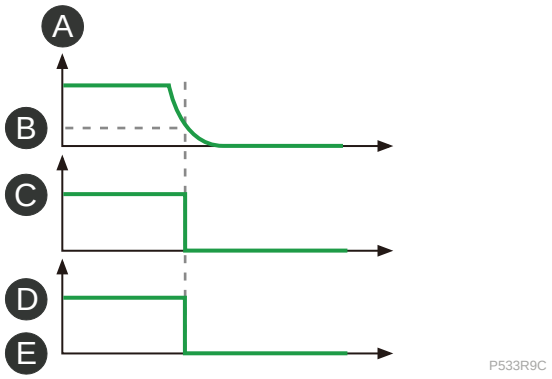
Timing diagram of a digital input during pick-up, page 488 and Timing diagram of a digital input during a drop-off, page 488 below illustrate the timing diagrams of a digital input during pick-up and drop-off:

Figure 314 - Timing diagram of a digital input during pick-up



A	Nominal voltage	B	Pick up value
C	Input seen as high level	D	Input seen as low level
E	Inrush time	F	Debounce time

Figure 315 - Timing diagram of a digital input during a drop-off



A	Nominal voltage	B	Drop-off value
C	Holding current	D	DI high
E	DI low		

Label and description texts can be edited with eSetup Easergy Pro according to the demand. Labels are the short parameter names used on the local panel and descriptions are the longer names used by eSetup Easergy Pro.

The digital input signals can be connected to the different outputs of the **Output matrix**, **Block matrix**, **Object block matrix**, **Auto-recloser 79 matrix** views in the **MATRIX** menu of eSetup Easergy Pro and Web HMI or used in the custom logic function.

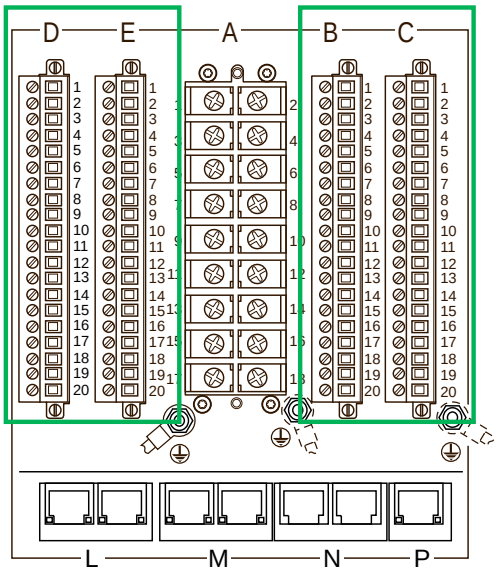
Default numbering of digital inputs

Every option card and slot has default numbering. After making any changes to the numbering, read the settings from the relay after the relay has rebooted.

Below is an example of PowerLogic P5x30 showing default numbering of digital inputs.

User can change the numbering of the following option cards - slot B, C, D, E.

Figure 316 - Default numbering of digital inputs for PowerLogic P5x30



P533NGA

Table 140 - Example of digital inputs numbering

Option boards	Slot B	Slot C	Slot D[134]	Slot E[134]
No option	DI1...DI4			
1 x 6I40	DI1...DI4	DI1...DI6		
2 x 6I40	DI1...DI4	DI1...DI6	DI1...DI6	
3 x 6I40	DI1...DI4	DI1...DI6	DI1...DI6	DI1...DI6
1 x 6I40 +1 x Arc-flash	DI1...DI4	DI1...DI6	DI1...DI3	
2 x 6I40 +1 x Arc-flash	DI1...DI4	DI1...DI6	DI1...DI3	DI1...DI6
1 x 6I40 +2 x Arc-flash	DI1...DI4	DI1...DI6	DI1...DI3	DI1...DI3

Characteristics

Table 141 - Characteristics of the digital inputs

Parameter	Value		
	Universal	Standard voltage	Customisable voltage
Mode	Universal (value by default)	24 V DC; 48 V DC; 110 V DC; 220 V DC; 220 V AC	Custom 24 V DC to 250 V DC; Custom 90 V AC to 230 V AC
Pick-up ratio	> 19 V	70%	40%...80%, 154 V max.
Drop-off ratio	< 12 V	60%	20%...60%, 12 V min.
Holding current	1.3 mA	2.3 mA (V ≤ 110 V) 1.3 mA (V > 110 V)	1...27 mA
Debounce time	0...100 ms		
State	0; 1		
Polarity position	NO; NC		
Power maximum	0.5 W for ambient temperature less than 70°C (158 °F); 0.8 W for ambient temperature less than 45°C (113 °F);		
Delay	0.00...60.00 s		

134. For PowerLogic P5x30 only

Table 141 - Characteristics of the digital inputs (Continued)

Parameter	Value		
	Universal	Standard voltage	Customisable voltage
On event	No; Yes		
Off event	No; Yes		
Counters	0 to 255 - 511 - 1023 - 2047 - 4095 - 8191 - 16383 - 32767 - 65535 Reset automatically to 0 if the limit is exceeded.		
Counter max value	Setting range is 8 to 16 bit counter		
Name of digital inputs	Label: short name for display on the local panel. String of max. 10 characters. Default is "DI1...DIx".		
	Description: long name for display in eSetup Easergy Pro or HMI String of max. 32 characters. Default is "Digital input 1...Digital input x".		

NOTE: Digital inputs can be assigned to a signal with normal state or inverted state.

Virtual inputs and virtual outputs

There are virtual inputs and virtual outputs that can, in many places, be used like their hardware equivalents except that they are located in the memory of PowerLogic P5. Virtual inputs can be used in many operations act like normal digital inputs such as: enable changing setting groups, block/enable/disable functions, program logics, and so on.

Virtual inputs can be selected to operate by the function buttons on local panel, the local mimic, communication or simply by using the **Virtual input** menu of eSetup Easergy Pro or Web HMI.

The activation and reset delay of virtual inputs/outputs is about 5 ms.

The status of virtual inputs and outputs can be read:

- with eSetup Easergy Pro in the **Virtual inputs** views of **CONTROL** menu and **Virtual outputs** views of **Device/Test** menu
- by local panel in **Virtual inputs** or **Virtual outputs** view of **Control** menu
- EcoStruxure Power Device application
- web HMI
- communication depending on the protocol

The virtual inputs and virtual outputs can be named through eSetup Easergy Pro or Web HMI in the Names for virtual inputs and Names for virtual outputs views of **CONTROL** menu.

The virtual input signals can be connected to different outputs of the **Output matrix**, **LED matrix**, **Block matrix**, **Object block matrix**, **Auto-recloser 79 matrix** views in the **MATRIX** menu of eSetup Easergy Pro and Web HMI or used in the custom logic function.

The virtual outputs can be controlled through output matrix (see **Output matrix** view in the **Matrix** menu of eSetup Easergy Pro and Web HMI).

Table 142 - Characteristics of the virtual inputs and outputs

Parameter	Value	Description	Note
Number of Virtual Inputs	50		
Number of Virtual Outputs	20		
VI1-VI50	0 1	Virtual input status is set to inactive. Virtual input status is set to active.	Editable when IED mode is set to "Test".
VO1-VO20	0 1	Virtual output status is set to inactive. Virtual output status is set to active.	Editable when IED mode is set to "Test".
Refresh period	5 ms	The activation and reset delay of the virtual inputs/outputs	
Event enabling	No Yes	Active edge event disabled. Active edge event enabled.	
Check L/R selection	No Yes	disabled enabled	
Name of virtual inputs and virtual outputs			
Label	String of max. 10 characters	Short name for virtual inputs and virtual outputs on the local display. Default is "VI1...VIn" and "VO1... VOn". n is the maximum number of the digital inputs or outputs.	Editable parameter (password needed)
Description	String of max. 32 characters	Long name for virtual inputs and virtual outputs. Default is "Virtual input 1 (or Virtual output 1)...Virtual input n (or Virtual output n)". n is the maximum number of the virtual inputs or virtual outputs.	Editable parameter (password needed)

Virtual input pulse time operation

VI1 to VI10 are configurable virtual inputs, they can operate on pulse mode, which is achieved by a settable VI pulse length.

When the VI pulse length is set to "0 = infinite", it keeps actual operation; and with any setting > 0 s, the VI state gets automatically reset to 0 (low/ inactive), once the pulse timer expires.

The pulse timer can be re-started while running, when a SCADA command with value “1” received, and can be reset instantaneously when a SCADA command with value "0" received.

NOTE: PowerLogic P5 cannot memorised the VI statuses, VI status will be reset to “0” when power supply lost.

Matrix

General information

The PowerLogic P5 protection relay has several matrices that are used for linking the hardware and software elements together to create a protection chain:

- **Output matrix**

  Used to link various inputs, outputs, statuses and signals to send a command to the contact relays and virtual outputs, to activate disturbance recording, and to provide SOL status.

- **Block matrix**

  Used to block protection stages

- **LED matrix**

  Used to control LEDs on the local panel

- **Object block matrix**

  Used to inhibit object control

- **Auto-recloser matrix**

  Used to control auto-recloser

- **Arc-flash matrix**

  Used for Arc-flash detection functions

- **Event matrix**

  See Logging and recording functions, page 524.

- **Goose matrix**

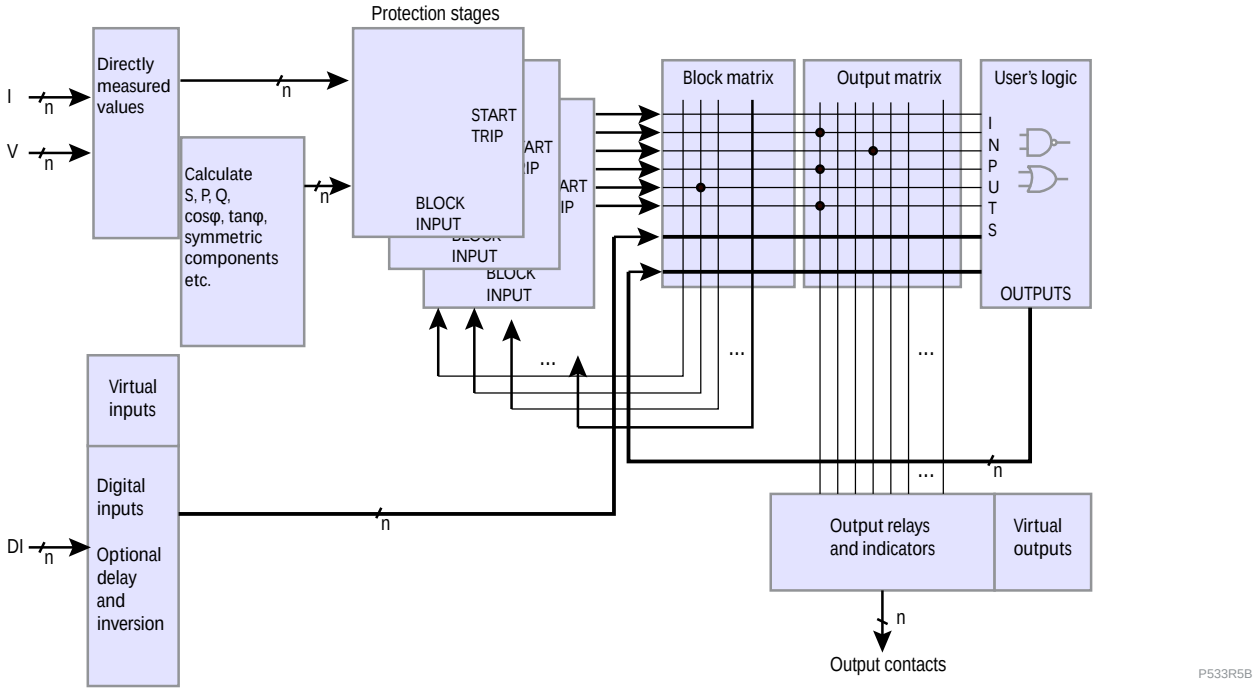
  Used in association with IEC61850 (see the Goose matrix view in the communication menu).

  It allows to associate up to 250 Goose messages (NIx) to a virtual input or a Goose message (NI).

- **General signals matrix**

  User configurable general trip signals with configuration of a dedicated matrix

Figure 317 - Blocking matrix and output matrix



Output matrix

The output matrix is used for connecting signals issued by different functions to the output relays (DO), virtual outputs (VO) and disturbance record trigger (DR).

The connecting signals to the outputs are the following:

- Protection signals from the different stages including setting changes
- Auto-recloser information
- Digital inputs
- Virtual inputs and outputs
- Object control command
- Function keys
- Goose
- Voltage sag/swell and interrupt
- Timers
- Inter-relay signals

The **Output matrix** setting view of eSetup Easergy Pro and Web HMI represents the state (de-energised/energised) of the digital output's coil. For example, an orange vertical line in the **Output matrix** and a logical "1" in the **Relays** view represent the energised state of the coil. The same principle applies for both NO and NC type digital outputs. The actual position (open/closed) of the digital outputs' contacts in coil's de-energised and energised state depends on the type (NO/NC) of the digital outputs. De-energised state of the coil corresponds to the normal state of the contacts.

A digital output can be configured as latched or non-latched. The releasing latches procedure is described in Releasing latches, page 499.

Programming matrix



Matrix connection without latch

The connection is shown as a single bullet.

- When the input signal is activated, the output is activated
- When the input signal is released, the output is released



Latched matrix connection

The latched connection is shown as a single bullet surrounded by a circle.

- When the input signal is activated, the output is activated
- When the input signal is released, the output will remain active until cleared manually (refer to Releasing latches, page 499).



No connection

The line crossing is empty.

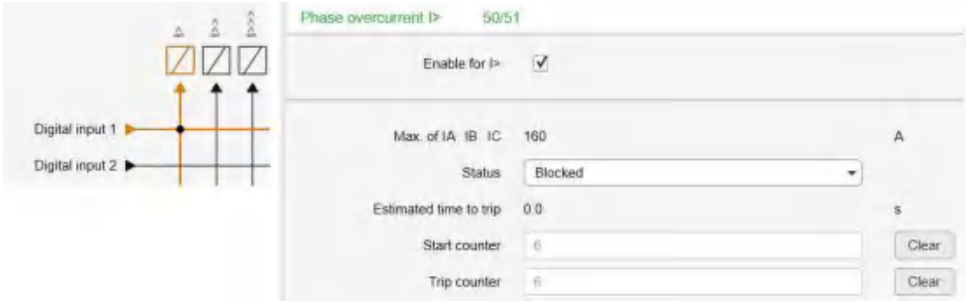
NOTE: Logic outputs (see Logic functions, page 507) are also assigned automatically in the output matrix when defined in any user programmable logic scheme.

Blocking matrix

The operation of any protection stage can be blocked using the blocking matrix in the **MATRIX** menu/**Block matrix** sub-menu. The blocking signal can originate from the digital inputs or it can be a start or trip signal from a protection stage or an output signal from the user's programmable logic.

The Blocked status becomes visible only when the stage is about to activate.

Figure 318 - A view from the setting tool showing a DI input blocking connection (left picture) and the result for the I> stage when the DI is active and the stage exceeds its current start value



NOTICE

UNINTENDED AND NUISANCE TRIPPING

- In the online mode, the blocking matrix is dynamically controlled by selecting and deselecting protection stages.
- Activate the protection stages first, then store the settings in the protection relay. After that, refresh the blocking matrix before configuring it.

Failure to follow these instructions can result in unwanted shutdown of the electrical installation.

LED matrix

The LED matrix defines the use of the Alarm LED , the trip LED , and the configurable LEDs on the local panel of PowerLogic P5 protection relay. A lot of functions can be assigned to each LED.

Table 143 - Inputs for LEDs

Input	LED mapping	Latch	Description	Not-e[135]
Protection, arc and programmable stages	green or red	Normal/ Latched/ BlinkLatch	Different type of protection stages can be assigned to LEDs	Set
Digital/virtual inputs and function buttons	green or red	Normal/ Latched/ BlinkLatch	All different type of inputs can be assigned to LEDs	Set
Object open/close, object final trip and object failure information	green or red	Normal/ Latched/ BlinkLatch	Information related to objects and object control	Set
Local control enabled	green or red	Normal/ Latched/ BlinkLatch	While remote/local state is selected as local the "local control enabled" is active	Set
Logic output 1-20	green or red	Normal/ Latched/ BlinkLatch	All logic outputs can be assigned to LEDs at the LED matrix	Set
Manual control indication	green or red	Normal/ Latched/ BlinkLatch	When the user has controlled the objectives	Set
Setting error, self diagnostic alarm, pwd open and setting change	green or red	Normal/ Latched/ BlinkLatch	Self diagnostic signal	Set
GOOSE NI 1-250	green or red	Normal/ Latched/ BlinkLatch	IEC 61850 goose communication signal	Set
GOOSE error	green or red	Normal/ Latched/ BlinkLatch	IEC 61850 goose communication signal	Set
Inter-relay signals	green or red	Normal/ Latched/ BlinkLatch	IRInx signal	Set

All the LEDs (6 for PowerLogic P5x20; 10 for PowerLogic P5x30) can be assigned as green or red in the **MATRIX** menu/**LED matrix** sub-menu of eSetup Easergy Pro. The selection of green and red at the same time will result in yellow.

The connection can be normal, latched or blink-latched (flashing).

NOTE: It is not possible to control LEDs directly from logics.

Normal connection

When the connection is normal, the assigned LED is active when the control signal is active. After deactivation, the LED turns off. LED activation and deactivation delay when controlled is approximately 10 ms.

Latched connection

A latched LED activates when the control signal activates but remains lit even when the control signal deactivates. Latched LEDs can be released by pressing the key on the local panel.

135. Set = an editable parameter (password needed)

Blink-latched connection

When the connection is "BlinkLatch", the assigned LED is active and blinking as long as the control signal is active. After deactivation, the LED remains latched and blinking. The latch can be released by pressing the ℝ key on the local panel.

Object block matrix

The object block matrix is used to link digital inputs, virtual inputs, function buttons, protection stage outputs, object statuses, logic outputs, alarm signals, inter-relay signals and GOOSE signals to inhibit the control of objects, that is, circuit breakers, isolators and earthing/grounding switches.

Typical signals to inhibit controlling of the objects like circuit breaker are protection stage activation, statuses of the other objects, interlocking made in logic or GOOSE signals. These and other signals are linked to objects through the object block matrix.

Auto-recloser matrix

The auto-recloser matrix is used to link digital inputs, virtual inputs, protection stage outputs, object statuses, logic outputs, alarm signals and GOOSE signals to control the auto-recloser. For more information, see Auto-recloser function (ANSI 79), page 424.

Arc-flash matrix

The arc-flash detection matrix uses three types of matrix:

- **Arc-flash light matrix**

  The arc-flash light matrix is used for connecting light signals detected by sensors or Goose or any virtual inputs to the different stages of the Arc-flash detection function.

- **Arc-flash current matrix**

  The arc-flash current matrix is used for connecting current signals and any virtual inputs to the different stages of the Arc-flash detection function.

- **Arc-flash output matrix**

  The arc-flash output matrix is used for connecting the different arc stage signals to the digital outputs.

See Arc-flash (ANSI 50ARC), page 373 for more information on the arc-flash protection function of the PowerLogic P5 protection relay.

General signals matrix

The general signals matrix provides user configurable general trip signals with configuration of a dedicated matrix.

In some applications, not all enabled protection functions are used to trip the circuit breaker. Some just generate signal, for example, a phase overcurrent protection stage sends a “high load current” alarm to the operation system to initiate re-dispatch actions, the “Global trip” signal will not be generated.

User-defined signals can be set up with programmable logic, which is the application specific OR combination of start or trip signals, with the use of a logic timer element for the minimum trip command time. The drawback is that these signals have no standardised correspondence with existing dedicated signals in communication protocols, especially in IEC 61850.

The general signals matrix allows user to configure general trip signals by configurable connections with input trip signals.

The configuration of general signals matrix is made by eSetup Easergy Pro in **MATRIX**/**Global signals matrix**. The timer is configured in **CONTROL**/**Global trip timer**.

The inputs are all trip signals of the protections of PowerLogic P5. Global trip signal is kept for backward compatibility as input of the general signals matrix.

There are 2 output signals General trip 1 and General trip 2, they can be inputs of other matrix. Each input signal can be linked/connected to one or both general trip signals.

When connecting the trip signal of a protection element to General trip 1 or General trip 2, user defines only the connection between the trip signal and the General trip 1 or General trip 2, further related general start and direction signals with all “attributes” (as required in the LN PTRC) will be automatically adapted.

The output signals of general signals matrix can be transferred with the communication protocols, namely in additional IEC 61850 LN PTRC instances, but also in legacy protocols, for example, IEC 60870-5-103.

Releasing latches

According to the matrix configurations different outputs and indicators can be latched or non-latched. A non-latched output or indicator follows the controlling signal. A latched output or indicator remains active after the controlling signal releases.

There is a common "release all latches" signal to release all the latched relays. This release signal resets all the latched digital outputs and indicators.

Each digital output can be latched or not independently through the output matrix.

The release of the latches can be done:

- Directly with the ℝ key on the local panel
- With a digital input/output or virtual input/output set in the **CONTROL** menu/ **Release latches** sub-menu of eSetup Easergy Pro or Web HMI
- With eSetup Easergy Pro, click **Device** button in the toolbar and select **Release all latches**
- With Web HMI
- Through communication

Mimic display

The PowerLogic P5 protection relay can display multiple mimic screens (up to 5) on the local panel. The mimic screen can be entered from the main screen/default screen.

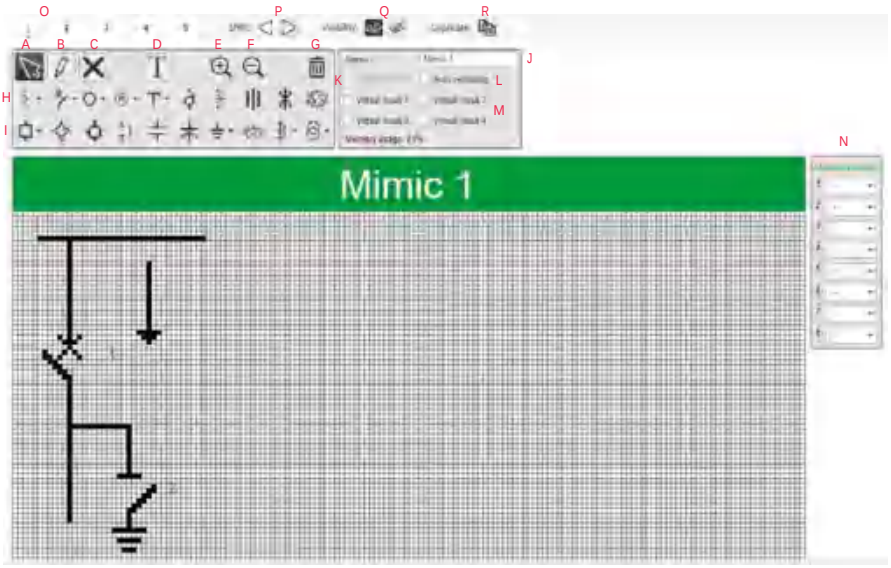
When pressing the mimic entry, the first mimic is shown on the local panel. The user can use the left/right navigation keys to switch between mimics. If the first mimic is currently displayed, only right navigation key is functional. If the 5th mimic is currently displayed, only left navigation key is functional. It is not possible to add or remove any mimic, but it can be hidden by clicking the **Visibility** button in the mimic configuration screen.

There are two ways to configure a mimic screen, from scratch, or from one existing mimic by clicking the **Duplicate** button located in the mimic configuration screen. The name and the content of each individual mimic can be edited. The content of each mimic is independent of the others. The user can click the left/right shift button to switch between mimic screens. The mimics can be configured in online mode (connected to the PowerLogic P5 by mini-USB port or Ethernet port) or offline mode.

Each mimic can display a single-line diagram, which can be created in eSetup Easergy Pro through the Mimic view of the **GENERAL** menu. Up to 8 analogue measurements (voltage, current, power...) based on the selection and up to 5 digital signals with fixed assignment can be displayed in one mimic. In order to display all the required information, the user can spread the information across multiple mimics.

Considering checking all the five mimics on default screen scenario, the user can use the up/down navigation keys to switch between mimics, and use the left/right navigation keys to view the **Main measurements**, firmware version and the **Alarm list** screens from the PowerLogic P5.

Figure 319 - Set up the Mimic view



A **Cursor**: used to move an object
To move an existing object, select the tool, point the cursor to the object until the object turns green and then drag and drop the object to the new position.

B **Draw line**: used to draw lines in the view
To draw a line, select the tool, click the left mouse button at the start point and then move the cursor to the second point and click again.

J Provides the PowerLogic P5 protection relay's location. The text comes from the **System info** view of the **GENERAL** menu

K **Remote / Local** state
Depending on the state, some settings and actions are not allowed
The remote / Local state can be changed in the **Objects** view of the **CONTROL** menu.

C **Delete object**: used to delete an existing object from the view
To delete an object, select the tool, point the cursor to the object until the object turns red and click.

D **Text**: used to insert text in the view
To insert text, select the tool, click at the position to place the text and then, in the pop-up dialog box, type in the text and click the **OK** button.
Use the Cursor tool to move the text if necessary.

E **Zoom in**: used to increase the size of the view
To zoom in, click the tool until the view reaches the desired size.

F **Zoom out**: used to decrease the size of the view
To zoom out, click the tool until the view reaches the desired size.

G **Clear view**: used to remove all objects from the view
To clear the view, click the tool and select **OK** to confirm.

H Different choice of configurable objects
The object's number corresponds to the number in the **Object** menu.

I Some predefined drawings for use in the view.

L **Auto reclosing** check box
To show or hide the Auto-reclosing state in the view

M **Virtual input x** check boxes
To show or hide the specified virtual inputs states in the view

N Up to 8 freely selectable measurements
To select the measurements to be shown in the view

O The sequence number of the mimic

P **Shift key**: used to switch between different mimics

Q **Visibility key**: used to hide/unhide the mimic

R **Duplicate key**: used to copy the current mimic

Table 144 - Mimic functionality

Parameter	Value	Description
Sublocation	Text field	Up to 20 characters. Fixed location.
Object 1–8	1–8	Double-click on top of the object to change the control number between 1 and 8. Number 1 corresponds to object 1 in **CONTROL** menu/ **Objects** sub menu.
Auto-reclosing	0 1	Possible to enable/disable auto-reclosing locally in local mode (L) or remotely in remote mode (R). Position can be changed.
Measurement display 1–8	Select the measurements from the drop down list	Up to 8 freely selectable measurements.
Virtual input 1–4	0 1	Change the status of virtual inputs while the password is enabled. Position can be changed.

Local panel configuration

The display and behaviour of the PowerLogic P5 protection relay's local panel can be configured in the **GENERAL** menu/**Local panel conf** sub-menu of the eSetup Easergy Pro.

Table 145 - Local panel configuration

Parameter	Value	Note
Contrast of LCD screen	0–15	For PowerLogic P5x20 only.
Display backlight control	Selection of digital inputs (DI), one virtual inputs (VI), one virtual outputs (VO), or one function key (Fx).	
Backlight off timeout	0.0–2000.0 min	Configurable delay for backlight to turns off when the protection relay is not used.

Table 145 - Local panel configuration (Continued)

Parameter	Value	Note
		Default value is 60 minutes. When value is zero (0.0) backlight stays on all the time.
Display evt time not sync	Checked unchecked	Event time shown normally if relay is synchronised, or otherwise in brackets.
Object for control buttons	Object 1 - Object 6	
Mode for control buttons	Selective Direct	Two different ways of controlling the object using the control buttons (I/O) (see Controllable objects, page 502)
Fault value scaling	PU Primary	PU: analogue values displayed in % or x rated value; Primary: analogue values displayed directly in primary units.
Date style	yy-mm-dd dd.mm.yy mm/dd/yy	
Clear events	- Clear	
Default screen		Used to set the default home screen of the local panel.

Controllable objects

The PowerLogic P5 protection relay allows the control of six objects, that is, circuit-breakers, disconnectors and earthing/grounding switches by the "select before operate" or "direct control" principle.

The object block matrix and logic functions can be used to configure interlocking to help ensure the control before the output pulse is issued. The objects 1 - 6 are controllable whilst the additional objects 7 - 8 are only able to show the status.

Controlling of objects 1–6 is possible in the following ways:

- through the object control buttons (I/O)
- through the local panel and display using single line diagram
- through the function key
- through a digital input
- through a remote communication
- through eSetup Easergy Pro setting tool
- through Web HMI
- through the EcoStruxure Power Device application

The connection of an object to specific controlling outputs is done via an output matrix (object 1 – 6 open output, object 1 – 6 close output). There is also an output signal "Object failed" that is activated if the control of an object is not completed.

Object states

Each object has the following states:

Setting	Value	Description
Object state	Undefined (00)	Actual state of the object
	Open	
	Close	

Setting	Value	Description
	Undefined (11)	

Basic settings for controllable objects

Each controllable object has the following settings:

Setting	Value	Description
DI for "obj open"	None, any digital input, virtual input or virtual output	Open information
DI for "obj close"		Close information
DI for "obj ready"		Ready information
Max ctrl pulse length	0.02...600 s	Pulse length for open and close commands. Control pulse stops once object changes its state
Completion timeout	0.02...600 s	Timeout of ready indication
Object control	Open/Close	Direct object control

If changing the states takes longer than the time defined by the "Max ctrl pulse length" setting, the object is inoperative and the "Object failure" matrix signal is set. Also, an undefined event is generated. "Completion timeout" is only used for the ready indication. If the "DI for 'obj ready'" is not set, the completion timeout has no meaning.

NOTE: The Object can only be controlled when its position is in a known state.

Output signals of controllable objects

Each controllable object has two control signals in the matrix:

Output signal	Description
Object x Open	Open control signal for the object
Object x Close	Close control signal for the object

Settings for read-only objects

Each read-only object has the following settings:

Setting	Value	Description
DI for "obj open"	None, any digital input, virtual input or virtual output	Open information
DI for "obj close"		Close information
Object timeout	0.02...600 s	Timeout for state changes

If changing states takes longer than the time defined by "Object timeout" setting, an "Object failure" matrix signal is set, and an undefined-event is generated.

Local or remote control

In Local mode, the digital outputs can be controlled via the local panel, but they cannot be controlled via a remote communication interface.

In Remote mode, the digital outputs cannot be controlled via the local panel, but only via a remote communication interface.

The Local or Remote mode is selected by one selectable digital input or using the local/remote button on local panel. When digital input is configured to switch between Local and Remote mode, the local/remote button will not take effect and so when it is pressed an alarm message appears, to remind the user that a digital input is applied to switch the Local or Remote mode. It is in Local mode when the digital input is OFF, and it is in Remote mode when the digital input is ON.

The selection of the L/R digital input is done in the **CONTROL** menu/**Objects** sub-menu of the eSetup Easergy Pro or Web HMI.

Object control with digital inputs

Objects can be controlled with digital inputs, virtual inputs or virtual outputs. There are four settings for each controllable object:

Setting	Active
DI for remote open / close control	In remote state
DI for local open / close control	In local state

If the protection relay is in a local control state, the remote control inputs are ignored and vice versa. An object is controlled when a rising edge is detected from the selected input. The length of digital input pulse should be at least 60 ms.

Object control with function keys

Each function key toggles an internal signal. This internal signal is available as an input of the output matrix, the block matrix, the auto-reclose matrix, the LED matrix and the object block matrix.

The function keys can also be used:

- To clear the minimum and maximum of current, voltage and power
- To clear the minimum and maximum of demand values and RMS demand values
- To select a setting group
- To select the IED modes (Normal / Test / Test-blocked)
- To enable / disable the auto-recloser
- To bypass the synchro-check
- As an input in the programmable logic

  NOTE: If the backlight for the LCD display is switched off, pressing a function key for the first time will only light up the LCD display. The function assigned to the function key will only be triggered when this function key is pressed a second time. This configuration is also valid for the other local panel keys.

Depending on the model of the PowerLogic P5 protection relay, there are different number of available function keys on the local panel:

- F1 for PowerLogic P5 x20
- F1 to F7 for PowerLogic P5 x30

The selection of the function keys for the objects is made in the **CONTROL** menu/ **Objects** sub-menu of the eSetup Easergy Pro or Web HMI.

The function keys are configured to control objects in the **CONTROL** menu/ **Function buttons** sub-menu of the eSetup Easergy Pro.

Setting function buttons

In the **CONTROL** menu/**Function buttons** sub-menu of the eSetup Easergy Pro, function buttons can be set to different type of functions:

- Fx (F1 to F7): work as function button. Status value will be changed between 0 and 1 on each pressing. The setting of pulse length is valid only when the function key is set to Fx type. When pulse length = 0, status value changes with each pressing of Fx, when length > 0, status value becomes to 1 when press, and change back to 0 after the delay time of pulse length setting.

- VI1...VI50: control the status of VI1 to VI50. VI value changes on each pressing.
- Object control: after set the function button to this value, you will have to make further settings in the **CONTROL** menu/**Objects** sub-menu of the eSetup Easergy Pro, in the section of Control object X, for example Control object 1, select Fx in **DI for local open control** or **DI for local close control**.
- Change test mode: if the function button is set to this function, when the button is pressed, you will be asked to set **Mode of use** (please refer to Mode of use for testing purposes, page 258) of the device.

Table 146 - Parameters for the function keys

Parameter	Value	Description
Status	0	Disabled
	1	Enabled
Selected control	V1...V50	Virtual input
	ObjCtrl	Object control
	Fn	Function key n
	ChgTstMod	Change the IED mode
Selected objects	-	No object selected
	xLocOpen; xLocClose	Shown when ObjCtrl is selected in the Selected control field.
Fn pulse length (0 = infinite)	0.00...600 s	Time delay common to all programmable function keys

Object control with I and O buttons

The PowerLogic P5 protection relay also has dedicated control buttons for objects. (I) stands for object closing and (O) controls object open command internally. **Object for control buttons** and **Mode for control buttons** are configured in the **CONTROL** menu/**Objects** sub-menu of the eSetup Easergy Pro or Web HMI.

Table 147 - Parameters of control buttons

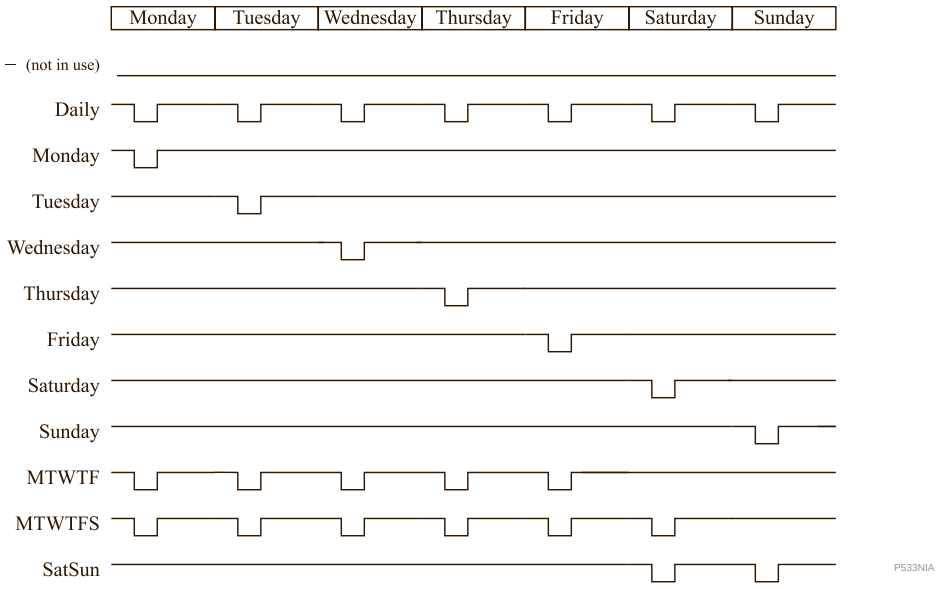
Parameter	Value	Unit	Description	Set
Object for control buttons	-		Disabled: the control buttons do not control any object.	Set
	Obj1...Obj6		Button I closes selected object if password is enabled. Button O opens selected object if password is enabled.	
Mode for control buttons	Selective		Control operation needs confirmation (select before operate)	
	Direct		Pressing the control button directly leads to action of the controled object.	

Timers

Description

The PowerLogic P5 protection platform includes four settable timers that can be used together with the user's programmable logic or to control setting groups and other applications that require actions based on calendar time. Each timer has its own settings. After setting the selected on-time and off-time you can then select whether the timer is activated every day or just selected days of the week (See the setting parameters for details). The timer outputs are available for logic functions and for the block and output matrices.

Figure 320 - Timer output sequence in different modes



You can force any timer, which is in use to on or off. The forcing is done by writing a new status value. Unlike the digital inputs no forcing flag is needed.

The forced timer status remains as forced until the next forced change or the next time the timer automatically changes status.

The status of each timer is stored in the non-volatile memory when the auxiliary power is switched off. At startup, the status of each timer is recovered.

Setting parameters

Table 148 - Setting parameters of timers

Parameter	Value	Description
Status	- 0 1	Not in use Output is inactive Output is active
On	hh:mm:ss	Activation time of the timer
Off	hh:mm:ss	De-activation time of the timer
Mode		For each four timers there are 12 different modes available:
	-	The timer is off and not running. The output is off, i.e. 0 all the time.
	Daily	The timer switches on and off once every day.
	Monday	The timer switches on and off every Monday.
	Tuesday	The timer switches on and off every Tuesday.

Table 148 - Setting parameters of timers (Continued)

Parameter	Value	Description
	Wednesday	The timer switches on and off every Wednesday.
	Thursday	The timer switches on and off every Thursday.
	Friday	The timer switches on and off every Friday.
	Saturday	The timer switches on and off every Saturday.
	Sunday	The timer switches on and off every Sunday.
	MTWTF	The timer switches on and off every day except Saturdays and Sundays
	MTWTFS	The timer switches on and off every day except Sundays.
	SatSun	The timer switches on and off every Saturday and Sunday.

Logic functions

PowerLogic P5 protection relay supports user-defined programmable logic for boolean signals. User-configurable logic can be used to create functionality that is not provided by the protection relay as a default. You can see and modify the logic in the **Logic** setting view of the **Control** menu in the eSetup Easergy Pro or Web HMI.

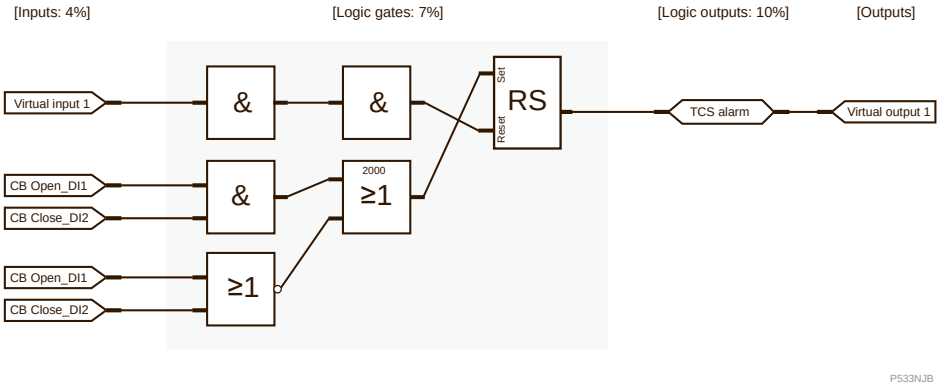
Table 149 - Available logic functions and their memory use

	Number of gates reserved	Max. number of input gates	Max. number of logic outputs
AND	1	250 (An input gate can include any number of signals.)	20
OR	1		
XOR	1		
AND+OR	2		
CT (count + reset)	2		
INVAND	2		
INVOR	2		
OR+AND[136]	2		
RS (set + reset)	2		
RS_D (set + D + load + reset)	4		

The consumed memory is dynamically shown on the configuration view in percentage. The first value indicates the memory consumption of inputs, the second value the memory consumption of gates, the third value the memory consumption of logic outputs, and the fourth value the memory consumption of outputs. The logic is operational as long as the memory consumption of the inputs, gates, logic outputs and outputs remains individually below or equal to 100%.

136. by selecting “AND+OR” and ticking “Reverse”

Figure 321 - Logic and memory consumption



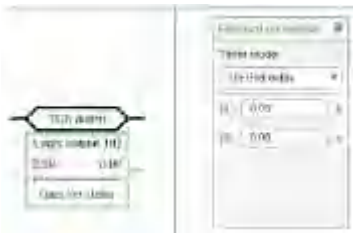
Logic timer feature

PowerLogic P5 protection relay logic function can be used to manage accurate breaker control and alarms with flexibility thanks to the logic timer feature included. Logic timer feature offers the possibility of assigning a freely configurable time characteristic to the output signal of each Boolean equation. The logic timer can be displayed and modified in the eSetup Easergy Pro, the Web HMI, or through IEC 61850.

The logic timer feature could be configured by clicking on any Logic output in the logic diagram, a window of **Signal mapping** will be pop up:



On **Signal mapping** window, make **Timer mode** setting checked, a Logic output (t) will be shown. By clicking on the Logic output(t), requested timer mode could be selected together with the dedicated time configured.



The protection relay's HMI screen could display a countdown logic timer pop-up window. It could be enabled in the **Logic timers** view of the **Control** menu of eSetup Easergy Pro or the local panel. The popup window could be closed by pressing any key.

Table 150 - Settings and characteristics of the logic timer

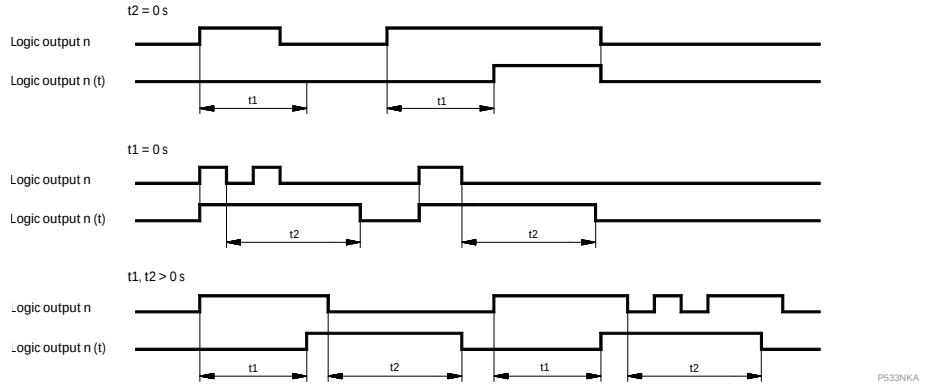
Settings/characteristics	Value
Timer mode	
Setting range	Op./Rel.delay; Op.delay/Pulse; Op./Rel.retrig; Op./Pulse.retrig; Minimum time
t1	

Table 150 - Settings and characteristics of the logic timer (Continued)

Settings/characteristics	Value
Setting range	0...60,000.00 s
Resolution	0.01 s
Accuracy	±1% or ±20 ms
t2	
Setting range	0...60,000.00 s
Resolution	0.01 s
Accuracy	±1% or ±20 ms

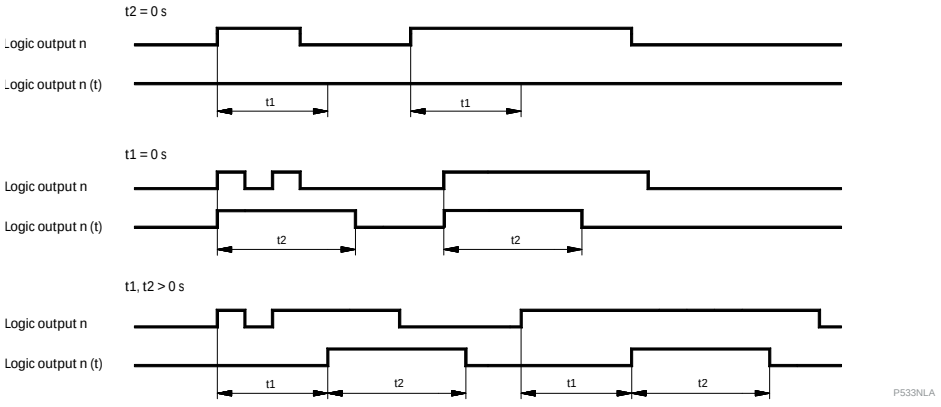
The following figures show the time characteristics for the various timer stage operating modes.

Figure 322 - Timer mode: Pickup/reset delay, non-triggerable (Op./Rel.delay)



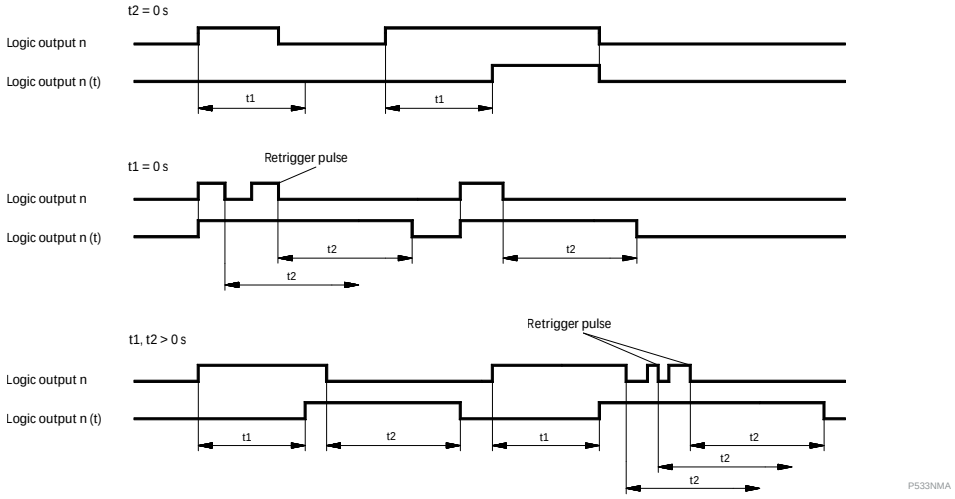
t1 operate delay t2 release delay

Figure 323 - Timer mode: Pulse, delayed pickup, non-triggerable (Op.delay/ Pulse)



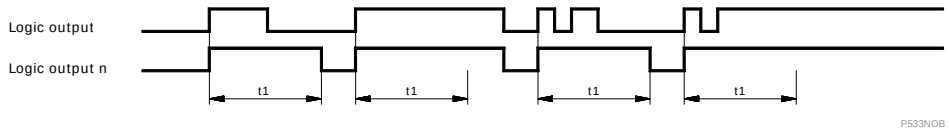
t1 operate delay t2 pulse delay

Figure 324 - Timer mode: Pickup/reset delay, retriggerable (Op./Rel.retrig)



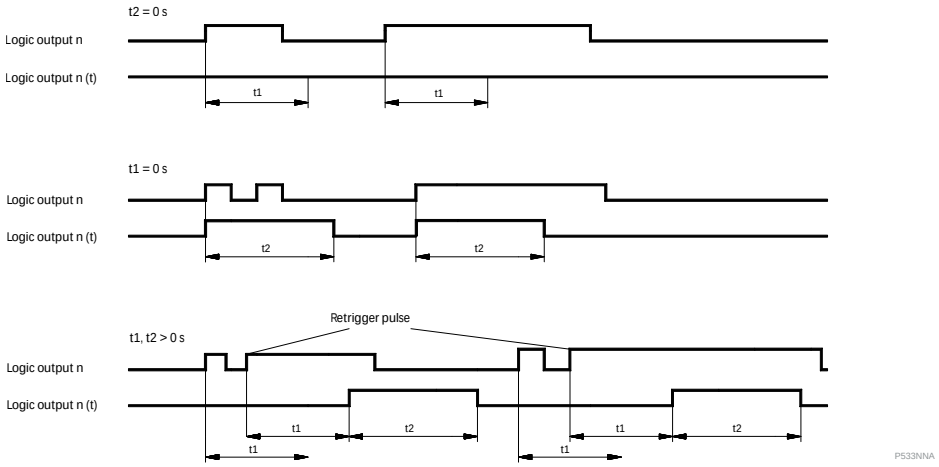
t1 operate delay t2 release delay

Figure 325 - Timer mode: Minimum time (Minimum time)



t1 minimum time

Figure 326 - Timer mode: Pulse, delayed pickup, retriggerable (Op./Pulse. retrig)



t1 operate delay t2 pulse delay

Table 151 - Logic gates

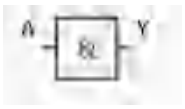
Logic gate	Symbol	Truth table
AND		<table><tr><th>In</th><th>Out</th></tr><tr><td>A</td><td>Y</td></tr><tr><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td></tr></table>

Table 151 - Logic gates (Continued)

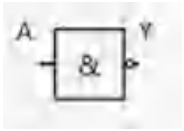
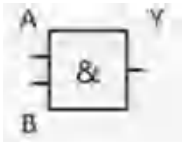
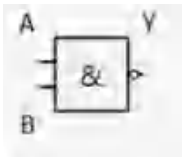
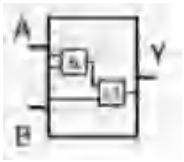
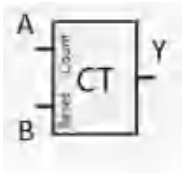
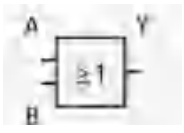
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<tr><td>1</td><td>1</td><td>1</td></tr>
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</td><td>
<table>
<tr><th colspan="2">In</th><th>Out</th></tr>
<tr><td>A</td><td>B</td><td>Y</td></tr>
<tr><td>0</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
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<tr><td>AND+OR</td><td>
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<tr><td>1</td><td>1</td><td>1</td></tr>
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</table>
</td></tr>
<tr><td>CT
(count+reset)</td><td>
</td><td>
<table>
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</table>
</td></tr>
<tr><td>OR</td><td>
</td><td>
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<tr><td>0</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td></tr>
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Table 151 - Logic gates (Continued)

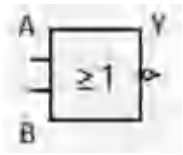
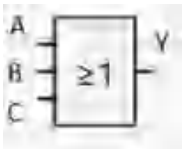
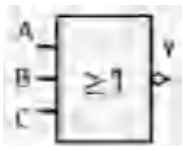
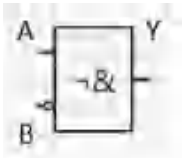
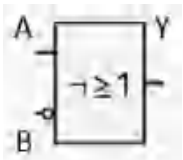
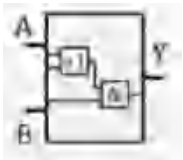
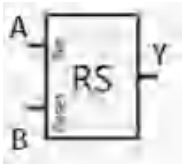
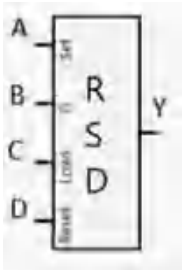
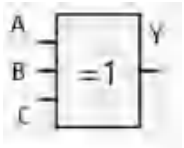
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<tr><th>Logic gate</th><th>Symbol</th><th>Truth table</th></tr>
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<tr><td>1</td><td>1</td><td>0</td></tr>
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</td></tr>
<tr><td></td><td>
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<tr><td>1</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td></tr>
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</table>
</td></tr>
<tr><td>INVAND</td><td>
</td><td>
<table>
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<tr><td>0</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>0</td></tr>
</table>
</td></tr>
<tr><td>INVOR</td><td>
</td><td>
<table>
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<tr><td>A</td><td>B</td><td>Y</td></tr>
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<tr><td>1</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>0</td></tr>
</table>
</td></tr>
<tr><td>OR+AND
(AND+OR
reversed)</td><td>
</td><td>
<table>
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<tr><td>1</td><td>1</td><td>1</td></tr>
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Table 151 - Logic gates (Continued)

<table>
<tr><th>Logic gate</th><th>Symbol</th><th>Truth table</th></tr>
<tr><td>RS
(set+reset)</td><td>
</td><td>
<table>
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<tr><td>Set</td><td>Reset</td><td>Y</td></tr>
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<tr><td>1</td><td>1</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>0</td></tr>
</table>
</td></tr>
<tr><td>RS_D
(set+D+load+reset)</td><td>
</td><td>
<table>
<tr><td>A</td><td>B</td><td>C</td><td>D</td><td>Y</td></tr>
<tr><td>Set</td><td>D-input</td><td>Load</td><td>Reset</td><td>Y</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
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<tr><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>x</td><td>x</td><td>x</td><td>1</td><td>0</td></tr>
</table>
</td></tr>
<tr><td>XOR</td><td>
</td><td>
<table>
<tr><td colspan="3">In</td><td>Out</td></tr>
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<tr><td>0</td><td>0</td><td>0</td><td>0</td></tr>
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<tr><td>1</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>0</td></tr>
</table>
</td></tr>
</table>

Advanced logic

PowerLogic P5 protection relay can also support an advanced programming tool (ISaGRAF™ Workbench of Rockwell Automation) for developing user-defined programmable logic. The advanced logic can be used in conjunction with the programmable logic to create a very flexible and strong logic capability. The programmable logic is optimised for execution speed whilst the advanced logic of ISaGRAF™ provides flexibility. Typically, high speed interlocks and tripping functions should use the programmable logic whilst less time demanding functions such as complex control functions are more suited to the advanced logic. ISaGRAF™ offers a solution compliant to the IEC 61131 and IEC 61499 standards.

To know whether the PowerLogic P5 protection relay supports the advanced logic function or not, check the second last bit of the model number. For PowerLogic P5 with V01.40x.yyy firmware version C stands for Advanced logic and CS Basic. D stands for Advanced logic and CS Advanced. For PowerLogic P5 with V01.500.101 firmware version and next ones, F stands for Advanced logic and CS Settable (CS Basic or CS Advanced).

P 5 x 2 0 - _ _ _ _ - _ _ _ _ _ - _ _ **C** _

P 5 x 3 0 - _ _ _ _ - _ _ _ _ _ - _ _ **D** _

P 5 x 3 0 - _ _ _ _ - _ _ _ _ _ - _ _ **F** _

ISaGRAF™ Workbench including text and graphics editors is used to develop specific custom applications in the following programming languages：

- SFC: Sequential Function Chart
- ST: Structured Text
- LD: Ladder Diagram
- FBD: Function Block Diagram
- SAMA: Scientific Apparatus Makers Association

PowerLogic P5 with ISaGRAF™ Runtime capability supports maximum 2048 boolean digital inputs and 128 boolean digital outputs. There is no limit on the number of gates and timers.

Table 152 - Settings and characteristics of the advanced logic

Settings/characteristics	Value
Inputs	
Number	2048 All boolean signals available in matrix.
Outputs	
Number	128 These outputs can be configured through matrix according to the application usage and can be used in the Programmable logic.
Execution rate	
Value	40 ms
Timer	
Accuracy	±1% or ±40 ms

The eSetup Easergy pro provides several parameters about the advanced logic function. **Project files CRC** is Cyclic Redundancy Check for project files, which is to check whether the content of the logic is changed. **Project name**, **Project comment**, **Configuration name** and **Configuration comment** can be customised in the ISaGRAF™ Workbench.

In order to create an advanced logic, the ISaGRAF™ Workbench software of Rockwell Automation needs to be installed on the computer and a license for

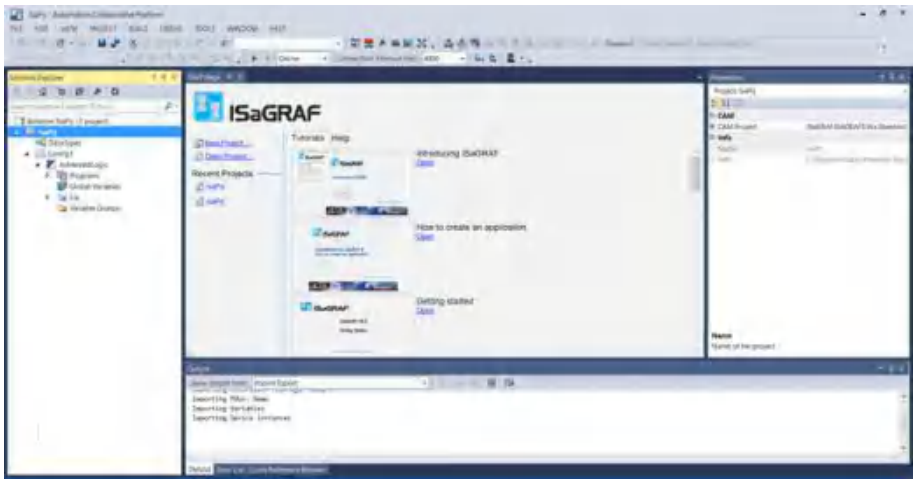
activating the ISaGRAF™ is needed. For more information on the license, please contact RAisagraf_sales@ra.rockwell.com or local Rockwell Automation Sales Office.

Creating an advanced logic offline

1. When ISaGRAF™ Workbench with an active license is installed on the computer, the logic can be created by clicking the **Edit advanced logic** in the **CONTROL** menu/**Advanced logic** sub-menu via the eSetup Easergy Pro. Then a default project will be opened in the ISaGRAF™ Workbench automatically. Whilst editing using the ISaGRAF™ Workbench, Easergy Pro will be locked out.

   NOTE: Only PowerLogic P5 products with the correct order option will have the **Advanced logic** sub-menu.

Figure 327 - View of ISaGRAF™ Workbench of Rockwell Automation



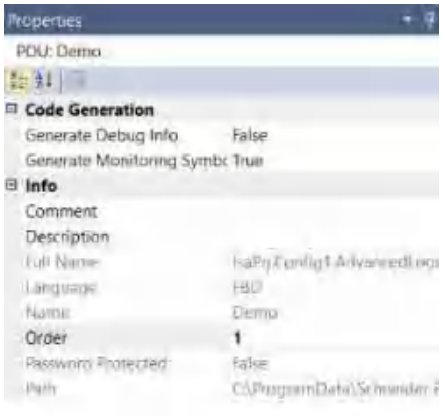
2. To create an advanced logic (in FBD as an example), double click **Demo**, which is under **IsaPrj**/**Config1**/**AdvancedLogic**/**Programs** at the left side of the ISaGRAF™ Workbench. To create an advanced logic in other programming languages, right click **Programs** and choose **add**. For more information on those properties and on building a logic in the ISaGRAF™ Workbench, click **HELP** on the title bar.

   The boolean signals of the PowerLogic P5 can be used as the variables in the ISaGRAF™ Workbench. The user can link the PowerLogic P5 signals to the variables in the ISaGRAF™ Workbench, by double clinking the variables in the logic diagram. The available signals include NI, DI, VI, VO, protection start or trip signals, and program logic output signals.

   PowerLogic P5 ISaGRAF™ logic supports a maximum of 128 boolean digital outputs. These outputs can be configured through matrix according to the application usage and can be used in the Programmable logic.

   When creating an advanced logic, in order to keep its performance, the following suggestions are recommended:

   - Try to create all the logic in one diagram. Logic is executed from top to bottom and from left to right in the ISaGRAF™ Workbench, thus follow this principle when creating logic.
   - If the logic is in multiple diagrams, pay attention to the order of those diagrams. Set the value of **Order** of the diagram, to be executed first, to 1 in the **Properties** panel, and so on.



NOTICE
IMPROPER OPERATION The property **resource name** should not be modified in the ISaGRAF™ Workbench. **Failure to follow these instructions can result in improper operation.**

3. When the logic is built, click **Save** and close the ISaGRAF® workbench. A pop-up window showing the information “Do you want to attach advanced logic project (ISaGRAF™) to the configuration?” appears on the screen of the eSetup Easergy pro. Click **Yes**.
4. In the eSetup Easergy pro, click **Save as** to save the complete configuration file, which includes the created advanced logic, locally.
5. Connect the P5 device through the eSetup Easergy pro, and open the saved configuration file. Then **Write** the configuration file to the P5 device.

eSetup Easergy Pro is the only way to download ISaGRAF™ logic into P5 device. In the process of downloading, if there are invalid signals, an alarm window will pop-up (while the ISaGRAF™ program continues to run).

Updating an advanced logic online

1. Connect the P5 device through the eSetup Easergy Pro.

2. Click the **Edit advanced logic** in the **CONTROL** menu/**Advanced logic** sub-menu via the eSetup Easergy Pro.
3. Update the advanced logic in the ISaGRAF™ Workbench.
4. After updating, click **Save** and close the ISaGRAF™ Workbench. Then A pop-up window appears on the screen of the eSetup Easergy pro. Click **Yes**.
5. **Write** the configuration file to the P5 device via the eSetup Easergy Pro.

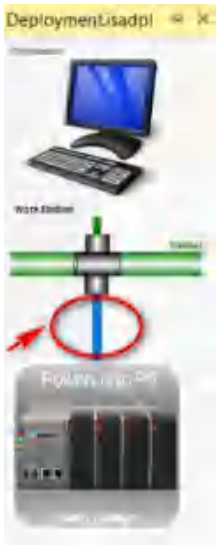
eSetup Easergy Pro is the only way to download ISaGRAF™ logic into P5 device.

Commissioning

NOTICE
CYBER SECURITY The ISaGRAF™ debugging protocols are without any security capabilities. The data is transmitted in clear text. Thus, the debug function must only be used in secured communication networks. It is strongly recommended to disable this debug (or commissioning) feature in normal operation mode, as done with default settings. **Failure to follow these instructions can result in improper operation.**

PowerLogic P5 supports the online commissioning function of the advanced logic. To enable the online debug, please: in eSetup Easergy Pro, go to the **Communication** menu, in the section **Protocol configuration**, uncheck the setting **Disable advanced logic port**.

1. Click **IsaPrj**. Then click **VIEW** on the title bar, and choose **Deployment View**.
2. Select part of the wire connecting the PowerLogic P5 in the deployment window.



3. Enter the IP address of the mini-USB port or the Ethernet port of the PowerLogic P5 in the **Properties** panel at the right side of the ISaGRAF™ Workbench.
4. **Save** the configuration, click **BUILD** and choose **Build Solution the logic**.
5. Download the advanced logic via the ISaGRAF™ Workbench to the P5 device by right clicking **IsaPrj**, and then select **Download**.

6. Select **Online** and click **Start Debugging button**.



The commissioning includes:

- Users can commission the logic in the ISaGRAF™ Workbench to highlight which part of the logic is being activated.
- Users can assign different values to the input to simulate the output to check the correct behaviour of the logic.

For more information on how to assign the values to the inputs in the simulation mode, please refer to the **HELP** on the title bar of the ISaGRAF™ Workbench.

NOTE: To commission an advanced logic, download it via the ISaGRAF™ Workbench (see Commissioning, page 517). After the commissioning, to execute the logic, **Write** it to the P5 device via the eSetup Easergy Pro.

Switchgear control and monitoring

Switchgear control and fail-safe position

For the PowerLogic P5 protection relay, operational reliability helps ensure the safety and availability of the installation.

This means avoiding the following 2 situations:

- Nuisance tripping of the protection

  Continuity of the electrical power supply is as vital for a manufacturer as it is for an electricity distribution company. Nuisance tripping caused by the protection can result in considerable financial losses. This situation affects the availability of the protection.

- Failure of the protection to trip

  The protection relay must detect faults in the electrical power system as quickly as possible.

  Power network systems consist of a set of components (cables, switchgear, protection relays, measurement transformers, MV/LV transformers, etc.) whose correct operation may be affected by failures. The consequences of failure of one of the power system components are varied and depend on factors specific to each power system.

  These include:

  - Power system topology
  - Type of connected users
  - Load types
  - Position of each component in the power system
  - Failure mode for each component, etc.

  In case a power system fails, it is the responsibility of the user to prioritise either continuity of the electricity supply, or shutdown of part of the power system. While designing the power system and its protection plan, knowledge of the failure modes for each element can be used to steer the failure into a particular state. This requires the failure mode for the power system elements to be as deterministic as possible.

  To comply with this approach, the PowerLogic P5 protection relay is equipped with self-tests that continuously check all its electronics and embedded software are operating correctly. The purpose of the self-tests is to put the PowerLogic P5 protection relay into a deterministic position, called the fail-safe position, in the event of failure or malfunction of one of its internal components. In the fail-safe position the PowerLogic P5 protection relay is no longer operational. All its output relays are forced into the off-position and the power system is no longer protected. If the auxiliary power supply disappears, the PowerLogic P5 protection relay's contact relays are also in the off-position.

  The table below indicates the possible types of behaviour in the event of PowerLogic P5 protection relay failure. Use in standard mode or in custom mode is described in the sections below.

Circuit Breaker with Shunt Trip Coil	Circuit Breaker with Undervoltage Trip Coil
The circuit breaker stays closed if PowerLogic P5 protection relay goes into the fail-safe position. Monitoring is required to detect whether the protection is no longer operational.	The circuit breaker opens automatically if PowerLogic P5 protection relay goes into the fail-safe position. The circuit breaker opens if the substation auxiliary voltage disappears.

Selecting the trip command and examples of use

NOTICE

RISK OF UNPROTECTED ELECTRICAL INSTALLATION

Always connect the watchdog output to a monitoring device to mitigate and take appropriate action when the selected trip command does not result in the installation tripping or when the PowerLogic P5 protection relay fails.

Failure to follow these instructions can result in unprotected electrical installation.

An analysis of the operational reliability of the whole installation should determine whether availability or safety of this installation should be prioritised if PowerLogic P5 protection relay is in the fail-safe position. This information is used to determine the choice of trip command as outlined in Selecting the trip command, page 520.

Table 153 - Selecting the trip command

Dia-gram	Control	Event	Trip	Advantage	Disadvantage
1	Shunt trip breaker or mechanical latching contactor	Internal failure or loss of the auxiliary power supply	No	Availability of the installation	Installation not protected until remedial intervention
2	Breaker with undervoltage trip coil (fail-safe)	Internal failure or loss of the auxiliary power supply	Yes	Safety of the installation	Installation not available until remedial intervention
3	Breaker with undervoltage trip coil (not fail-safe)	Internal failure	No	Availability of the installation	Installation not available until remedial intervention
		Loss of auxiliary power supply	Yes	Safety of the installation	Installation not available until remedial intervention
4	Contactor without coil latching (permanent order)	Internal failure or loss of the auxiliary power supply	Yes	Safety of the installation	Installation not available until remedial intervention

Figure 328 - Example of use with shunt trip coil (diagram 1)

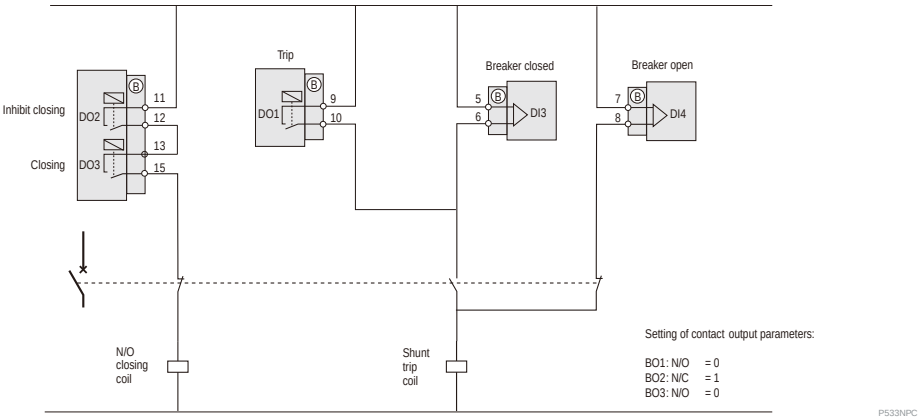


Figure 329 - Example of use with undervoltage trip coil with fail-safe condition (diagram 2)

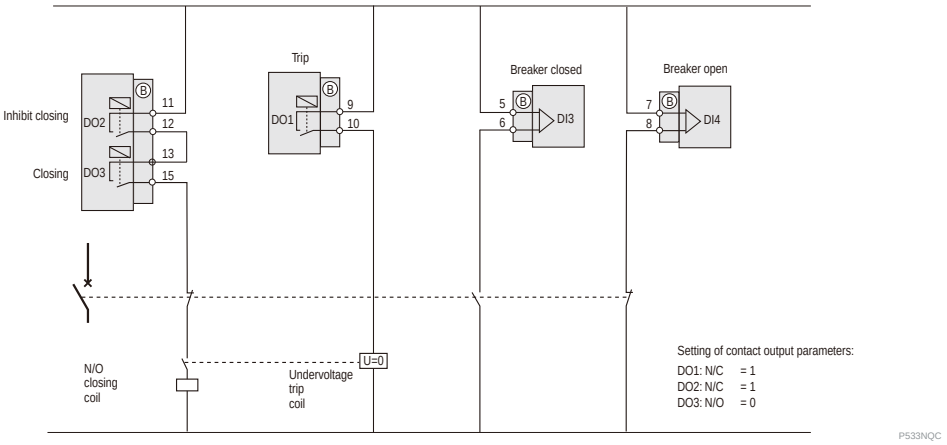
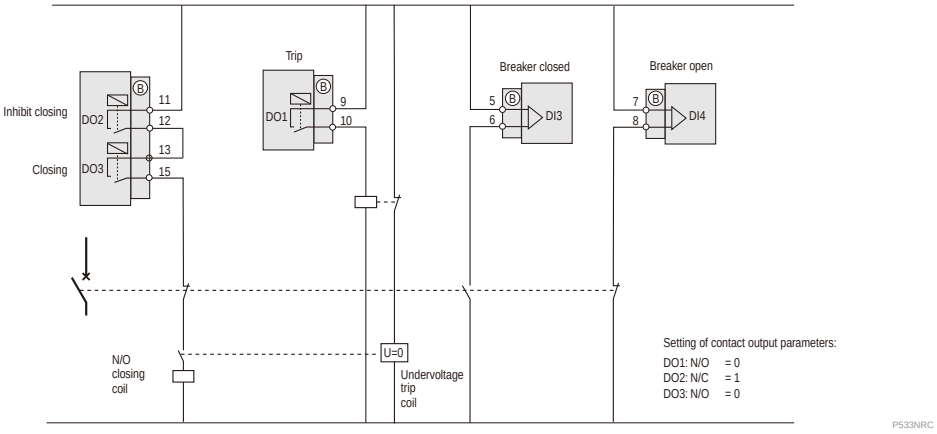
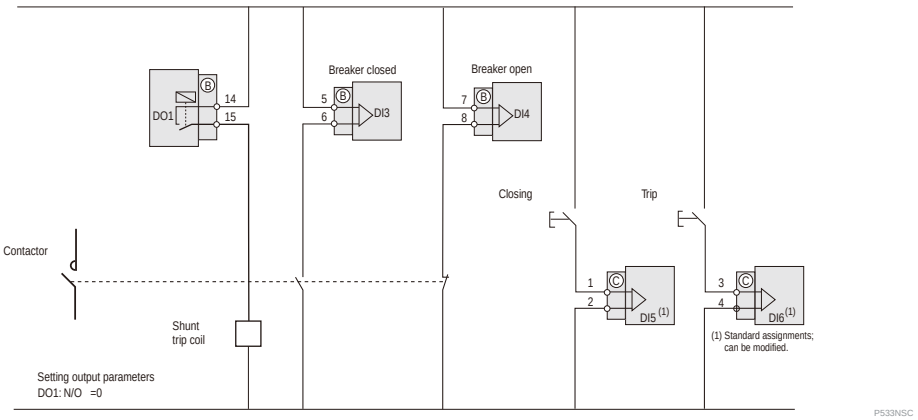


Figure 330 - Example of use with undervoltage trip coil without fail-safe condition (diagram 3)



NOTE: When using an undervoltage trip coil, it is recommended to install a free wheel diode in parallel to the opening coil in order to slow down its operation in the event of a microbreak on its power supply.

Figure 331 - Example of use with contactor under permanent order command (diagram 4)



Programmable switchgear interlocking

Switchgear interlocking can be easily done using the object matrix.

For example, if object 1 is the circuit breaker, object 2 the isolating switch, and object 4 the ground switchgear, the blocking scheme could be configured as below:

1. When CB is closed, the isolating switch open operation is blocked.
2. When ground switchgear is closed, the CB close operation is blocked.

Local control on single-line diagram

The objects can be controlled directly on the local panel in the mimic screen that includes the single-line diagram.

1. Press the OK key.
2. With the ◁ and ▷ arrow keys, select the object, or one of the four virtual inputs, or the auto-reclosing (if they are displayed in the mimic).
3. Press the OK key to bring up the menu list.
4. Select Open or Close and then press the OK key.

NOTE: Only the objects configured connected in Output matrix can be selected in Mimic screen.

Logging and recording functions

Time tagging

For operations and fault analysis all data are logged with an accurate date and time.

The items that are time tagged and logged are:

- Events
- Disturbance recording
- Fault data logging
- Voltage interruptions
- Maximum and minimum values of the last 31 days or last 12 months

The PowerLogic P5 protection relay time stamp resolution is 1 ms.

Event buffer

The PowerLogic P5 protection relay provides a logging and recording of all important events that happen during operation. All “operationally relevant” signals, each fully tagged with date and time at signal start and signal end, are registered and stored in chronological order. For example, an event can be, start-on, start-off, trip-on or trip-off of any protection stage, alarm-on or alarm-off, a digital input change, etc. Each event is associated with a unique code. The selection of signals to be considered in the event logging and recording can be configured by the user.

As an example, a typical trip event is shown in Example of I>1 trip-on event and its visibility in local panel and communication protocols, page 524.

Table 154 - Example of I>1 trip-on event and its visibility in local panel and communication protocols

Event	Description	Local panel	Communication protocols
Code CHENN: 01E02	CH = event channel, channel 1 NN = event code, event 2	No	Yes
A-B-C	Fault type	Yes	No
Event desc: I>1 trip on 2 pu	Event text and fault value	Yes	No
yyyy-mm-dd: 2018-01-31 hh:mm:ss:nnn: 08:35:13.413	Date Time	Yes	Yes

Timestamp is truncated to 1 ms in event list. The logged events can also be read using:

- Local panel (see the **Events list** view under the **Events** option of the **Logs** menu)
- eSetup Easergy Pro or Web HMI (see the **Event buffer** view in the **LOGS** menu)
- Communication: In this case, only the latest event can be read.

On the local panel, the code is replaced by a ranking number.

With eSetup Easergy Pro, the events can be stored to a file, which is very helpful if the PowerLogic P5 protection relay is not connected to a SCADA system.

SCADA systems are reading events using any of the available communication protocols.

Event configuration

To configure which events are recorded the event enabling matrices are used (see the Event enabling views in the **LOGS** menu of eSetup Easergy Pro). This allows the optimisation of reporting by selecting the most useful events and deselecting the ones of no interest. This prevents them from being written to the event buffer.

- Event enabling - stages 1

  This matrix is used to activate an event when there is a change of the Start and Trip status of a protection function/ stage. Select **On**, **Off** or **both**.

- Event enabling - stages 2

  This matrix is similar to the Event enabling - stages 1 matrix but dedicated to functions which provide more information than start and trip signals (e.g. thermal image protection).

- Event enabling - objects

  This matrix is dedicated to generate events associated to the defined objects such as circuit breaker status and controls.

- Event enabling - AR

  This matrix is dedicated to the auto recloser function and is used to generate events associated with auto reclose states and status.

- Event enabling - logic

  This matrix is used to generate events when one of the logic equations (up to 20) gets true or false.

- Event enabling - other

  This matrix is dedicated to system monitoring including setting group change.

The maximum size of the buffer is 2000 events and can be exported as a PDF file via eSetup Easergy Pro **Print** menu. 300 events can be displayed by eSetup Easergy Pro. Only the latest 300 events, or the oldest 300 events, can be read on the local panel according to the scroll order parameter.

All events are stored in non-volatile memory inside the PowerLogic P5 protection relay and can be saved every 150 ms in the backup memory if available (Extension board option).

When the buffer is filled the oldest event will be overwritten when a new event occurs. The shown resolution of a time stamp for an event is one millisecond, but the actual resolution depends on the particular function creating the event. For example, most protection stages create events with a 5 ms, 10 ms or 20 ms resolution. The absolute accuracy of all time stamps also depends on the protection relay's time synchronisation.

Event buffer overflow

The normal procedure is to poll events from the PowerLogic P5 protection relay all the time. If this is not done, the event buffer could reach its limits. In that case, the oldest event is deleted and the newest is displayed with an OVF (overflow) code on the local panel.

The Event setting parameters can be configured in **Logs**/**Event logs**/**Counter** of the local panel .

Characteristics

Table 155 - Setting parameters for events

Parameter (description/label)	Value	Description
Clear events/Clear events	- Clear	 Clear the buffer of events
Fault value scaling/Fault value		Scaling of event fault value
	PU	Per unit scaling
	Primary	Primary scaling
Display evt time not in sync/Event synchro.	On (check mark)	Event time shown normally if relay is synchronised
	Off	Event time is shown in brackets if relay is not synchronised

Table 156 - Measured and monitored parameters for events

Parameter (description/label)	Value	Description
Event buffer size/ Counter	2000	Event buffer size

Disturbance recording

Description

The PowerLogic P5 protection relay provides for fault events a disturbance recording with the sampled analogue values of pre-selected analogue currents and voltages before, during and after a fault event. Additionally, the calculated frequency, the states of digital inputs (DI) and output (DO) signals are provided for detailed fault analysis. The complete list of provided signals is shown in Disturbance recording parameters (measurements and monitored values), page 528.

Triggering the recording

The recording can be triggered by any start or trip signal from any protection stage, by a digital input, logic output or GOOSE signals. The triggering signal is selected in the output matrix (vertical signal DR). The recording can also be triggered manually. All the recordings are time stamped. The recording can be made at 48 samples/cycle or 24 samples/cycle rate.

Reading recordings

The recordings can be downloaded with eSetup Easergy Pro. The recording is in COMTRADE format. This also means that other programs can be used to view and analyse the recordings made by the PowerLogic P5 protection relay.

PowerLogic P5 disturbance records can be read as well thru IEC 61850 and DNP3 ethernet protocols and DNP3 and IEC 60870-5-103 serial communication protocols. In case disturbance record is downloaded with sFTP, PowerLogic P5 generate and compress disturbance recorder COMTRADE data file with DEFLATE format (rfc1950) by using public domain zlib functions. To decompress the COMTRADE data file, please follow inflate API process defined in Zlib specification. For detail, please visit home page of zlib (http://www.zlib.net/).

Number of channels

A maximum of 30 records can be stored with a mix of analogue and digital signals:

- 14 Analogue signals
- 124 Digital Signals (40 Digital inputs; 20 Digital outputs; 32 Start signals; 32 Trip signals)

A pre-selection of the channels and their order in the fault recording is made per default and can be changed by the user with the parameters shown in Disturbance recording parameters (measurements and monitored values), page 528.

Table 157 - Examples of disturbance recording durations

Selected signals	Maximum time setting
4 analogue input signals, up to 40 digital input signals , up to 20 digital output signals , start and trips signals[137][138]	48/cycle: 6.06 s 24/cycle: 12.12 s
4 analogue inputs and trip signals	48/cycle: 10.92 s 24/cycle: 21.86 s
4 analogue inputs, start and trip signals	48/cycle: 9.10 s 24/cycle: 18.20 s
8 analogue signals, up to 20 digital input signals, up to 20 digital output signals and trip signals	48/cycle: 4.96 s 24/cycle: 9.92 s
8 analogue signals, up to 20 digital input signals, up to 20 digital output signals, start and trip signals	48/cycle: 4.55 s 24/cycle: 9.10 s
9 analogue input signals, frequency, up to 40 digital input signals, up to 40 digital output signals, all start and trip signals	48/cycle: 3.41 s 24/cycle: 6.82 s

137. Digital input signal means digital inputs (DI), virtual inputs (VI), etc.
138. Digital output signal means digital outputs (DO), virtual output (VO), etc.

NOTE: eSetup Easergy Pro provides directly the maximum recording length when the signals to record are selected (see the bottom section of the Disturbance recording view in the General menu).

NOTE: If the disturbance record is not correctly displayed in eSetup Easergy Pro, please try to change the setting of Encoding in Wavewin. You can find the .exe file from ...\Easergy Pro\Wavewin\Wavewin.exe. Double click **wavewin32.exe**, click on **Options\Display** from the menu bar, in pop-up **System Settings** window, select **Language** tab, then change the setting of **Encoding:** to UTF8, click **Ok** button.

Parameters

Table 158 - Disturbance recording parameters (measurements and monitored values)

Parameter (description/label)	Value	Description
Sample rate/SR		Sample rate per cycle (two options to select: 48/cycle or 24/cycle)
Maximum time setting/MaxLen		Maximum time setting (in second) This value depends on the number and type of the selected channels and the configured recording length.
Status/Status		Status of recording
	-	Not active
	Run	Waiting for a triggering
	Trig	Recording
Add recorder channel/AddCh		Add one channel. The maximum number of channels used simultaneously is 16.
	IA, IB, IC	Phase current
	IN	Measured neutral current by CSH or CTs according to the model of PowerLogic P5
	VAB, VBC, VCA	Phase to phase voltage (only available in three voltage measurement modes: 2VPP+VN, 2VPP+VN+VPPy, VPP/VPPy)
	VA, VB, VC	Phase to neutral voltage (only available in four voltage measurement modes: 3VP, 3VP/VPy, 3VP/VPPy, 3VP+VN)
	VN	Neutral voltage
	f	Frequency (reference side)
	IN.sens	Sensitive neutral current
	VABy	Phase to phase voltage taken from other side of the CB for synchro-check scheme
	VAy	Phase to neutral voltage taken from other side of the CB for synchro-check scheme
	fy	Frequency (comparison side)
	DI	Digital inputs 1-20 and virtual inputs 1-4 status
	Other DI	The remaining digital inputs available and the function keys status
	DO	All digital outputs and virtual outputs 1-6 status
	Starts	Start signals of all enabled protection functions
	Trips	Trip signals of all enabled protection functions
Remove all channels/ClrCh	-; Clear	Remove all channels

Table 159 - Disturbance recording parameters (settings)

Parameter (description/label)	Value	Description
Recording length/Time	0.1...30 s	Recording length (in second)
Pre trigger time/PreTrig	0...100%	Amount of recording before triggering
Disturbance recording event	On (checkmark); Off	The event log is created or not when Disturbance recording is triggered.
Recording memory events	On (checkmark); Off	The event log is created or not when Disturbance recording is reset (clear the recording, reset the time and so on).
Manual triggering/ManTrig	-; Trig	Command to launch manually a new disturbance recording
Clear oldest buffer/Clear	-; Clear	Clear the oldest disturbance recording
Clear all buffers/ClrAll	-; Clear	Clear all the disturbance recordings

The selection of signals depends on the model of PowerLogic P5 protection relay and also on the voltage measurement mode.

Characteristics

Table 160 - Disturbance recording characteristics

Characteristics	Values	Note
Sample rate	48 samples/cycle 24 sample/cycle	
Recording time (one record)	0.1...30 s	
Pre-trigger rate	0...100%	
Number of selected analog channels	0...16	
File format	IEC 60255-24:1999 IEC 60255-24:2013	ASCII format

The recording time and the number of records depend on the time setting and the number of selected channels.

Voltage interruptions

Description

The PowerLogic P5 protection relay includes a simple function to detect voltage interruptions. The function calculates the number of voltage interruptions and the total time of the voltage-off time within a given calendar period. The period is based on the relay's real-time clock. The available periods are:

- 8 hours, 00:00...08:00, 08:00...16:00, 16:00...24:00
- one day, 00:00...24:00
- one week, Monday 00:00...Sunday 24:00
- one month, the first day 00:00...the last day 24:00
- one year, 1st January 00:00...31st December 24:00

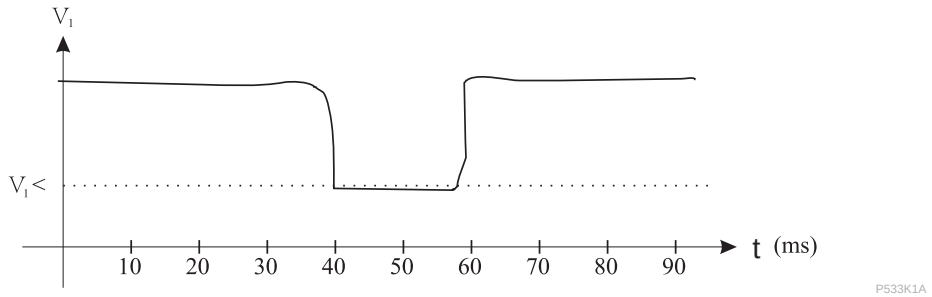
After each period, the number of interruptions and the total interruption time are stored as previous values. The interruption counter and the total time are cleared for a new period. Previous values are overwritten.

Voltage interruption is based on the value of the positive sequence voltage V1 and a set limit value. Whenever the measured V1 goes below the limit, the values of the interruption counter and the total time counter starts are incremented.

The shortest recognised interruption time is 40 ms. If the voltage-off time is shorter, it may be recognised depending on the relative depth of the voltage dip.

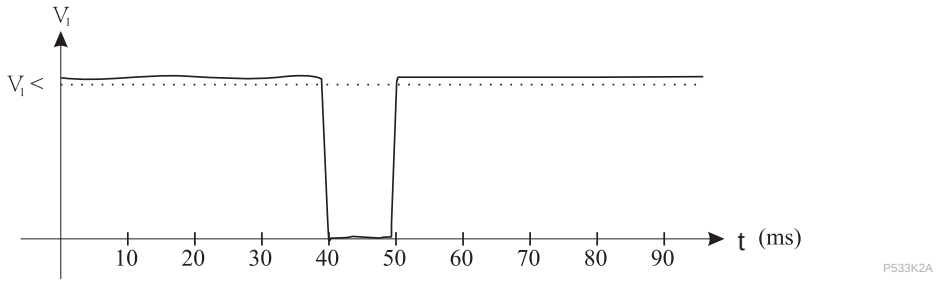
If the voltage has been significantly above the limit V1< and then there is a small and short under-swing, it is not recognised.

Figure 332 - A short voltage interruption which is probably not recognised



On the other hand, if the limit V1< is high and the voltage has been near this limit, and then there is a short but very deep dip, it is recognised.

Figure 333 - A short voltage interrupt that will be recognised



Settings and measurements

The following Setting parameters of the voltage interruption function, page 531 describes the setting parameter used for the voltage interruption and Measured and recorded values of the voltage interruption function, page 531 shows the related measured values available.

Table 161 - Setting parameters of the voltage interruption function

Parameter	Value
Voltage low limit/V<	
Setting range	10%...120% Vn[139]
Resolution	1% Vn[139]
Reset ratio	> 103%
Accuracy	3%
Int. Calc. period/Period	
Options	8h; Day; Week; Month; Year
Characteristic time	
Start time	< 60 ms
Disengaging time	< 60 ms

Table 162 - Measured and recorded values of the voltage interruption function

	Parameter	Value	Description
Measured value	Voltage	LOW; OK	Current voltage status
	V1		Measured positive sequence voltage
Recorded values	Interruption counter/Count		Number of voltage interruptions during the current observation period
	Prev. # of interrupts/Prev		Number of voltage interruptions during the previous observation period
	Total interrupt time/ Total		Total (summed) time of voltage interruption during the current observation period **NOTE:** Total interrupt time "5 20" means 5 days and 20 hours.
	Previous total int. time/Prev		Total (summed) time of voltage interruption during the previous observation period

139. Vnom

Fault data logging

Fault log provides fault signals including the measured fault data captured during a fault sequence. The fault logs are logged in chronological order with reference to the specific fault.

A new fault log is triggered by a starting signal of a protection function.

As an example, a typical fault log is shown in Example of I>1 LOG and its visibility in local panel and communication protocols, page 532.

There is detailed information available of the eight latest faults: date, time stamp, setting group active, fault type, fault phase, fault value, I/Vpole angle, elapsed delay, pre-fault current and fault direction.

The information can be different according to the protection functions.

Table 163 - Example of I>1 LOG and its visibility in local panel and communication protocols

Parameters (description/label)	Value	Description
Date/Date	2022-02-28	Time stamp of the fault log, date
hh:mm:ss:ms	13:28:41.321	Time stamp, time of day
Group/SetGrp	1	Active setting group during fault
Fault type/Fault type	A-N	Fault type
Fault phase/Fault phase	A	Fault phase
I>1 fault value/Fault value	5.00 pu	Maximum fault current
I/Vpol angle	120°	I/Vpol angle
Elapsed delay/End delay	100%	Elapsed time of the operating time setting. 100% = trip
Pre-fault current/Pre-fault current	0.00 pu	1 s average phase currents before the fault
Fault direction	Forward	Fault direction

Table 164 - Example of VT supervision and its visibility in local panel and communication protocols

Parameter (description/label)	Value	Description
Date/Date	2018-02-12	Time stamp of the fault log, date
hh:mm:ss:ms	09:45:15.245	Time stamp, time of day
V2 value/V2	x V	Negative sequence voltage
I2 value/I2	x A	Negative sequence current

The fault logs can be read via:

- Local panel

  In the **Log** view of each protection function in the **Protection** sub-menu
- eSetup Easergy Pro or Web HMI

  In each protection function view in the **Protection** menu
- Communication

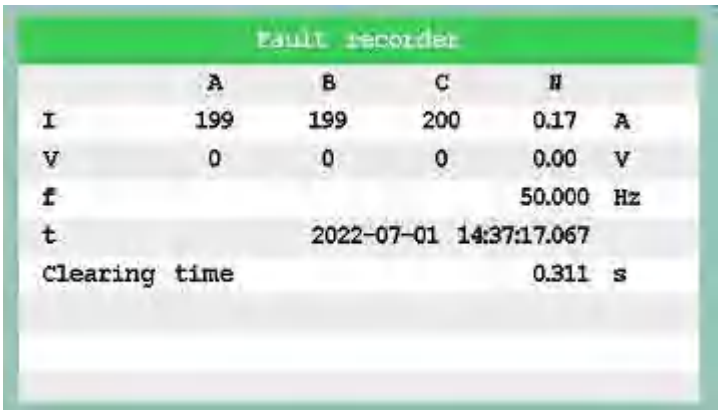
  In this case, only the latest fault logs can be read.

Fault recorder

PowerLogic P5 provides a dedicated fault recorder panel to display the last fault information. Compared to the fault data logging, fault recorder can provide additionally the magnitude of all the phases.

Fault record is triggered instantaneously by general trip signal. This function records the fault information right after the global trip signal is issued.

Figure 334 - An example of fault recorder in P5x30 local panel



From the fault recorder panel, you will find the following information:

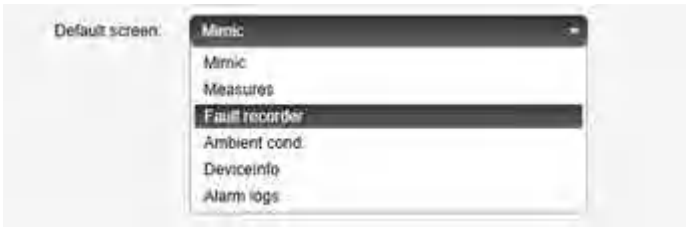
- IA, IB, IC magnitudes in primary [A]
- VA, VB, VC magnitudes in primary [V]
- IN.calc (derived value regardless sensing mode) in primary [A]
- VN.calc (derived value regardless voltage connection mode) in primary [V]
- Frequency magnitude f in [Hz]
- Trip time stamp (= Time when global trip (on event))
- Clearing time (the interval from trip to CB open) = Time when CB open (on event) – Time when global trip (on event)

Access fault recorder screen

After a fault occurred, the fault record can be read from local panel. There are two methods to access:

- When alarm messages popup or current view is the home screen, press *i* key to access the **Fault recorder** screen to check the last fault information in detail.
- After setting *Fault recorder* as default screen (in the eSetup Easergy Pro software, in **GENERAL**/**Local panel conf**.), when default screen is displayed, press < or > key to access the **Fault recorder** screen.

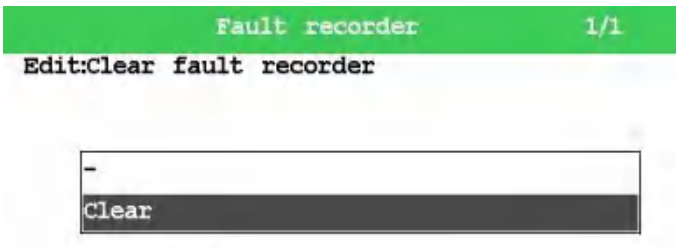
Figure 335 - Setting Fault recorder as default screen



Reset fault recorder value

Fault recorder value can be reset by following one of the two methods:

- On local panel, go to **LOGS & ALARMS /Fault recorder** screen, select *Clear* option.



- In eSetup Easergy Pro, go to **Device/Clear** page, enable the **Clear fault recorder** checkbox, then click **OK**.

After the reset operation, all the values will be reset to default values.

InterRelay communication log

The InterRelay communication log records the following events:

- Comm link failure on/off
- Comm failure on/off
- Comm error on/off
- Address not paired on/off
- Loopback test mode on/off
- Loopback test OK on/off
- Loopback test NOK on/off

The InterRelay communication logs can be enabled/disabled by eSetup Easergy Pro in **LOGS**/**Event enabling – other**, in the **InterRelay communication** section.

Running hour counter

Description

The running hour counter is typically used to monitor the service time of the motor or appropriate feeder. This function calculates the total active time of the selected digital input, virtual I/O or function key. The resolution is 10 seconds.

Settings / characteristics

Table 165 - Running hour counter settings/characteristics

Settings / Characteristics (description/label)	Value
Engine running hours/Run hours	
Setting range	0...876000 h
Engine running/Runs (in seconds)	
Setting range	0...3599 s
Resolution	10 s
Start counter/Starts	
Setting range	0...65535
Running hour status/Status	
Options	Stop; Run
Run hour DI link	
Options	Selection of one digital input (DI), one virtual input (VI), one virtual output (VO), or one function key (Fx).
Started at	Date and time of the last activation
Stopped at	Date and time of the last inactivation

Maximum and minimum values of the last 31 days and 12 months

Maximum and minimum values of the phase currents and active/reactive/apparent power measurements from the last 31 days and the last 12 months are stored in the relay's non-volatile memory. Corresponding time stamps are stored for the last 31 days. This can be viewed in the **LOGS** menu/**Month max** sub-menu of the eSetup Easergy Pro.

The registered values are listed in the following table:

Table 166 - Registered values

Measurement	Max	Min	Description	31 days	12 months
IA, IB, IC	■		Phase current (fundamental frequency value)		
IN.meas, IN.sens	■		Neutral current		
S	■		Apparent power	■	■
P	■	■	Active power	■	■
Q	■	■	Reactive power	■	■

The timebase can be a value from one cycle to one minute. Also a demand value can be used as the timebase and its value can be set between 10 and 60 minutes.

Table 167 - Parameters of the day and month registers

Parameter	Value	Description
Timebase		Parameter to select the type of the registered values
	20 ms	Collect min and max of one cycle values[140]
	200 ms	Collect min and max of 200 ms average values
	1 s	Collect min and max of 1 s average values
	1 min	Collect min and max of 1 minute average values
	demand	Collect min and max of demand values
ResetDays		Reset the 31 day registers
ResetMonth		Reset the 12 month registers

140. This is the fundamental frequency RMS value of one cycle updated every 20 ms.

System clock and synchronisation

The PowerLogic P5 protection relay's internal clock is used to time-stamp events and disturbance recordings.

The system clock should be externally synchronised to get comparable event time stamps for all the protection relays in the system.

The synchronising is based on the difference of the internal time and the synchronising message or pulse. This deviation is filtered and the internal time is corrected softly towards a zero deviation.

Time zone offsets

Time zone offset (or bias) can be provided to adjust the protection relay's local time. The offset can be set as a Positive (+) or Negative (-) value within a range of -15.00 to +15.00 hours and a resolution of 0.01 h. Basically, resolution by a quarter of an hour is enough.

Daylight saving time (DST)

The protection relay provides automatic daylight saving adjustments when configured. A daylight saving time (summer time) adjustment can be configured separately and in addition to a time zone offset in the **GENERAL** menu/**System clock** sub-menu of the eSetup Easergy Pro.

Daylight time standards vary widely throughout the world. Traditional daylight/ summer time is configured as one (1) hour positive bias. The new US/Canada DST standard, adopted in the spring of 2007 is one (1) hour positive bias, starting at 2:00am on the second Sunday in March, and ending at 2:00am on the first Sunday in November. In the European Union, daylight change times are defined relative to the UTC time of day instead of local time of day (as in U.S.), so European customers need to carefully check the local country rules for DST.

The daylight saving rules are by default UTC +2:00 (24-hour clock):

- Daylight saving time start: Last Sunday of March at 03.00
- Daylight saving time end: Last Sunday of October at 04.00

To help ensure proper hands-free year-around operation, automatic daylight time adjustments must be configured using the “Enable DST” setting in the **GENERAL** menu/**System clock** sub-menu of the eSetup Easergy Pro and not with the time zone offset option.

Synchronisation modes and priority

PowerLogic P5 provides multiple synchronisation modes. The modes and priority are listed as follows.

Priority	Mode
1	IEEE1588
2	IRIG-B
3	SNTP
4	SNTP backup
5	DI pulse signal
6	Modbus
7	IEC101/103
8	DNP3

Synchronisation with DI

The clock can be recognised by reading minute pulses from digital or virtual inputs. The sync source is selected with the SyncDI setting. When a rising edge is detected from the selected input, the system clock is adjusted to the nearest minute. The length of the digital input pulse should be at least 50 ms. The delay of the selected digital input should be set to zero.

Synchronisation correction

If the sync source has a known offset delay, it can be compensated with this setting. This is useful for compensating hardware delays or transfer delays of communication protocols. A positive value compensates a lagging external sync and communication delays. A negative value compensates any leading offset of the external synch source.

Sync source

When the protection relay receives new sync message, the sync source display is updated. If no new sync messages were received within the last 200 or 400 seconds, the protection relay switches over to internal sync mode.

The timeout check value is either 200 seconds or 400 seconds, depending on the following cases:

- if no SNTP server IP address is available or only one SNTP server IP address is available, the timeout check value is 200 seconds.
- if there are two available SNTP server IP addresses, the timeout check value is 400 seconds.
- if the time source is IEEE1588, the timeout check value is 400 seconds, not affected by the available number of SNTP IP addresses.

Sync source: IRIG-B

IRIG-B synchronisation is supported by the IRIG-B module connected to the optional extension module of the protection relay.

Deviation

The time deviation means how much the system clock time differs from the sync source time. The time deviation is calculated after receiving a new sync message. The filtered deviation means how much the system clock was really adjusted. Filtering takes care of small deviation in sync messages.

Auto-lag/lead

The protection relay synchronises to the sync source, meaning that it starts automatically leading or lagging to stay in sync with the master. The learning process takes a few days.

Table 168 - Clock synchronisation parameters

Parameter (description/label)	Value	Description
synchronising source/ SySrc		Clock synchronisation source
	Internal	If there is no synchronising source within 200 s or 400 s, Internal will be the clock synchronisation source, refer to Synchronisation modes and priority, page 538 for more information.
	DI	Digital input
	SNTP	Protocol sync
	ModBus	Protocol sync
	ModBus TCP	Protocol sync

Table 168 - Clock synchronisation parameters (Continued)

Parameter (description/label)	Value	Description
	IEC101	Protocol sync
	IEC103	Protocol sync
	DNP3	Protocol sync
Minute sync pulse DI/ SyncDI[141]		The digital input used for clock synchronisation. Possible value depends on the type of I/O card installed.
	-	DI not used for synchronising.
	Select one digital or virtual input	
Synch correction/ SyOS	-10000.000... +10000.000 s	synchronisation correction for any constant deviation in the synchronising source
Auto adjust interval/ AAIntv[142]	0.0...1000.0 s	Adapted auto-adjust interval for 1 ms correction
Average drift/AvDrft	lead; lag	Adapted average clock drift sign
Sync message counter/MsgCnt	0...65535	The number of received synchronisation messages or pulses
Latest time deviation/ Dev	± 32767 ms	Latest time deviation between the system clock and the received synchronisation
Filtered sync deviation/FilDev	± 125 ms	Filtered synchronisation deviation

Table 169 - System clock parameters

Parameter (description/label)	Value	Description
Date/Date		Current date
Time of day/Time		Current time
Date style/Style	yyyy-mm-dd	Date format
	dd-mm-yyyy	
	mm-dd-yyyy	
Time zone/Time zone	-15.00...+15.00[143]	UTC time zone for SNTP synchronisation.[144]
Status of DST/DST	enabled; disabled	Daylight saving time for SNTP
Enable event	enabled; disabled	

141. Set the DI delay to its minimum and the polarity so that the leading edge is the synchronising edge.
142. If external synchronisation is used, this parameter is set automatically.
143. A range of -11 h - +12 h would cover the whole Earth but because the International Date Line does not follow the 180° meridian, a wider range is needed.
144. Decimal numbers are used, e.g. the time zone of 5:45 is expressed as 5.75.

Monitoring functions

Trip circuit supervision (ANSI 74)

Description

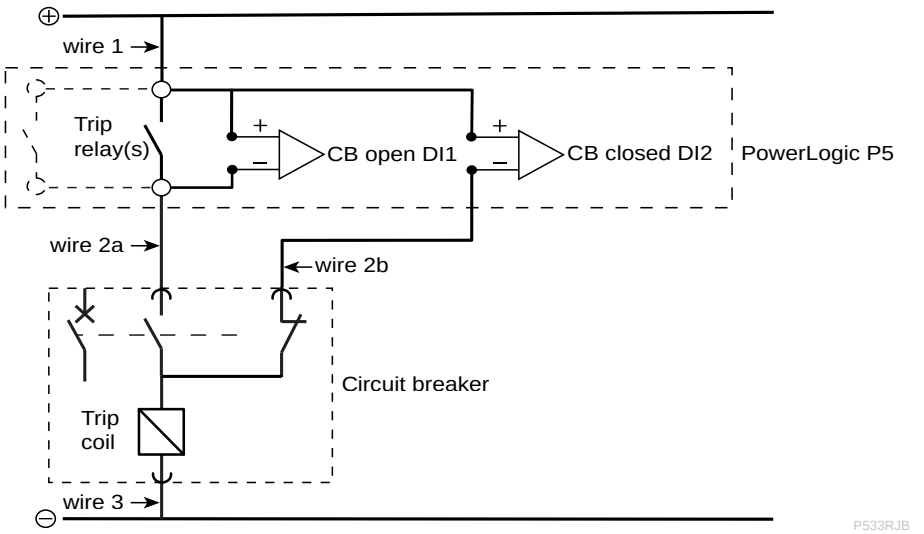
Trip circuit supervision monitors the wiring from the protective device to the circuit breaker trip coil. This function monitors the availability of the circuit when it is requested to trip and reports an issue if needed.

By default, this user-configurable supervision function uses the PowerLogic P5 programmable logic to monitor the circuit continuity, loss of auxiliary supply voltage or mismatching of the CB position indication contacts. Depending on user settings, the function inhibits closing of the circuit breaker.

Trip circuit supervision scheme

The trip circuit supervision scheme using two digital inputs 52a and 52b can be implemented as illustrated in the following wiring diagram. No external resistors are needed for this scheme to function.

Figure 336 - Trip circuit supervision scheme



In the normal condition, when the trip circuit is OK, the status of inputs is opposite (0,1) or (1,0). When the trip circuit is not OK (coil, wires, auxiliary contact state or auxiliary voltage failure), both logic inputs are in the same state and an alarm is issued after a delay. This delay is needed to help prevent false signaling during breaker opening events. The timing is set based on breaker operating time and trip pulse length.

The following table summarises the TCS alarm output depending on the CB and its auxiliary contact positions as well as possible wiring failure conditions.

CB position	Conditions	CB open DI1	CB closed DI2	TCS alarm
Closed	Trip circuit OK	Closed	Open	False
	Wire 1 failure[145]	Open	Open	True
	Wire 2a failure[145]	Open	Open	True
	Wire 3 or trip coil failure[145]	Open	Open	True

145. "failure" indicates that one or more of the components are permanently open circuit or short circuit.

CB position	Conditions	CB open DI1	CB closed DI2	TCS alarm
Open	Trip circuit OK	Open	Closed	False
	Wire 1 failure[146]	Open	Open	True
	Wire 2b failure[146]	Open	Open	True
	Wire 3 or trip coil failure[146]	Open	Open	True

Figure 337 - Block diagram of trip circuit supervision (ANSI 74)

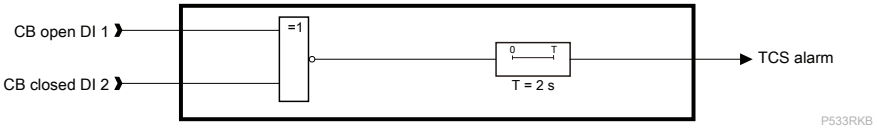
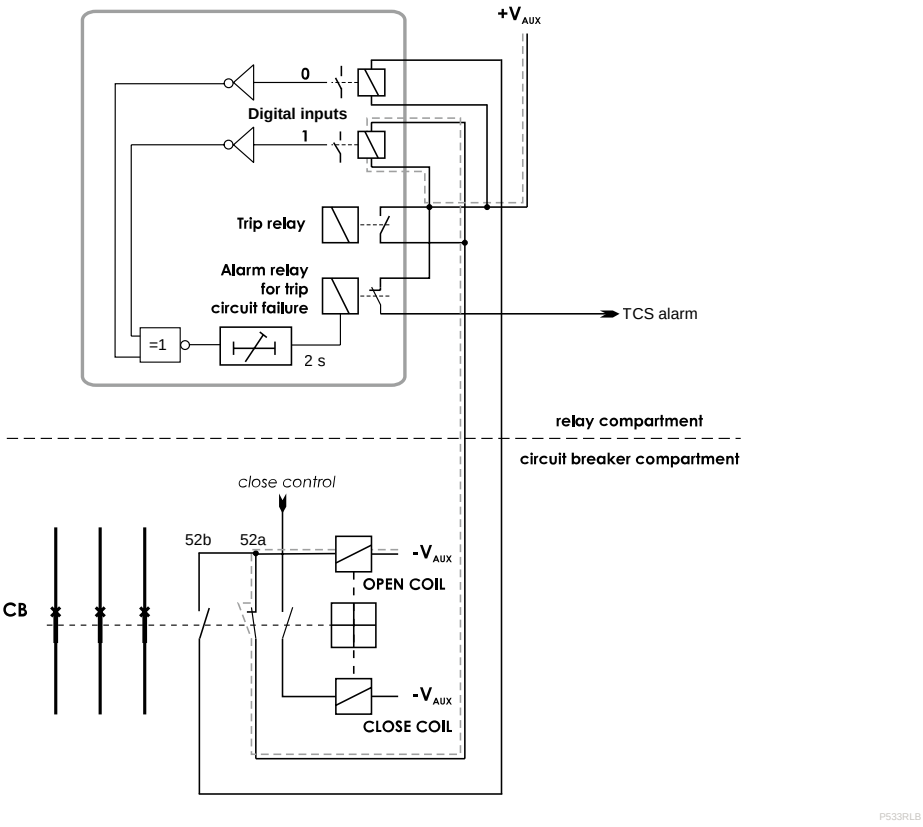
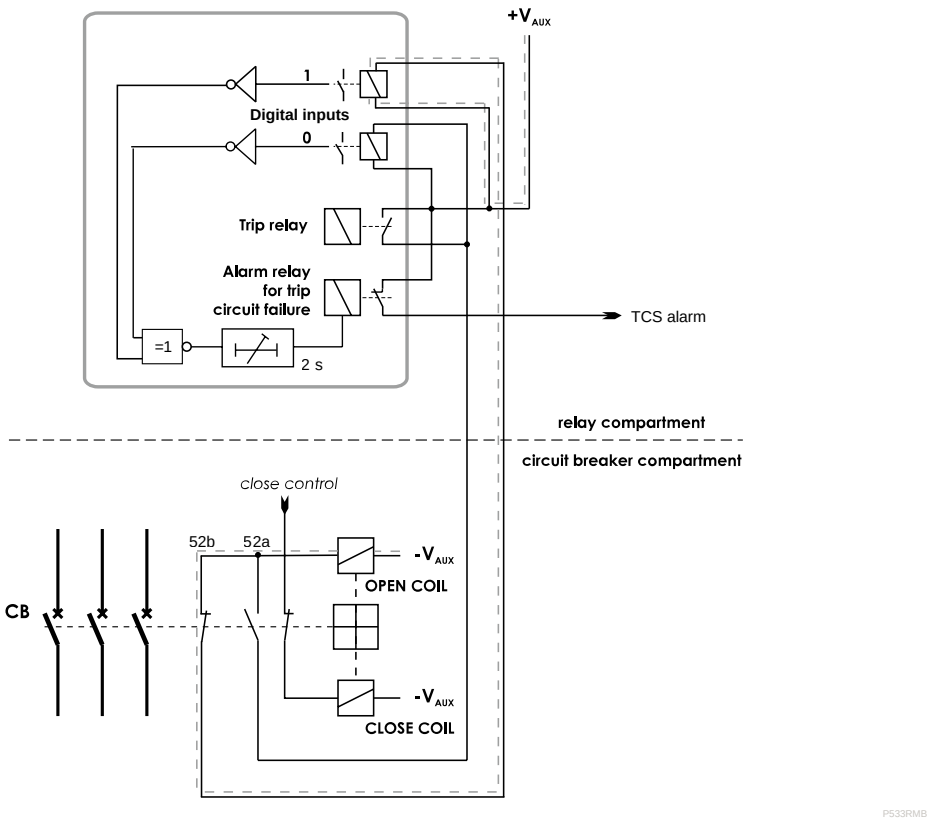


Figure 338 - TCS with two digital inputs when the CB is in closed position



146. "failure" indicates that one or more of the components are permanently open circuit or short circuit.

Figure 339 - TCS two digital inputs when the CB is in open position



The figure below shows the default logic configuration of TCS in PowerLogic P5. In this example the TCS is latched when an error condition is encountered and reset using a virtual input.

Figure 340 - An example of logic configuration for TCS

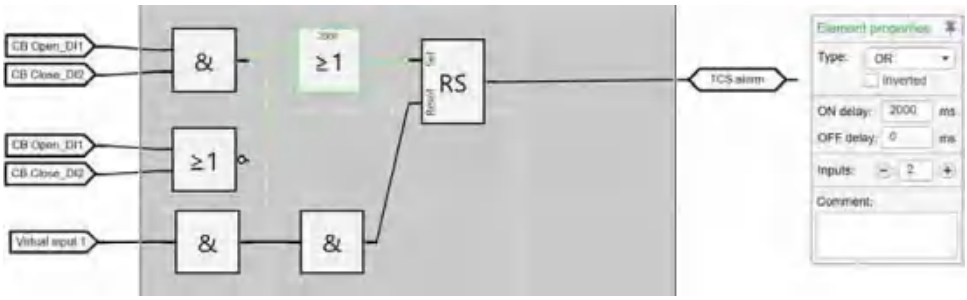
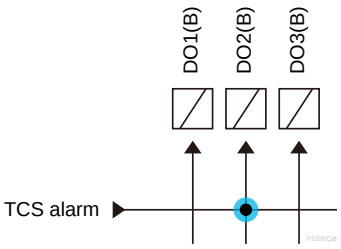


Figure 341 - An example of output matrix configuration for TCS



Transformer monitoring (ANSI 26/63)

Introduction

The transformer monitoring function (ANSI 26/63) is used to monitor signals from external Buchholz or Thermostat devices. Big transformers are usually fitted with one or more Buchholz relays.

A Buchholz relay detects gases that arise due to normal ageing processes of the transformer insulation. After a sufficient amount of gas has accumulated, the alarm contact is activated. This measurement principle has the effect that the alarm is also activated if the filling level of the insulating oil sinks below the mounting place of the Buchholz relay due to a leakage. Since in such a case the filling level sinks quite rapidly, it is common to have a separate detection hardware for this, which then issues an insulation alarm.

The number of such relays mounted at the transformer is dependent on the size and construction details (mainly whether it is 3-phase or three single-phase transformers, and whether it is with or without tap changer(s)).

Depending on the situation, the Buchholz relay either alarms operations or trips the CBs to prevent the transformer from damages. These alarm and trip signals can be routed to the protection IEDs for logging purposes, for using its communication link to transmit the signals to the SCADA system, or in case of the Buchholz trip to activate the tripping also through the protection IED trip circuit.

Main features of transformer monitoring function:

- Log relevant events when the input signals change state
  It can log any state change of the 8 signals (5 for alarm, 2 for trip, 1 for blocking) in the event buffer.
- Feed the trip input signals into the global trip signal.
  It can show alarm on the local panel when any of the 2 trip signals (gas trip/ oil flow trip) gets asserted.

Depending on the digital input signals, transformer monitoring indicates one of the following statuses:

Table 170 - Statuses of the transformer monitoring

Status	Description
-	Normal status, function is enabled and in normal operation (= in none of the following statuses); or function is not enabled.
Alarm	Function is enabled and in normal operation (not blocked) and any of the alarm input signals is active (= any of the 5 DIs for insulation alarm/ oil temperature alarm/ gas alarm/ oil at minimum level/ oil at maximum level is active).
Trip	Function is enabled and in normal operation (not blocked) and any of the trip input signals is active (= any of the 2 DIs for gas trip/ oil flow trip is active).
Blocked	Function is enabled and input assigned at “DI for blocking” is active.

The monitoring signals are readily available in P5 matrices as DI or VI with customizable names. Customization of DI/VI names is readily available to prevent doubts and mistakes about their meanings. Therefore there is no need to add the signals from transformer monitoring into any matrix.

Figure 342 - Transformer monitoring function in eSetup Easergy Pro

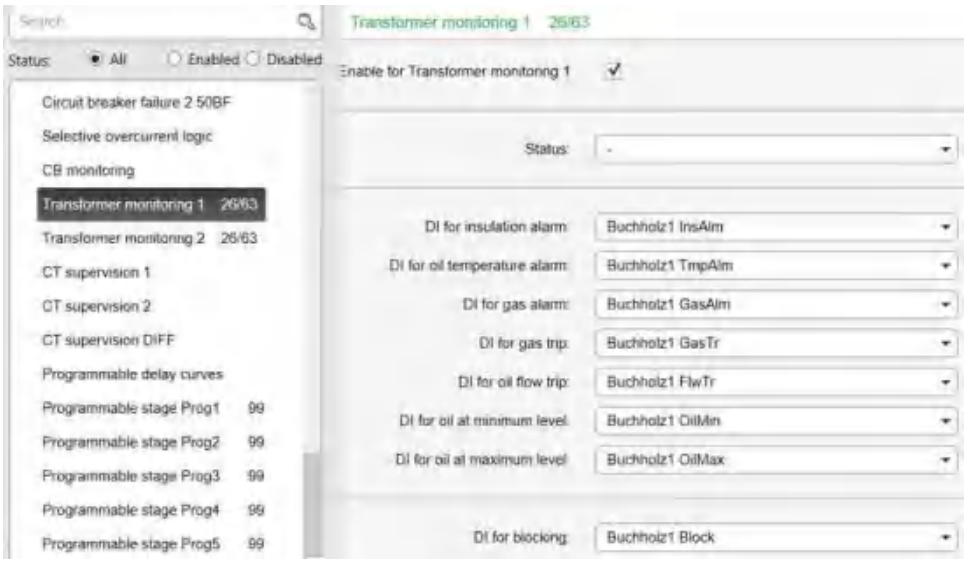
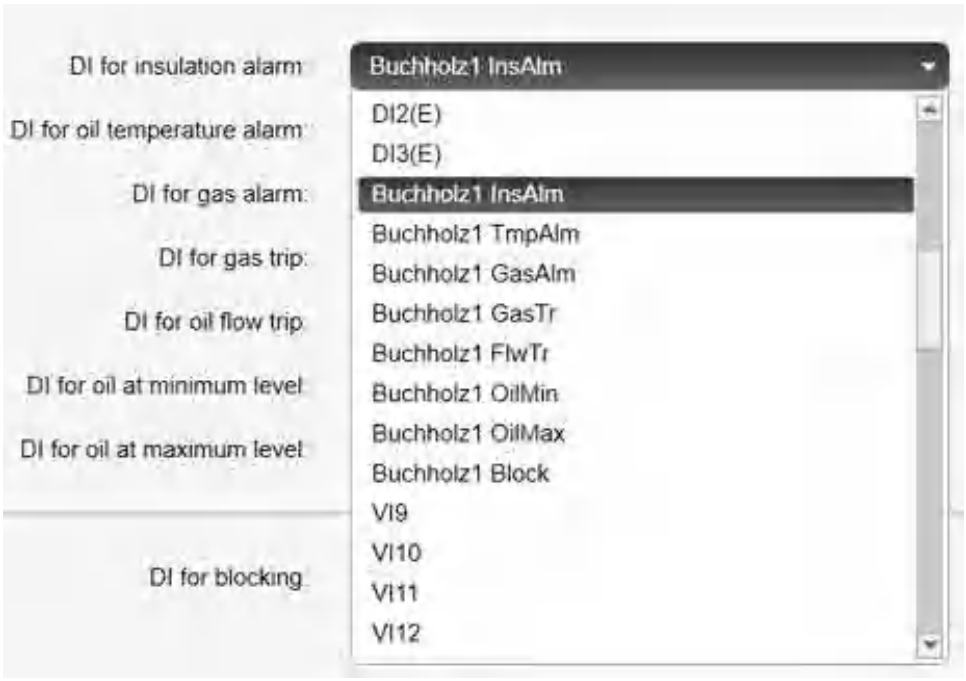


Figure 343 - DI/VI List



NOTE: The names of VI1 to VI8 have been customised in the figure above.

About setting group

The configuration of this monitoring function is independent from P5 setting groups. Only general settings are required.

Available links to P5 inputs

Although the signals are wired electrical input signals from physical Buchholz relays, they can be made available not only for assignment to the P5 physical opto-coupler inputs, but also to virtual (GOOSE) inputs.

DI signal

Table below lists the digital input signal for one instance of transformer monitoring.

Table 171 - 8 signals from transformer monitoring

Signal name	Description
Insulation alarm	Insulation liquid critical (refill insulation medium)
Oil temperature alarm	Insulation liquid temperature alarm
Gas alarm	Gas in insulation liquid alarm
Oil at minimum level	Insulation liquid level minimum
Oil at maximum level	Insulation liquid level maximum
Gas trip	Gas in insulation liquid trip
Oil flow trip	Insulation liquid flow trip because of gas
Block	Input assigned at “DI for blocking” is active

Blocking input signal

The purpose of blocking input signals is to inform the function about a defect in the monitoring system (defect sensor, loss of supply voltage, etc.). If this input is active, transformer monitoring function continues to read the connected digital input signals.

If transformer monitoring function is enabled and the block input signal gets asserted, then the global trip signal gets reset once it is triggered from this function only.

Global trip signal

If transformer monitoring function is enabled and in normal operation (not blocked) and any of the trip input signal (= any of the 2 DIs for gas trip/oil flow trip) gets asserted, then it will feed the trip signal into the global trip signal.

Three cases will reset the global trip signal if it is triggered from transformer monitoring function only.

- If transformer monitoring function is enabled and in normal operation (not blocked) and all the trip input signals get reset.
- If transformer monitoring function is enabled and the block input signal gets asserted.
- If transformer monitoring function gets disabled.

Characteristics

Table 172 - Characteristics of the transformer monitoring (ANSI 26/63)

Settings and characteristics	Values
Enable for Transformer monitoring	
Options[147]	Disabled; Enabled
Status	

147. Configured via Output Matrix

Table 172 - Characteristics of the transformer monitoring (ANSI 26/63) (Continued)

Settings and characteristics	Values
Options[148]	-; Alarm; Trip; Blocked
DI for insulation alarm	
Range	DIx; VIx
DI for oil temperature alarm	
Range	DIx; VIx
DI for gas alarm	
Range	DIx; VIx
DI for gas trip	
Range	DIx; VIx
DI for oil flow trip	
Range	DIx; VIx
DI for oil at minimum level	
Range	DIx; VIx
DI for oil at maximum level	
Range	DIx; VIx
DI for blocking	
Range	DIx; VIx

148. Configured via Output Matrix

Circuit breaker monitoring

Description

Periodic maintenance of circuit breakers is necessary to help ensure that the trip circuit and mechanism operate correctly and that the interrupting capability has not been compromised due to previous fault interruptions. The PowerLogic P5 protection relay records various statistics related to each circuit breaker operation, allowing an accurate assessment of the circuit breaker condition. Statistics are recorded to allow evaluation of both the electrical wear of the breaker contacts and the mechanical wear of the breaker mechanism.

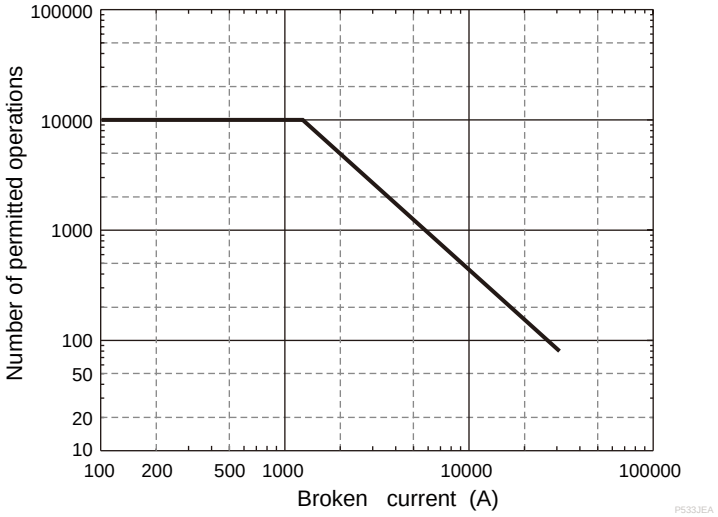
Transformer differential protection P5T30 provides one such CB monitoring element which can be linked to one CB and to the measured phase currents of that end accordingly.

Electrical wear

Breaker curve

The permitted CB operation number is defined by a CB permissible operation curve (CB wear curve). This curve is usually available in the documentation of the CB manufacturer. The curve specifies the permissible number of operations for every level of broken current.

Figure 344 - An example of circuit breaker permissible operation curve



As shown in the figure below, in the PowerLogic P5 protection relay, this curve is parameterised in the CB monitoring function with a maximum of eight points in the form of [CurveIx, CurveNx]. If less than eight points are needed, the unused points are set to [I_{BIG}, 1], where I_{BIG} is more than the maximum breaking capacity.

Table 173 - Values of the above circuit breaker wear characteristic graph

Point	Interrupted current (kA)	Number of permitted operations
1	0 (mechanical age)	10,000
2	1.25 (rated current)	10,000
3	31.0 (maximum breaking current)	80
4 - 8	100	1

The values are taken from the figure above. The table (circuit breaker curve) is edited with eSetup Easergy Pro or Web HMI in the **CB Monitoring** view of the protection menu.

Two alarms on “Operations left” limit

The CB monitoring function is designed with two alarms, each with two parameters:

- Alarm current level

  This parameter can be set to the CB's nominal current or any typical application current for the first alarm, and to a typical fault current for the second alarm.

- Operations left limit

  This parameter determines when an alarm is activated. When the “operations left” at the given current level drops below this limit, the alarm is started.

The permitted operations at these two alarm levels can be calculated automatically according to the breaker curve and logarithmic interpolation (see next section). Any actual interrupted current is logarithmically weighted for the two given alarm current levels and the number of operations left at the alarm points is decreased accordingly. PowerLogic P5 protection relay shows the allowed “operations left” in the **PROTECTION** menu/**CB Monitoring** sub-menu, based on the breaker curve, logarithmic interpolation and actual interrupted current.

Logarithmic interpolation

The permitted number of operations for the currents between the defined points is logarithmically interpolated using this equation:

$$C = \frac{a}{I^{n}}$$

P533JFA

where

C = permitted operations

I = broken current

a, n = constant according to the following two equations, where ln represents the natural logarithm function, C_k/C_{k+1} is the permitted number of operations defined by CurveN, Curve(N+1) in the breaker curve table, and I_k/I_{k+1} is the corresponding broken current defined by CurveIk, CurveI(k+1) in the breaker curve table.

$$a = C_k I_k^{n}$$

P533JJA

$$n = \frac{ln\frac{C_k}{C_{k+1}}}{ln\frac{I_{k+1}}{I_k}}$$

P533JGA

Each time a trip signal is detected, the corresponding permitted operations shall be calculated based on the broken current I_{brk}:

$$C_{brk} = \frac{a}{I_{brk}^{n}}$$

P533JHA

The corresponding decreased number of operations of the alarm level is calculated as:

$$\Delta = \frac{C_{alarm}}{C_{brk}}$$

P533JIA

Example of logarithmic interpolation

According to the equations above and the breaker operation curve points definition taken from An example of circuit breaker permissible operation curve, page 548:

- 10000 operations at 1.25 kA

- 80 operations at 31 kA

if the alarm 2 current setting is 6 kA, then the permitted number of operations can be calculated as follows:

$$n = \frac{ln\frac{10000}{80}}{ln\frac{31000}{1250}} = 1.5038$$

P533JKA

$$a = 10000 \times 1250^{1.5038} = 454 \times 10^{6}$$

P533JLA

$$C_{alarm2} = \frac{a}{I_{brk}^{\ n}} = \frac{454 \times 10^{6}}{6000^{1.5038}} = 945$$

P533JMA

Thus, the maximum number of current-breaking operations at 6 kA is 945. A useful alarm level for “Operations left” could be in this case for example 50, which is about five percent of the maximum.

If the interrupted three phase currents are IA = 12.5 kA, IB = 12.5 kA and IC = 1.5 kA, the corresponding decreased number of operations of phases A, B for alarm 2 are calculated as:

$$C_{brk1,2} = \frac{a}{I_{brk}^{\ n}} = \frac{454 \times 10^{6}}{12500^{1.5038}} = 313$$

P533JNA

$$\Delta_{1,2} = \frac{C_{alarm}}{C_{brk}} = \frac{945}{313} = 3$$

P533JOA

In phase C, the current is less than the alarm limit current 6 kA. For such currents, the decrement is one (just mechanical wear).

Five ranges of cumulative current

Each time the CB opens, the broken current is added to the corresponding total cumulative broken current, phase by phase. The cumulative broken current is given in $(kA)^2$.

In addition to the total cumulative broken current, there are five cumulative broken current ranges to assess the breaking device pole condition. Each range’s high limit value is configurable and the low limit value equals to the high limit of its previous range. Each range has three different counters, one for each phase, to record how many times the broken current falls into the range. The cumulative broken current record is configured in the **PROTECTION** menu/**CB Monitoring** sub-menu.

The cumulative broken current is also computed by phase. When the PowerLogic P5 protection relay is in test mode or the CB has been withdrawn, the cumulative broken current is not updated.

An alarm signal will be generated when the cumulative broken current of any phase exceeds the "broken I alarm setting".

Mechanical wear

CB Open counter, Protection Trip counter and Rack out counter

The “CB Open” counter is to record the number of CB close to open operation. It is incremented even if the PowerLogic P5 protection relay is in test mode.

The “Protection Trip” counter is to record CB open times issued from Global trip. This counter can also be set to a custom value but it does not increment during test mode.

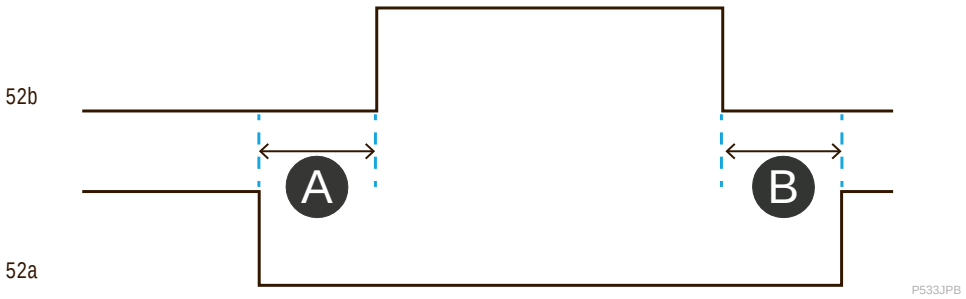
If, for whatever reason the circuit breaker does not open successfully after the pulse setting time out (configured in object), the trip counters are not incremented.

The “Rack out” counter is to record the number of racking in/out operations of the CB truck. It is incremented in both, normal and test mode.

Open time, close time and charging time

If two different digital signals are used to indicate the 52a (open) and 52b (close) status of the CB position, the open time is measured from the moment when the “52b” status becomes false to the moment when the “52a” status becomes true; the close time is measured from the moment when the “52a” status becomes false to the moment when the “52b” status becomes true, as shown in Figure below.

Figure 345 - Open and close time determination



A Open time B Close time

However, if the CB position is only configured as 52a or 52b, the open time and close time will be recorded as 0 each time when its related status changes.

The charging time is computed from the moment when the CB position changes to close to the moment when the spring status changes to ready. The spring status is configured through "DI for object ready" setting in Objects.

Open/close times and charging times are recorded for 8 latest operations in the PowerLogic P5, each with a timestamp. If the time recorded exceeds the range, the time will be tagged as a "dummy" value (65535) which allows the customer to easily detect something is wrong with the CB.

Table 174 - Range of CB monitoring recording data

Recording data	Range
Opening or closing time	0...300 ms
Charging time	0...1 min
Number of mechanical operations	0...65535
Rack-in rack-out operations	0...65535

These CB open times, close times and charging times are also recorded when the PowerLogic P5 is in test mode.

Parameters of the CB monitoring function

Table 175 - Parameters of the CB monitoring function

Parameter	Value	Unit	Description	Note
CB monitoring status				
AI1A AI1B AI1C AI2A			Operation number left for - Alarm 1, phase A - Alarm 1, phase B - Alarm 1, phase C - Alarm 2, phase A	

Table 175 - Parameters of the CB monitoring function (Continued)

Parameter	Value	Unit	Description	Note
AI2B AI2C			- Alarm 2, phase B - Alarm 2, phase C	
Latest broken current				
hh:mm:ss:ms / Date			Time stamp of the latest trip operation	
Phase current IA Phase current IB Phase current IC		A A A	Broken current of phase A Broken current of phase B Broken current of phase C	
Cumul. broken current IA/CmltvIA		$(kA)^2$		
Cumul. broken current IB/CmltvIB		$(kA)^2$		
Cumul. broken current IC/CmltvIC		$(kA)^2$		
Alarm				
Alarm 1				
Current level	0.00...100.00	kA	Alarm1 current level	Editable
Operation limit	100,000...1		Alarm1 limit for operations left	Editable
Alarm 2				
Current level	0.00...100.00	kA	Alarm2 current level	Editable
Operation limit	100,000...1		Alarm2 limit for operations left	Editable
Circuit breaker curve setting				
Current points (CurveIx, x = 1, 2, … 8)	0.00...100.00	kA	8 current points of the CB wear characteristic	Editable
Limit for operation left (CurveNx, x = 1, 2, … 8)	0...100,000		8 permitted operation numbers according to CurveIx	Editable
Cumulative broken current setting				
High limit	0.0...100.0	kA	High limit setting for each range	Editable
Broken I alarm setting	0...65,535		Cumulative broken current alarm threshold	Editable
Event setting				
'Op. limit alarm 1 On' event	On ; Off		Enable/disable the 'Alarm1 on' event	Editable
'Op. limit alarm 1 Off' event	On ; Off		Enable/disable the 'Alarm1 off' event	Editable
'Op. limit alarm 2 On' event	On ; Off		Enable/disable the 'Alarm2 on' event	Editable
'Op. limit alarm 2 Off' event	On ; Off		Enable/disable the 'Alarm2 off' event	Editable
'Broken I Alarm on' event	On ; Off		Enable/disable the 'Broken I Alarm on' event	Editable
'Broken I Alarm off' event	On ; Off		Enable/disable the 'Broken I Alarm off' event	Editable

Parameter	Accuracy
Characteristic of recorded data	
Opening or closing time	±5 ms
Charging time	±1 s
Number of mechanical operations	1
Cumulative squared broken current	±10%
Rack-in rack-out operations	1

Current transformer supervision (ANSI 60)

Description

The Current Transformer Supervision (CTS) feature is used to detect failure of one or more phase current inputs to the protection relay. Failure of a phase CT or an open circuit of the interconnecting wiring can result in:

- Incorrect operation of current protection functions
- Risks of unexpected CT secondary voltages generated

Three operation modes can be selected:

- 3I only

  If the magnitude of one phase current is below 1% Inom, while the magnitude of the other two phase currents is within 0.05 - 1.2 Inom and the angle between them is 110° - 130°, the function issues a fast alarm after 20 ms and a delayed alarm after the operation delay has elapsed.

  When the minimum value of magnitude of the three phase currents exceeds 0.1 Inom or CTS reset input is activated, the alarm will be reset.

- IN & VN

  If neutral current exceeds the pick-up value and the neutral voltage is less than the pick-up value, the function issues a fast alarm immediately and a delayed alarm after the operation delay has elapsed.

  The alarm will be reset when IN drops below 95% of the neutral current pick-up value or VN is higher than 103% of the neutral voltage pick-up value or CTS reset input is activated.

- Both

  CT failure is detected if one of the above modes is fulfilled.

CTS provides 2 signals: Fast Alarm and Latched Alarm after settable operate delay.

Both CTS signals are provided with a fix reset time of 100 ms.

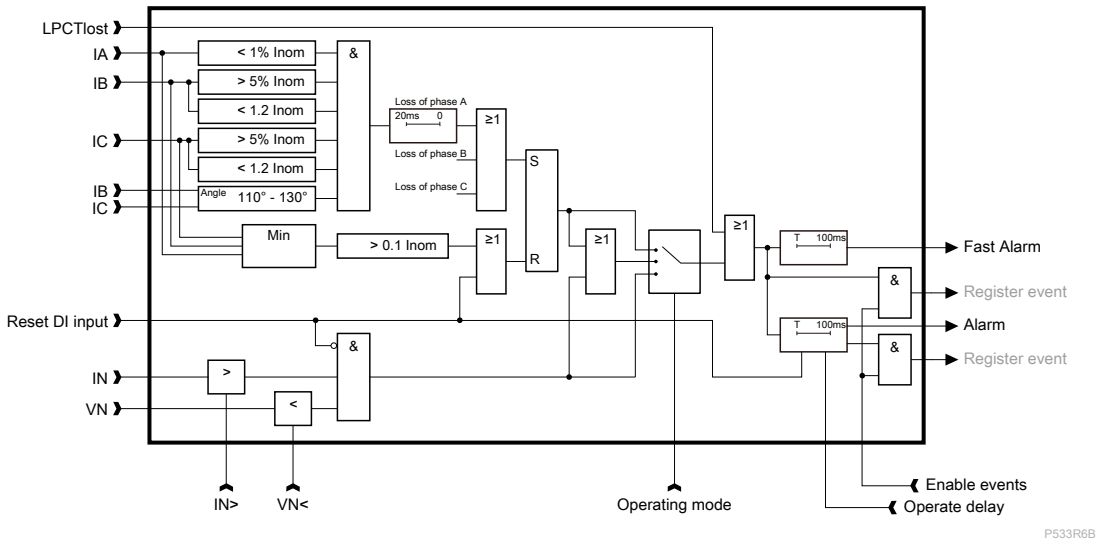
The function is inactive if only 2 phase current sensors are connected (2 CT mode). It is recommended for the user to decrease the maintenance interval for the current sensors in this mode.

In addition to supervising the phase current inputs, the CT supervision function (CTS) also provides supervision of the physical connection of LPCT. If the physical connection of any LPCT is lost, an “LPCT connection loss” alarm will be issued. Please note in this case all the three phase current measurements are lost.

With transformer differential protection P5T30 two CTS elements are available with a fix link to the measured currents of one end (CTS-1 to end 1, CTS-2 to end 2).

Block diagram

Figure 346 - Block diagram of the current transformer supervision function



Characteristics

Table 176 - Settings and characteristics of the current transformer supervision function (ANSI 60)

Settings/characteristics (description/label)	Values
Neutral current IN> / IN>	
Setting range	0.08...4.00 pu[149]
Resolution	0.01 pu[149]
Accuracy	±3%
Reset ratio	95% ± 2%
CT input selection[150]	
Setting range	CT-1 is fixed for CT supervision 1, CT-2 is fixed for CT supervision 2.
Neutral voltage VN< / VN<	
Setting range	0.01...0.30 pu[151]
Resolution	0.01 pu[151]
Accuracy	±3%
Reset ratio	103% ± 2%
Operate delay / Operate delay	
Setting range	0.04...10.00 s
Resolution	0.01 s
Accuracy	±1% or ±30 ms at IN and VN
Characteristic times	
Disengaging time	< 160 ms

149. Inom
150. Available for P5T30 only.
151. √3 x Vnom

Table 176 - Settings and characteristics of the current transformer supervision function (ANSI 60) (Continued)

Settings/characteristics (description/label)	Values
CTS operating mode	
Options	3I only; IN&VN; Both
CTS reset input	
Options	Selection of one digital input (DIx)
Delayed CTS on event	
Options	Enable; Disable
Delayed CTS off event	
Options	Enable; Disable
Fast CTS on event	
Options	Enable; Disable
Fast CTS off event	
Options	Enable; Disable
Settings of CTS	
Enable CTS	On/Off
I_1>	0.05...4.00 Inom
I_2/I_1 low	5%...100%
I_2/I_1 high	5%...100%
Operate delay	0.00…10.00 s

Table 177 - Measured values of CT

Parameter	Unit	Description
Max. of IA IB IC	A	Maximum value of phase currents
Min. of IA IB IC	A	Minimum value of phase currents
IN.calc	A	IN calculated value
Measured VN	V	Measured neutral voltage
Calculated VN	V	Calculated neutral voltage

Voltage transformer supervision (ANSI 60)

Description

The PowerLogic P5 protection relay supervises the voltage transformers (VTs) wiring between the connector A terminals and the sensors. If there is a fuse in the voltage transformer circuitry, the blown fuse helps prevent or distorts the voltage measurement. Therefore, an alarm should be issued. Furthermore, in some applications, protection functions using voltage signals should be blocked to avoid false tripping such as:

- Earth/ground fault overvoltage and directional earth/ground fault overcurrent using calculated neutral voltage
- Phase undervoltage or negative sequence overvoltage
- Directional overcurrent
- Power

The Voltage Transformer Supervision (VTS) function detects the loss of one or several phase voltage inputs using various well known methods:

- The detection of the presence of negative sequence voltage and the absence of negative sequence current. The negative sequence voltage V2 and the negative sequence current I2 are calculated. If V2 exceeds the V2> setting and at the same time, I2 is less than the I2< setting, the function issues an alarm after the operation delay has elapsed. This criterion is meaningful only when a reasonable minimum current is flowing, i.e. if the maximum phase current is greater than the minimum current setting I>(min).
- This function detects the loss of all three voltages under load conditions when current inputs are available. If three phase voltages are dropped to a value below 30% pu (1 pu = √3 x Vprim.nom), at the same time the maximum phase current is below the maximum load current and above the minimum load current, VTS fast block signal will be activated. Minimum load current is ground charging capacitive current, which should be above line current without load.
- Digital input (DI) for indicating miniature circuit breaker (MCB open) position
- The VT supervision function (VTS) also provides supervision of the physical connections of the three phase LPVTs. If the physical connection of any phase LPVT is lost, an internal “LPVT loss” signal will be accepted to immediately trigger the VTS function.

  If according to above conditions a loss of voltage is detected, immediately a "VTS fast block" signal is issued, intended for instantaneous blocking of voltage dependent functions to help prevent maloperation. A further "VTS alarm" signal will be issued after a settable time delay to help prevent unnecessary alarming upon spurious VTS operation.
- In case that the “Enable VN compare” is set to On, “Delta_VN>” is used to compare the magnitude difference between two neutral voltages.

VT supervision will reset when all the following conditions are satisfied:

- Negative sequence voltage V2 is less than V2> setting.
- Maximum phase to phase voltage is greater than 30% pu (1 pu = √3 x Vprim. nom).
- MCB input resets.
- LPVT loss input resets.

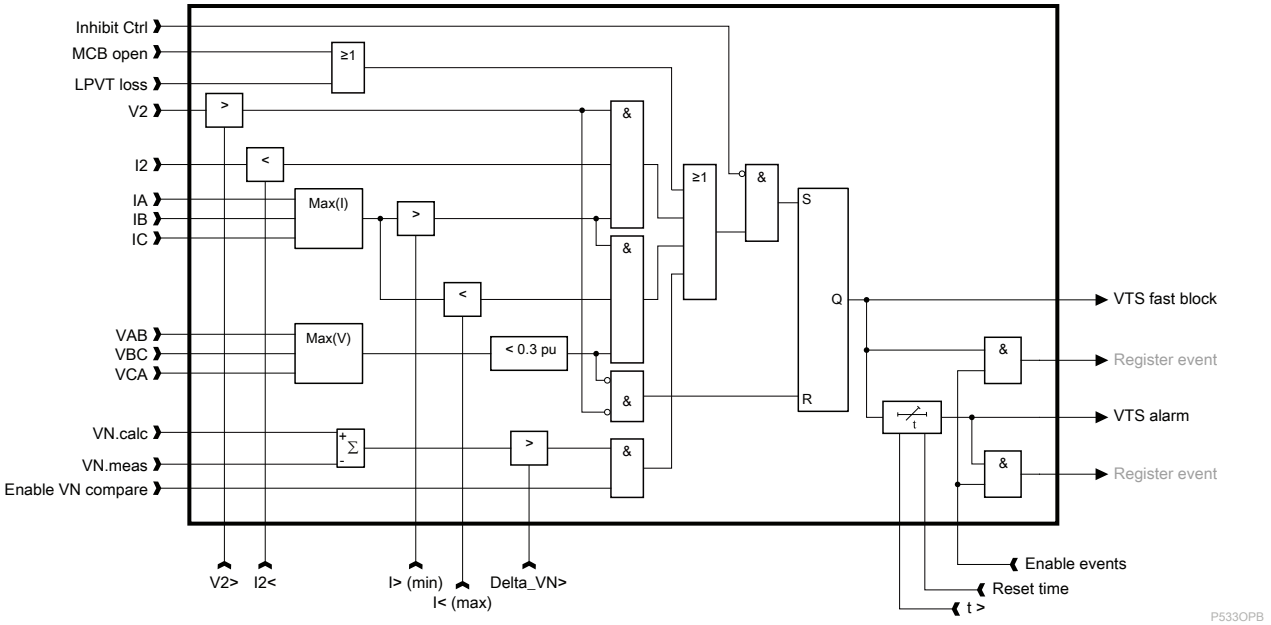
When the VT failure condition is not satisfied for 10 s, the “VTS alarm” will be reset.

In addition, the VTS function can be blocked by inhibit control function.

NOTE: For PowerLogic P5V20's VTS function, only MCB input is available.

Block diagram

Figure 347 - Block diagram of the voltage transformer supervision function



Characteristics

Table 178 - Settings and characteristics of the voltage transformer supervision function (ANSI 60)

Settings/characteristics (description/label)	Values
Enable VTS	
Options	Off/On
V2> setting/V2>	
Setting range	0.02...2.00 pu[152]
Resolution	0.1
Accuracy	±2% or ± 0.2 V (secondary), whichever is bigger
I2< setting/I2<	
Setting range	0.02...2.00 pu[153]
Resolution	0.01
Accuracy	±2% or 0.02 pu[153], whichever is bigger
Operate delay/Operate delay	
Setting range	0.00...60.00 s
Resolution	0.02 s
Accuracy	±1% or ±10 ms, whichever is bigger
DI for MCB position/MCB	
Options	Selection of one digital input (DI)
Inhibit ctrl/InhCtrl	

152. √3 x Vnom
153. Inom

Table 178 - Settings and characteristics of the voltage transformer supervision function (ANSI 60) (Continued)

Settings/characteristics (description/label)	Values
Options	Selection of one input (DI; VI)
I>(min) setting/I>(min)	
Setting range	0.02...1.00 pu[154]
Resolution	0.01 pu[154]
Accuracy	±1% or 0.02 pu[154]
I<(max) setting/I<(max)	
Setting range	0.10...20.00 pu[154]
Resolution	0.01 pu[154]
Accuracy	±1% or 0.02 pu[154], whichever is bigger
V<	
Value	30% pu[155], fixed
Accuracy	±1% or ± 0.1 V (secondary), whichever is bigger
Enable VN compare	
Options	Off/On
Delta_VN>	
Setting range	0.05...1.00 pu[155]
Resolution	0.01 pu[155]
Accuracy	±2% or ± 0.2 V (secondary), whichever is bigger
Reset time (fixed)	
Value	10 s
Accuracy	30 ms
Characteristic times	
Reset time	< 30 ms
Setting group/SetGrp	
Number	1

154. Inom
155. √3 x Vnom

PowerLogic P5 and bay condition monitoring

In order to provide a basic indication about the IED and bay condition, a user scalable signaling “Protection active” is provided with PowerLogic P5.

The prerequisite for this feature is that the PowerLogic P5 must be in the normal operational state (not blocked by any defect, detected by internal self-monitoring).

The configuration can be found in the **Control** menu/**Good condition** sub-menu.

Table 179 - Settings and characteristics of the good condition function

Settings/characteristics	Description
Global trip	A trip issued by the protection function (except arc detection)
Any output latched	Any latched trip which still needs to be reset by the user
Auto reclosing in progress	A definite trip or ends up with an unsuccessful reclosing
Motor start inhibition	Motor start inhibition is present due to excessive number of motor starts (if this feature is enabled).

The user can select one or more of the above settings as the conditions to trigger the signaling “Protection active”. When any signal from the selected setting(s) is presented, the status of the signaling “Protection active” changes to “Protection active”, otherwise the status is in idle state.

The signaling can be used:

- For local indication via LED, for example: to increase the awareness of the PowerLogic P5 and bay condition prior to any local operation
- For local or remote indication via outputs
- As the blocking condition in object control, for example: to help prevent dangerous bay open/close commands while the status changes to “Protection active”
- For remote information by logging related event(s)

Maintenance

The PowerLogic P5 protection relays together with their extension units, communication accessories, arc-flash detection sensors and cabling, require maintenance in work according to their specification. Keep a record of the maintenance actions. The maintenance can include, but is not limited to, the following actions.

Safety instructions

This page contains important safety instructions that must be followed precisely before attempting to install, repair, service or maintain electrical equipment. Carefully read and follow the safety instructions described below.

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- NEVER work alone.
- Turn off all power supplying this equipment before working on or inside it. Consider all sources of power, including the possibility of backfeeding.
- Always use a properly rated voltage sensing device to confirm that all power is off.
- Do not power a withdrawn mobile part of the PowerLogic P5 protection relay with voltage > 24 V. Put back the withdrawable part in the fixed part before powering it on.

Failure to follow these instructions will result in death or serious injury.

⚠DANGER

FIRE HAZARD

If you are authorised to withdraw the relay:

- Disconnect the power supply before removing or replacing a module or the withdrawable part of the protection relay.
- Never touch electronics parts (risk of damage due to electrostatic discharge).
- Before replacing the withdrawable part, clean all debris and contaminants from the case, the withdrawable part, and the connectors.
- In case of module or withdrawable part replacement, perform the commissioning operations before using the protection relay.
- Apply proper tightening torque to all wire connections.

Failure to follow these instructions will result in death or serious injury.

⚠CAUTION

RISK OF SETTING CHANGES ERASED

Never plug in or draw out the communication modules while the PowerLogic P5 protection relay is in service.

Failure to follow these instructions can result in injury or equipment damage.

Self-monitoring

Watchdog relay

The PowerLogic P5 protection relays are equipped as standard with a watchdog relay (digital output 4 in slot B). This is a changeover relay which is kept permanently in the on-position by the PowerLogic P5 protection relay. In the event of protection relay failure, or if the auxiliary power supply fails, the watchdog relay reverts to the off-position.

Maintenance/Test LED

The PowerLogic P5 protection relay has gone into the fallback position following detection by the embedded self-tests of the failure of one of its internal components. In this case, the PowerLogic P5 protection relay is no longer

operational. This LED may light up when the protection relay is energised during all the start phase of the PowerLogic P5 protection relay (for about 60 seconds). This is normal and does not indicate any internal failure. When the start phase of the protection relay is completed, the LED is off if no internal failure is detected.

Purpose of the self-tests

The PowerLogic P5 protection relay runs a series of self-diagnostic tests for hardware and software in boot sequence and also performs runtime check. These self-tests detect any failure and can avoid random PowerLogic P5 protection relay behaviour. The main aim is to avoid an unwanted tripping or failure to trip in the event that it occurs on the power system or on the equipment to protect.

The PowerLogic P5 protection relay can detect two types of internal failure:

- A major failure when the protection functions cannot be processed properly or can initiate an unwanted trip. In this case, The PowerLogic P5 protection relay goes into the fallback position:
  - The output relays are in the off-position
  - Watchdog relay (DO4 contact output on slot B) goes into the off-position
  - The LED, LED, and the configurable LEDs are off
  - The ON LED, on the local panel, is on
  - The LED on the local panel is on
  - A message is displayed on the local panel: it allows Schneider Electric to make a diagnosis.
  - The communication is inoperative
  - The communication with eSetup Easergy Pro is inactive depending on the type of internal failure

- A minor defect, is a malfunction of components (hardware or firmware) which is not used directly by protection functions (namely, memory, used for logging emergency events, communication channels, etc.). It shall not result in loss of PowerLogic P5 protection relay operability.
  - The output relays stay in their current status
  - Watchdog relay (DO4 contact output on slot B) stays energised
  - The LED, LED, and configurable LEDs stay in their current position
  - The ON LED, on the local panel, is on
  - The LED on the local panel is off
  - An alarm message is displayed on the local panel to highlight the origin of the issue.

    Press the key to remove the message (the alarm message is logged in the Alarm message list).
  - The communication is still operational depending on the type of the internal failure
  - The communication with eSetup Easergy Pro, on the local panel is active depending on the type of internal failure

List of self-tests

The self-tests are described in the table below.

Table 180 - List of self-tests

Name	Execution Period
Hardware configuration versus the product model number	On energisation and during operation
Power supply	
Internal drivers (FPGA)	
EEPROM boards	
NOR Flash memory	
NAND flash memory	
DDRAM memory	
Back up memory	
Internal bus	
Display and graphic libraries	
RTD presence (MET148-2)	
Micro processor	
Firmware (system and application) and setting consistency	
Digital inputs	
Digital outputs	

Backup memory

The PowerLogic P5 protection relay has an optional feature of a removable back up memory. This feature provides a mechanism for storing the product settings and other related information separately to the removable part of PowerLogic P5.

The memory allows quick, restoration of settings should there be a need to exchange the withdrawable part. As a result, the mobile part can be replaced and back in service in a matter of minutes.

The optional back up memory is included in the extension module that can be installed in Slot P. This extension module also includes connectivity to support IRIG-B and thermal sensors.

Figure 348 - The optional extension module (slot P) that includes the back-up memory



The backup memory stores the following information:

- Settings
- Event and alarm history
- Disturbance recordings
- Product serial number
- Product Cortec
- Persistent data included Thermal value, Running Hours, Accumulated energy etc.
- Language file

NOTE: The PowerLogic P5 access information such as passwords and users are not stored in the backup.

Two versions of the information are held in the backup memory together with a verification CRC.

This allows one of the copies to be written and verified before erasing the second thus keeping the integrity of the data stored even if there are any power interruptions during the write process.

NOTE: There is always one valid backup version with CRC check in the backup memory even when new backup is in progress.

Automatic storage

The PowerLogic P5 automatically stores all settings, events and disturbance recordings at 2AM local time every day.

As indicated above the secured process means that the memory can not be corrupted as the save is verified before previous data is overwritten.

NOTE: Due to this unique feature the important data and settings are always secured locally and not based on any remote storage on a control system.

Manual storage of settings

In addition to the daily automatic storage, the settings can be stored to the memory at any time by choosing the command from the local panel HMI.

To save the settings manually:

1. Press the ⌂ key to enter the main menu and then select the **Device/Test** icon using the arrow keys.
2. Press the OK key to enter the **Device/Test** sub menu.
3. Select the **Back-up** option using the ▽ key and press OK.
4. Press OK, select **Man. Trig** and then press OK.

```
      Backup Memory  1/2
Trigger backup memory
Status                    Idle
Man. Trig                    -
```

5. Press the ▽ key to select **On**.
6. The status shows **Busy**; when the storage is complete the status goes back to Idle.

Replacement of the withdrawable part

Should there be a need to replace the withdrawable part, the back-up memory provides a simple and quick mechanism to bring the protection relay back into service.

Power the unit down and extract the moving part using the green handle. If the removable part is secured with screws please follow the installation instructions (Unscrewing the front face locking screws, page 50) to remove the screws. Press the lock on the handle upwards and pull the handle. Insert the new unit with a matching order code and push the handle back to its original position and install back the screws.

After re-powering the module, the following “New backup content found” notification appears.

```
New backup content found.
 2020-07-17  14:22:36
      VOL.300.103
 P5F30-EACB-IBBEH-AABC
       Compatible
⌂ Ignore          OK Restore
```

Choose what happens with the back up memory.

Press the OK key to keep the information in the back up memory or the ⌂ button to discard and help prevent the pop up occurring again.

NOTE: This action does not restore the settings. Follow the ‘Restore from Backup memory’ process described below.

Restore from backup memory

The settings can be restored from the backup memory at any time by choosing the command from the front HMI.

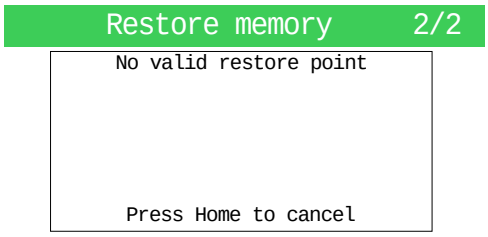
To restore the settings manually:

1. Press the key to access the main menu and then select **Device/Test** by using the arrow keys.
2. Press the OK key to enter the **Device/Test** sub menu.
3. Press the key to select the **Back-up** option and then press OK.
4. Press the key to enter the second setting page **Restore Memory** and then press OK.
5. Press the key to select the **Trig restore memory** parameter and then press OK.
6. Press the key to select **On**.

   The PowerLogic P5 shows the following notification window:

   CAUTION
   All the settings, events, records will be replaced by backup. Don't apply an unverified backup against unpredictable risks.
   Recheck relay after restore.
   OK Restore Cancel

7. Press the OK key to accept restore.
   - If the stored file is incompatible with the hardware, "No valid restore point" notification is displayed.

   - If the file is compatible and PowerLogic P5 is connected to eSetup Easergy Pro, the device requires a manual restart when the screen indicates "RESTART".

   - If the file is compatible and there is no connection, PowerLogic P5 reboots automatically.
8. Following the reboot, the file in the back up memory is verified before restoring the settings. Press OK to accept restore.
9. In the next step the files are copied and verified.
10. When the files are restored successfully, press OK.
11. The PowerLogic P5 protection relay reboots and the restore is completed.
12. After reboot the "New backup content found" notification might pop-up again, press the key to help prevent repetition of restore.

Restore process confirmation

The restore process can be confirmed from the local panel HMI.

1. Select the second screen in the **Back-up** sub menu by pressing the ▷ key.

   The screen does not display any information while restoring is in progress.

2. When restoring is completed, the device information appears on the screen.

   The **Compliance check** parameter shows status “Checking” for a short while and changes to “True” after a successful restoring process.

```
      Restore memory    2/2

  Update                    -
  Firmware                  -
  Ref.                      -
  Compliance check          -
  Manual restore            -
```

```
      Restore memory  2/2
Update  2020-06-02 15:07:24
Firmware         V01.300.101
Ref.  P5U20-AABB-CABAH-AABB
Compliance check       True
Manual restore            -
```

Preventive maintenance

The PowerLogic P5 protection relay requires maintenance in order for it to work according to the specification.

⚠WARNING

UNEXPECTED SYSTEM OPERATION

Carry out periodic system testing as per the testing recommendation in this manual or if the protection system scheme has been changed.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

Introduction

To obtain the maximum availability of the installation, it is essential to help ensure that the PowerLogic P5 protection relay is operational at any times.

The PowerLogic P5 protection relay's internal self-tests, the watchdog relay, and the LED alert the user in the event of internal protection relay failure. Nevertheless, elements outside the PowerLogic P5 protection relay are not subject to these self-tests and it is therefore necessary to carry out regular preventive maintenance.

Check the PowerLogic P5 protection relay visually and pay attention to dirty components, loose wire connections, damaged wiring, user interface screen and LEDs, and other mechanical connections.

Then, to perform maintenance, carry out all the recommended commissioning tests.

First test all the digital inputs and outputs involved in tripping the circuit breaker. A test of the complete chain including the circuit breaker is also recommended.

The software setting tool, eSetup Easergy Pro, is especially useful during maintenance tests and procedures.

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. See NFPA 70E, NOM-029-STPS-2011, or CSAZ462.
- The arc fault detection system is not a substitute for proper PPE when working on or near equipment being monitored by the system.
- Information on this product is offered as a tool for conducting arc-flash hazard analysis. It is intended for use only by qualified persons who are knowledgeable about power system studies, power distribution equipment, and equipment installation practices. It is not intended as a substitute for the engineering judgement and adequate review necessary for such activities.
- Only qualified personnel is allowed to install and service this equipment. Read this entire set of instructions and check the technical characteristics of the device before performing such work.
- Perform wiring according to national standards (NEC) and any requirements specified by the customer.
- Observe any separately marked notes and warnings.
- NEVER work alone.
- Before performing visual inspections, tests, or maintenance on this equipment, disconnect all sources of electric power. Assume all circuits are live until they are completely de-energised, tested, and tagged. Pay particular attention to the design of the power system. Consider all sources of power, including the possibility of back feeding.
- Always use a properly rated voltage sensing relay to ensure that all power is off.
- The equipment must be properly grounded.
- Connect the device's protective ground to functional earth according to the connection diagrams presented in this document.
- Do not open the device. It contains no user-serviceable parts.
- Install all devices, doors and covers before turning on the power to this device.

Failure to follow these instructions will result in death or serious injury.

Intervention frequency

Test the PowerLogic P5 protection relay periodically according to the end user's safety instructions and national safety instructions or law.

The necessary time between visual inspections and functional checks depends on the installation operating conditions. Generally, we recommend to carry out periodic checks or tests every four (4) years. In corrosive or harsh offshore environments, functional testing should be carried out more often; we recommend every three (3) years.

For the testing procedures, see Commissioning, page 147.

The table below summarises the recommended frequency of interventions.

Test	Periodicity
User interface check	1 year
Relay health check	4 years
Date and time synchronisation check	4 years
Wiring and connections check	4 years
Analogue inputs operation check	4 years

Test	Periodicity
Digital inputs wiring and operation check	4 years
Digital outputs wiring and operation check	4 years
Arc-flash detection system check	3 years

Preventive maintenance tasks

User interface test

The LED and display unit test is used to check that each LED on the local panel and in each segment of the display is working correctly.

To perform the test, press and hold down the menu selection key. After 2 seconds, all LEDs on the local panel and all segments of the display light up.

Protection relay health check

⚠CAUTION

RISK OF SETTING CHANGES ERASED

- Never plug in or draw out the communication modules while the PowerLogic P5 protection relay is in service.
- Check and make sure that the communication module is locked.

Failure to follow these instructions can result in injury or equipment damage.

The health check includes the following tasks:

- Check that the different currents and voltages measured by the PowerLogic P5 protection relay are appropriate for the load being powered.
- Check that the PowerLogic P5 protection relay LED is off and no maintenance message displayed on the local panel.
- Check the health of boards and modules with eSetup Easergy Pro (**Device info** view of the **Device/Test** menu)

Date and time synchronisation check

Check date and time synchronisation (modify date and time setting and wait for date and time synchronisation).

Inspection of the rear panel

Check that the connections, including the earth/ground terminal and the CT connections, are tight and free from corrosion.

If the CT connections are not tightened properly, this generates excessive heat rise which can lead to the destruction of connector A and the CTs.

Wiring and connection check

⚠⚠DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Use the appropriate (3 or 4-terminal) copper jumper for common connections.
- After cabling, protect the rear connector A with the two protective caps.

Failure to follow these instructions will result in death or serious injury.

Check the wiring connections in the rear panel: for the type of screws, screwdriver to be used, and torque (see Installation, page 37).

In addition to the periodic wiring and connections check, a thermal measurement with thermal camera is recommended to make visible any warm points of the installation so that loose connections could be detected and corrected before a real issue occurs.

Check the earth/ground connections (two ends).

Place back the two protective caps (connector A) before powering on the PowerLogic P5 protection relay.

Analogue input operation check

Check current transformers (CTs/LPCTs), voltage transformers (VTs/LPVTs), earth/ground fault current CTs, and, if used, core balanced CTs connection:

- Cable(s) (and group of cables) in the middle of the CT.
- Voltage cable shielding.
- Check that measured analogue values and angles are compliant on the local panel.

Digital input wiring and operation check

Check digital inputs statuses (in Control menu on the local panel and in the **Digital Inputs** view of the **Control** menu in eSetup Easergy Pro). Check that physical inputs states are correct, according to normal input configuration and wirings.

Digital output wiring and operation check

Check the digital outputs operation:

- If accessible, check physical digital outputs position (continuity tester).
- Check digital outputs statuses (in the Control menu on the local panel display and in the **Relays** view of the **Device/Test** menu in eSetup Easergy Pro).

Checking the trip chain

Check regularly that the complete trip chain, from the CTs to the PowerLogic P5 protection relay and through to the trip coil, is always operational.

The complete protection chain is validated during the simulation of a fault that causes tripping of the switchgear by the PowerLogic P5 protection relay.

Simply testing one function can demonstrate that the whole system is working correctly, provided it has been installed correctly.

To validate the complete protection chain, proceed as follows:

1. Select one of the protection functions that trips the switchgear.

2. Depending on the function(s) selected, inject a current or a voltage corresponding to a fault and note whether the switchgear trips.

Arc-flash detection system maintenance

⚠⚠DANGER

HAZARD OF UNEXPECTED SYSTEM OPERATION

- If the arc-flash detection unit is no longer supplied with power or is in permanent non-operational state, the protection functions are no longer active and all the output contacts are dropped out.
- To detect a power-off or a permanent fault state, connect the watchdog (SF) output contact to a monitoring device such as SCADA or DCS.

Failure to follow these instructions will result in death or serious injury.

Keep record of the maintenance actions performed for the system.

The maintenance can include but is not limited to:

- visual inspection
- periodic testing
- hardware cleaning
- sensor condition and positioning check
- checking the obstruction of sensors

Hardware cleaning

Pay special attention to help ensure that the device, its extension units and sensors do not become dirty.

⚠⚠DANGER

HAZARD OF UNEXPECTED SYSTEM OPERATION

- Do not use any type of solvents or gasoline to clean the device, sensors or cables.
- When cleaning the sensor, make sure that the cleaning solution does not contact anything other than the sensor.

Failure to follow these instructions will result in death or serious injury.

- If cleaning is required, wipe out dirt from the device.
- Use a dry cleaning cloth or equivalent together with mild soapy water to clean any residues from the light sensor.

Sensor condition and positioning check

Always check that the sensor positioning remains as it was originally designed after:

- commissioning
- sensor replacement
- modification procedure
- cleaning
- arc-flash fault
- periodic testing

Check for obstruction of the sensors.

Troubleshooting

Troubleshooting assistance

The PowerLogic P5 is a withdrawable protection relay. The faulty protection relay can be removed from its outer case without disconnecting the wires from the terminals. This allows to quickly replace a protection relay, provided that the spare part is available.

The replacement of a protection relay is done with the following steps:

1. Perform a diagnostic check on the protection relay:
   - The status of the watchdog relay (DO4 contact relay on slot B)
   - The status of the "" and "" LEDs as well as the configurable LEDs
   - The ON LED and the " " LED on the local panel
   - The messages displayed on the local panel
   - The alarm list and maintenance file downloaded with eSetup Easergy Pro
2. Check the compatibility of the spare part: the labels on the fixed and the withdrawable parts are the same.
3. Recover the configuration from the backup memory (optional) and restart of the new protection relay, following the instructions displayed on the local panel.

The PowerLogic P5 is a modular protection relay. The modules that can be replaced individually are:

- The communication modules
- The extension modules with back-up memory

Identification of the modules can be accessed:

- From the local panel of the PowerLogic P5 protection relay (in the Device/ Test menu)
- From eSetup Easergy Pro (Boards view of the Device/test menu)
- From the web server and the EcoStruxure Power Device application

Troubleshooting the PowerLogic P5

If nothing happens when the PowerLogic P5 protection relay is switched on, troubleshoot the device according to Troubleshooting a protection relay that shows no signs of energising, page 573 below:

Table 181 - Troubleshooting a protection relay that shows no signs of energising

LED Indication	Possible Causes	Actions
All LEDs are off. Nothing displayed on the screen.	Connector B not plugged in.	Plug in the connector B.
	Connector B inverted with another connector: • Connector C for PowerLogic P5 x20 • Connector C, D, E for PowerLogic P5 x30	Put connectors in the correct position. Check the connector is identified according to the slot.
	Auxiliary power absent	Check the auxiliary power level (see label on the side of the device)
	Polarity reversed on terminals	Check that the + polarity is on terminal 19 and the - polarity is on terminal 20 for DC power.

Table 181 - Troubleshooting a protection relay that shows no signs of energising (Continued)

LED Indication	Possible Causes	Actions
	Internal failure	Change the active part.

If a maintenance message is displayed, troubleshoot the device according to Troubleshooting a protection relay according to maintenance messages, page 574 below:

Table 182 - Troubleshooting a protection relay according to maintenance messages

Message information	Possible Causes	Actions
Maintenance message with: Module ID = 3 Error type = -7	Mismatch between hardware configuration and product model number.	Check the model number on fixed part with model number on the withdrawable. 1st five characters after the application reference should be the same: P5xx0-**AAAA**-**A**xxxx-xxxx
Maintenance message with: Module ID = 3 Error type = -5 Completed by one of these references: • 3CT-CSH • 3CT-4VT-CSH • 5CT • 5CT-4VT • 4VT • LPCT-LPVT	Hardware failure detected on the fixed part (slot A) when the PowerLogic P5 protection relay is powered on. The message specifies the board impacted by the defect.	Change the fix part of the PowerLogic P5 protection relay with the equivalent one.
Maintenance message with: Module ID = 3 Error type = -5 Completed by one of these references: • 6DI-4DO • ARC-FLASH • CPU P5x20 • CPU P5x30 • PSU30H-DI-DO • PSU30L-DI-DO • PSU20-DI-DO	Hardware failure detected on the withdrawable part when the PowerLogic P5 protection relay is powered on. The message specifies the board impacted by the defect.	Change the withdrawable part of the PowerLogic P5 protection relay with the same model number.
Alarm message completed by one of these references: • EXTENSION-BKUP • COM SRL RS485 • COM SRL FO • COM ETH 2TP-M (on slot M) • COM ETH 2FO-M (on slot M) • COM ETH 2TP-L (on slot L) • COM ETH HSR/PRP RS485 module 2TP • COM ETH HSR/PRP RS485 module 2FO	Hardware failure detected on the optional boards when the PowerLogic P5 protection relay is powered on.	Check that the hardware resources are equivalent or exceeds those used in the configuration file.
Message appears during a reboot of the PowerLogic P5 protection relay. The boot is not complete and the following message is displayed: - Firmware not complete (in English only)	Major issue on the CPU board of the PowerLogic P5 protection relay.	Change the withdrawable part of the PowerLogic P5 protection relay with the same model number.

Table 182 - Troubleshooting a protection relay according to maintenance messages (Continued)

Message information	Possible Causes	Actions
Alarm message completed by the reference: MET148-2	MET148-2 loose connection	Check the MET148-2 module is well connected to the Extension and backup memory board. See Troubleshooting the MET148-2 module, page 577 for more information.
CT supervision Alarm message	Connection issue from CT/ LPCT transformer to the PowerLogic P5 protection relay	Check the connection from MV transformer to the analogue input of the PowerLogic P5 protection relay. Switch off/switch on the protection relay. If the failure is persistent, change the rack of the PowerLogic P5 protection relay .
VT supervision Alarm message	Connection issue from MV transformer to the PowerLogic P5 protection relay	Check the connection from MV transformer to the analogue input of the PowerLogic P5 protection relay. For LPVT, check if the three LPVTs are connected on the LPVT hub. Switch off/switch on the protection relay. If the failure is persistent, change the rack of the PowerLogic P5 protection relay.
Alarm message completed by “RTD x Open Circuit Fault On” or by: “RTD x Short Circuit Fault On”, where x is the number of the RTD	The RTD number x on the MET148-2 module is disconnected or short-circuited.	As the message is common to the RTD channels of the MET148-2 module, go to the temperature measurement display screen to determine which RTD is affected by the defect. Measurement displayed: • Tx.x = -**** = RTD disconnected (T > 205 °C (401 °F)) • Tx.x = **** = RTD short-circuited (T < -35 °C (-31 °F)) Then check the connection of RTDs.
Alarm message “Incompatible hardware or firmware version, operation stopped”	Incompatible firmware or hardware versions	Check the firmware or hardware version.
Maintenance message with: Module ID = 17 Error type = -1	CS certificate expired or CS configuration potentially inconsistent	Please contact Schneider Electric Customer Care Center.

Recover failed device

In case of the PowerLogic P5 can not start normally, or been stuck in failed mode, you can recover the failed device with eSetup Easergy Pro:

1. Disconnect the power supply of P5.
2. Connect P5 to the laptop with eSetup Easergy Pro installed by USB cable to make firmware upgrade in low power mode.
3. Launch eSetup Easergy Pro, click on the **Tools** button on the **menu bar**, then click on **Recover failed device**.

Troubleshooting the communication modules

	Possible Causes	Actions
Loose of communication during operation	Change of parameters (PowerLogic P5 protection relay, Scada), connection issue, hardware issue	For Ethernet board, check the traffic with the leds embedded on the RJ45 connectors. Check all the information and parameters at scada level. Check all the parameters at the PowerLogic P5 protection relay level. Check all intermediate devices (switches, etc.) installed between Scada and the PowerLogic P5 protection relay. Check the connections. Replace the communication board.
Alarm message completed by “Slot x board is missing”	The communication board on slot X is missing.	Complete the configuration with the right communication option.
Alarm message completed by “Slot x is not configured”	There is a communication board on Slot x, but the model number is not configured.	Configure the model number with the right option.
Alarm message completed by “Slot x mismatch”	There is a communication board on Slot x, but its model number does not match the existing one in the system configuration.	In order to match the communication board and the model number, take one of the following corrective measures: • Change the communication board • Configure the right model number

Troubleshooting arc-flash system

This table describes some common problems in the arc-flash system and how they can be solved.

Messages	Possible Causes	Actions
The trip signal does not reach the circuit breaker.	Faulty trip circuit wiring.	Check that the wiring of the trip circuit is not faulty.
The protection does not trip even when a sufficient light signal is provided.	The protection needs both light and current information to trip.	Check the dip switch configuration. The protection may be configured to require both the light and current condition to trip.
Faulty sensor wiring detected by the self-supervision.	Loose sensor wire.	Check the sensor wiring. The sensor wire may have loosened in the terminal blocks.
Error message indicating blocked sensor channel.	Light pulse to the arc-flash sensor is too long.	Check that the light pulse to the arc-flash sensor is not too long. If light is supplied to the arc-flash sensor for more than three seconds, the self-supervision function activates and switches the light sensor channel to daylight blocking mode, and the sensor channel is blocked. Remove the light source to reset the blocked channel.

Troubleshooting the MET148-2 module

LED Indication	Possible Causes	Actions
MET148-2 green and red LEDs off	Fault wiring	RJ45 plugs of CCA77x cords clipped correctly into sockets.
MET148-2 green LED on. MET148-2 red LED off.	No response from the MET148-2 module.	Check the position of the module number selection jumper: • MET1 for first MET148-2 module (temperatures T1 to T8) • MET2 for second MET148- 2 module (temperatures T9 to T16). • If the jumper position needs to be changed, reboot the MET148-2 module (by disconnecting and reconnecting the interconnection cord). • Change the extension module.
MET148-2 red LED flashing.	Faulty wiring, MET148-2 powered but loss of dialogue with base unit.	Check module connections: • RJ45 plugs of CCA77x cords clipped correctly into sockets. • If the MET148-2 module is the last in the chain, check that the line terminating jumper is in the **Rc** position. In all other cases, check that the jumper is in the position marked  .
MET148-2 red LED on.	More than 3 remote modules connected.	Remove a remote module.
	MET148-2 module internal failure.	Change MET148-2 module.

Firmware upgrade

NOTE: This section applies to firmware upgrade operation only. For firmware downgrade, please contact Schneider Electric Customer Care Center.

From time to time it may be necessary to upgrade the firmware of your PowerLogic P5. There could be a number of reasons for this, new functionality, security patches or correction of product behaviour.

The firmware upgrade feature of the PowerLogic P5 protection relay provides the possibility for the user to upgrade the application firmware themselves through eSetup Easergy Pro.

Upgrading the firmware requires the eSetup Easergy Pro software to be connected to the device to be upgraded. This can be done either through the mini-USB port on the local panel or one of the rear Ethernet ports.

You must also have access to the zip file containing the firmware version you wish to upgrade to. This file typically has the format PowerLogic-P5-firmware-Vxx.xxx.xxx.zip. Please contact Schneider Electric Customer Care Center to get the package.

Please be aware that the contents of this file must come from Schneider Electric and the firmware signature will be checked to help ensure that it has come from a genuine source before the product is updated.

NOTICE

RISK OF DATA LOSS

- Please save your configuration files, disturbance records and events before starting the firmware upgrade.
- After the firmware upgrade is done, the operator needs to first connect to the device and retrieve all configurations through eSetup Easergy Pro, open the saved file, and then select the **Copy all to DEVICE** option from the **File** menu.
- The operator needs to rebuild the logics and matrix.
- The operator needs to reload the second language package.

Failure to follow these instructions will result in loss of all configurations, disturbance records and events.

The process for upgrading the firmware on the PowerLogic P5 protection relay is as follows:

1. Connect the laptop that runs eSetup Easergy Pro to the PowerLogic P5 protection relay and log in with “InstallerLevel”.
2. Open the main menu from the top-left corner of the application, select the **Update firmware...** option, and then select the new firmware package from the folder where you saved the package.
3. The application performs the following operations before starting the upgrade:
   a. Check User's rights
   b. Checking firmware package
4. If every check is passed, the application gets ready to upgrade the firmware and prompts the user to confirm. Click **OK** to confirm and the application will reboot the device, and after that the new firmware will take effect.
5. After rebooted, a message *Firmware update successful* will be displayed in alarm list.

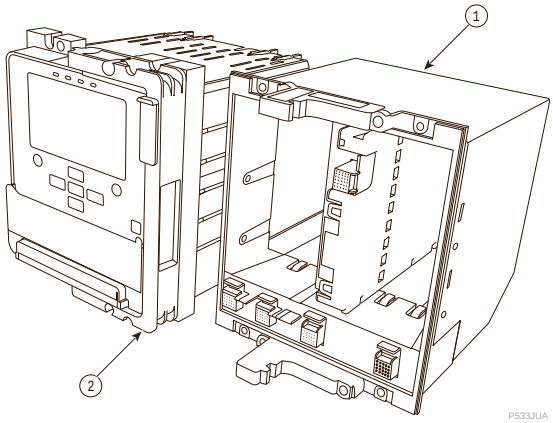
Replacing the PowerLogic P5 protection relay

The PowerLogic P5 is a withdrawable protection relay. It is made up of the following two parts (The fixed and withdrawable parts of the PowerLogic P5 protection relay, page 579):

- A rack ① including the CT/VT and LPCT/LPVT modules (fixed part). The CT/VT and LPCT/LPVT inputs are isolated and fixed. When the device is withdrawn, CTs remain connected.
- A withdrawable part ② which contains all the electronics (including the I/O board, CPU board and power supply).

  The withdrawability is realised by unlocking and pulling out the green handle on the local panel.

Figure 349 - The fixed and withdrawable parts of the PowerLogic P5 protection relay



① Fixed rack

② Withdrawable part

To limit the time of interventions for maintenance reasons, the faulty protection relay can be removed without disconnecting the wires or the connections. This allows to quickly replace an PowerLogic P5 protection relay, provided that the spare part is available.

The spare withdrawable part must be compatible with the one which is replaced. The compatibility rules are as follows:

- The spare part must have the same hardware resources
- The spare part must have the same product model number
- The spare part must have the same major software version

To avoid any unintended withdrawing, and for security reasons, the removable part is fixed to the rack by 3 screws for PowerLogic P5 x20 and 4 screws for PowerLogic P5 x30 protection relays.

The procedure for replacing the PowerLogic P5 protection relay is as follows:

Diagnosis for replacement

For the diagnostic of the protection relay, check the following:

- The status of the watchdog relay (DO4 contact relay on slot B)
- The status of the ⓘ LED and ⚡ LED, and the configurable LEDs
- The ON and LEDs on the local panel

- The Alarm list and Maintenance file to checked and downloaded with eSetup Easergy Pro

Preliminary operations

NOTE: If the PowerLogic P5 protection relay is still working, do not hesitate to save configuration, settings and parameters to the back-up memory of the extension module (optional) if it is available in the protection relay. For saving (backup), go to the backup view of the Device/Test menu on the local panel.

1. Power off the PowerLogic P5 protection relay.
2. Unscrew the 3 screws on PowerLogic P5 x20 (or 4 for PowerLogic P5 x30) that fix the local panel to the relay outer case. Refer to Unscrewing the front face locking screws, page 50.

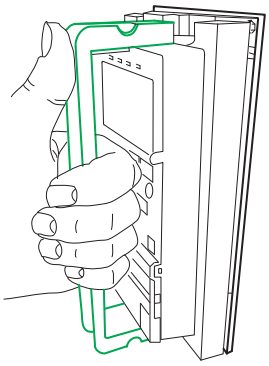
Screws	3 screws mounted on PowerLogic P5x20; 4 screws mounted on PowerLogic P5x30
Tools	(-) 6.5 mm (1/4 in.) or (+) PZ2 screwdriver (Digital torque screwdriver for installing)

3. Push upward the handle lock that locks the device handle.
4. Close the shutter of the local panel if it is open.

Removal

1. Using the device handle, pull the withdrawable part of the protection relay to detach it from the outer case (pull the device handle from the top and bottom when side access is difficult).

Figure 350 - Pulling the withdrawable part by its handle



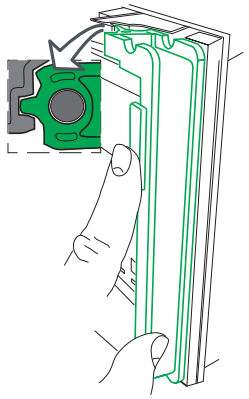
2. Extract the withdrawable part of the protection relay, using your both hands to help ensure a secure grip.
3. Check the model numbers on both the withdrawable part and the outer case.

Installation

1. Before replacing the module:
   - For compatibility of the spare part, check that the identification on the labels on the fixed and the withdrawable parts are the same.
   - Visually check the cleanliness and state of the rear connectors (rear part and lower part).
2. With the device handle fully open, insert the withdrawable (spare) part gently into the fixed part.

3. Push down the handle to lock the withdrawable part. The lock tab on the handle locks the handle to the local panel automatically.

Figure 351 - Locking the withdrawable part by the handle



4. For highly vibrating environment, put in place the screws (3 for PowerLogic P5 x20 and 4 for PowerLogic P5 x30) for locking the local panel to the relay case.

Tools	• Screws removed in the preliminary operation • (-) 6.5 mm (1/4 in.) or (+) PZ2 screwdriver
Tightening torque	1 N · m (8.85 lb-in)

NOTE: The screws are not mandatory for the installation of the spare part, but recommended for security reasons.

Subsequent operations

After installing the PowerLogic P5 protection relay, perform the following operations if necessary:

1. Switch on the PowerLogic P5 protection relay and check the relay operation. Check the model number (from the Device/Test menu on the local panel) and compare it with the associated model number displayed in eSetup Easergy Pro.
2. If an extension module with backup memory is available on the PowerLogic P5 protection relay, update the device configuration.
3. For recovery of the configuration from the backup memory (optional) and restart of the new protection relay, follow the instructions displayed on the local panel.

Change a communication module

⚠CAUTION

RISK OF SETTING CHANGES ERASED

- Never plug in or draw out the communication modules while the PowerLogic P5 protection relay is in service.
- Check and make sure that the communication module is locked.

Failure to follow these instructions can result in injury or equipment damage.

The PowerLogic P5 is a modular protection relay; The modules which can be replaced individually are:

- The communication modules
- The external modules

Identification of the module can be accessed:

- From the local panel of the PowerLogic P5 protection relay (**Device Info** menu)
- From eSetup Easergy Pro (**Device Info** view of the **Device/Test** menu)
- From the web server and the EcoStruxure Power Device application

Preliminary operation

Before changing a communication module:

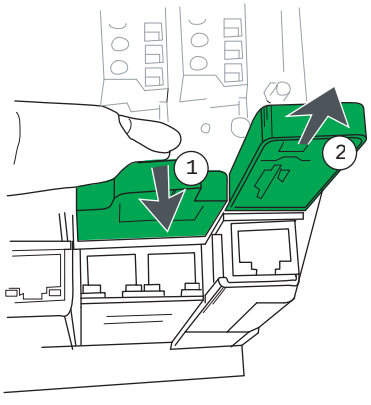
1. Power off the PowerLogic P5 protection relay.
2. Check if it there is enough space (> 15 cm or 6 in.) in the rear and lower part of the case to extract the modules. If not possible, remove the case from its support.

Removal

The module can be easily removed from the PowerLogic P5 protection relay:

1. Push down the locking tab ①.
2. Gently pull the communication module forward ②.

Figure 352 - Removing the communication module

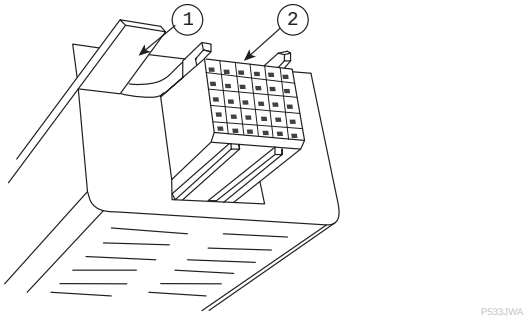


Installation

Install the module according to the following steps:

1. Before replacing the module, check visually the front plate ① and the connector ②.

Figure 353 - Front plate and connector of the communication module



2. Insert the module into its location.
3. Gently push the module to the front plate until it locks (a click is heard when the locking tab is locked).

Subsequent operation

After installing the module:

1. Check that the module is locked (visual check).
2. Switch on the PowerLogic P5 protection relay and verify that the module has been detected:
   - On the local panel, enter the **Home** menu/**Device/Test** sub-menu and check this in the **Board** menu item.
   - With eSetup Easergy Pro see the **Device/Test** menu/**Device Info** sub-menu.

Return for expert assessment

To return the PowerLogic P5 protection relay for expert assessment, use the original packaging if possible.

If the full product is returned, the active part must be installed in the fix part and properly fixed with screws.

The PowerLogic P5 protection relay must be returned accompanied by its settings sheet and the following information:

- Name and address of the initiator
- PowerLogic P5 protection relay type and serial number
- Date of the incident
- Detailed description of the incident
- LED status and message displayed at the time of the incident
- List of stored events

End of life

At end of life, PowerLogic P5 protection relays must be dismantled to facilitate the recovery of the various constituent materials.

The proportion of recyclable material is higher than 65%. This percentage includes the metallic materials and marked thermoplastics conforming to the current legislation, as well as the subassemblies that must be sent to specialised treatment systems: 3 to 5 electronic cards, and an LCD screen that can easily be disassembled.

It is calculated according to "ECO'DEEE recyclability and recoverability calculation method" (version V1.20, September 2008, presented to ADEME, the French Agency for Environment and Energy Management).

Revision history

Document version	Description	
P5/EN M/11A 2019-05	First edition for initial product release	
	Hardware version	A
	Firmware version	V01
	Release / Build	001.029
	Configuration tool	eSetup Easergy Pro V2.0.0 or later
		CET850 V3.1.2 or later
P5/EN M/22A 2019-11	Hardware version	A
	Firmware version	V01
	Release / Build	200.008
	Configuration tool	eSetup Easergy Pro V2.2.0 or later
		CET850 V3.2.0 or later
	Hardware	LPCT/LPVT available for P5U20 Ethernet communication module with RSTP redundancy (reference REL51042)
	Local panel	Local panel layout enhanced
	U_2>, U_2>>	Negative sequence overvoltage protection (ANSI 47)
	I_0/U_0>, I_0/U_0>>	Neutral admittance protection (ANSI 21YN)
	N>	Motor restart inhibition function (ANSI 66) enhanced
	CB monitoring	CB monitoring function enhanced
	Firmware upgrade	Firmware upgrade feature
	USB data transfer	USB data transfer function available
	I_2> I>, I>> I_0>, I_0'>, I_0'>> Iφ>, Iφ>> I_0φ>, I_0φ>>, I_0φ>>>	The following features are available: • STI and CO8 curves to the IEC and IEEE curve types, respectively • IDMT reset curve
	Logic gate	Logic gate number increased to 250
P5/EN M/33A 2020-07	Hardware version	A
	Firmware version	V01
	Release / Build	300.103
	Configuration tool	eSetup Easergy Pro V3.0.0 or later
		CET850 V3.3.0 or later
	Hardware	12I4O and 5I5O modules available 24 to 48 V DC voltage power supply module available for P5x30
	Motor speed detection	Motor speed detection available
	Motor speed>1, Motor speed>2	Motor overspeed (ANSI 12) protection available
	Motor speed<1,Motor speed<2	Motor underspeed (ANSI 14) protection available

	ABS	Motor Anti-backspin (ABS) protection available
	Inrush	Inrush detection enhanced
	Ih2>	2nd harmonic detection (ANSI 68H2) removed
	Motor status	Motor status enhanced
	Logic timer	Logic timer available
	Global trip timer	Global trip timer available
P5/EN M/33B	Hardware version	A
2021-02	Firmware version	V01
	Release / Build	301.103
	Configuration tool	eSetup Easergy Pro V3.1.0 or later
		CET850 V3.4.0 or later
	VTS	Voltage transformer supervision enhanced
	Special access control	F1 key access control and communication SCADA access control available
P5/EN M/33C	Hardware version	A
2021-07	Firmware version	V01
	Release / Build	303.101
	Configuration tool	eSetup Easergy Pro V3.2.1 or later
		CET850 V3.6.1 or later
	Logic functions	The information for logic functions updated
P5/EN M/44A	Hardware version	A
2021-10	Firmware version	V01
	Release / Build	400.101
	Configuration tool	eSetup Easergy Pro V4.0.0 or later
		CET850 V4.0.0 or later
		Easergy Studio V9.3.3 or later
	Operate time delay	**Global update of operate time delay philosophy. Start time compensation removed.**
	General nomenclature update	**IL1, IL2 and IL3 changed to IA, IB and IC; VL1, VL2, VL3 changed to VA, VB, VC; U12, U23, U31 changed to VAB, VBC, VCA, change of labels for protection stages, change of the units for modified protection elements**
	64REF	Restricted earth/ground fault protection available
	Phase overcurrent protection	Harmonized direction and non-directional phase overcurrent protection with phase segregation information, 6 stages in total
	Earth fault over current protection	Harmonized direction and non-directional earth fault overcurrent protection, 6 stages in total
	Overfrequency	Two dedicated over frequency stages
	Underfrequency	Increase the number of stages to 8
	Residual overvoltage	Algorithm refinement
	Overvoltage/ Undervoltage	Algorithm updated to have phase to phase and phase to neutral voltage selection, phase segregation information added

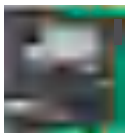
	Advanced logic engine	More complex logic feature with ISaGRAF available
P5/EN M/44B 2022-07	Hardware version	A
	Firmware version	V01
	Release / Build	402.101
	Configuration tool	eSetup Easergy Pro 4.2.0 or later
		CET850 V4.2.0 or later
		Easergy Studio V9.4.0 or later
	Rate of change of frequency protection	Algorithm revised, frequency and frequency + RoCoF modes introduced. Increased accuracy. 9 independent stages with the same settings and performance introduced.
	Overcurrent protection	Definite time setting range updated.
	Undercurrent protection	Pick-up setting range updated. Low-current block limit setting introduced. The function is now available in P5F30.
	Broken conductor protection	Algorithm revised. The precondition for operation is the positive phase sequence component greater than 5% of nominal value. 2nd stage with the same settings and performance introduced.
	Emergency restart	New automation function for motor application introduced.
	Virtual inputs	VI1 to VI10 are configurable virtual inputs, they can operate in pulse mode with a settable pulse length.
	Default mimic	Improved manipulation of default mimic screens. Use arrow-up or arrow-down keys to scroll between visible Mimics 1-5.
	Disturbance recorder	Auto-Reclose, CB monitoring, SOL, CTS/VTS related signals added to Disturbance Recorder.
	Alarms	Fault direction added to 67/67N related alarms.
	System	Confirmation popup window displayed when firmware upgrade is completed successfully.
		Special access control by F1 button enhanced with auto log-out within 3 mins and reset button behaviour.
		Connection between P5 and Easergy Pro improved.
	Communication	Ethernet/IP protocol data model updated.
		Modbus protocol data model updated.
		IEC 60870-5-103 protocol data model updated.
		Enhancements and bug fixes in IEC 61850 fPN feature.
	Advanced logic engine	Advanced logic can be now viewed with ISaGRAF Workbench Demo only (without ISaGRAF Workbench license).
	Nomenclature	Change for setting units from In/% to pu.
	Continuous engineering	Regular corrections & bug fixes package introduced.
P5/EN M/44C 2022-09	Hardware version	A
	Firmware version	V01
	Release / Build	402.201
	Configuration tool	eSetup Easergy Pro 4.2.0 or later
		CET850 V4.2.0 or later
		Easergy Studio V9.4.0 or later

	Rebranding to PowerLogic	The product has been renamed to PowerLogic keeping its design, specification, performance, missing profile, safety and reliability unchanged.
P5/EN M/44D 2023-05	Hardware version	A
	Firmware version	V01
	Release / Build	500.102
	Configuration tool	eSetup Easergy Pro 4.3.0 or later
		CET850 V4.4.2 or later
		Easergy Studio V9.4.0 or later
	Offer structure	P5T30 Transformer Differential protection relay introduced as new model in P5x30 platform.
		Settable Cybersecurity license introduced. New configuration options introduced: E - Settable CS, F - Settable CS and Advanced Logic Engine.
	Interposing CT	New possibility for neutral current measurement introduced. CSH30 interposing CT can be used now to interface CSH neutral current inputs with standard 1A or 5A core-balance CTs.
	Recording	Last fault record summary screen introduced.
		Additional sampling rate option introduced: 24 samples/ cycle.
	Cybersecurity	Compatibility with LDAP server introduced.
	Continuous engineering	Regular package of corrections & bug-fixes introduced.
P5/EN M/44D 2023-05	Hardware version	A
	Firmware version	V01
	Release / Build	500.103
	Configuration tool	eSetup Easergy Pro 4.3.0 or later
		CET850 V4.4.2 or later
		Easergy Studio V9.4.0 or later
	Continuous engineering	Regular package of corrections and adaptations to support the manufacturing process.
P5/EN M/44E 2023-11	Hardware version	A
	Firmware version	V01
	Release / Build	500.104
	Configuration tool	eSetup Easergy Pro 4.3.0 or later
		CET850 V4.4.2 or later
		Easergy Studio V9.4.0 or later
	Continuous engineering	The issue with incorrect UTC time records in Daylight Saving Time mode has been fixed.

Order information

Protection relay

For ordering, please visit www.se.com and use PowerLogic P5 Product Selector. Alternatively, please contact Customer Care Center stating a complete model number (according to below table) and quantity.



PowerLogic P5

Schneider Electric

		Slot D	Slot E	Slot B	Slot C		Slot A	Slot L	Slot M	Slot N	Slot P		Model	Firmware	Function	Language
Application																
Feeder protection relay	P5F30 -					-						-				
Motor protection relay	P5M30															
Transformer differential relay	P5T30															
Universal protection relay	P5U20															
Voltage protection relay	P5V20															
Slot D - Additional I/O in P5x30 **																
Without		A														
6DI + 4DO		B														
3 Arc sensors + 3DI + 3DO		C														
5DI + 5DO		D														
12DI + 4DO		E														
Slot E - Additional I/O in P5x30 **																
Without			A													
6DI + 4DO			B													
3 Arc sensors + 3DI + 3DO			C													
5DI + 5DO			D													
12DI + 4DO			E													
Slot B - Power supply																
48 - 250 V DC / 100 - 230 V AC + 4DI + 3DO + WD				C												
24 - 48 V DC + 4DI + 3DO + WD *				D												
Slot C - Additional I/O **																
without					A											
6DI + 4DO					B											
5DI + 5DO					D											
12DI + 4DO					E											
Slot A - CT/VT																
3 phase CT + 2 neutral CT (available for P5U20)							B									
3 phase CT + 1 neutral CSH (available for P5U20)							C									
4 VT (available for P5V20)							D									
3 phase CT + 2 neutral CT + 4 VT (available for P5F30, P5M30)							G									
3 phase CT + 1 neutral CSH + 4 VT (available for P5F30, P5M30)							H									
3 LPCT + 1 neutral CSH + 4 LPVT (available for P5F30, P5M30, P5U20)							I									
6 phase CT + 2 neutral CT + 1 VT (available for P5T30) *							J									
Slot L - 2nd Ethernet communicaition port																
Without								A								
Ethernet TP module with RSTP (2*RJ45)								B								
Slot M - Ethernet communication port																
Without									A							
Ethernet TP module with RSTP (2*RJ45)									B							
Ethernet FO module with RSTP (2*LC)									C							
Ethernet FO module with HSR/PRP (2*LC)									D							
Slot N - Serial communication port																
Without										A						
RS485 serial line module										E						
RS485 FO serial line module										F						
Ethernet FO module with HSR/PRP (2*LC) (when option D is selected on Slot M)										D						
Slot P - Extension port																
Without											A					
Extension module + Backup memory											H					
Model version																
Version A													A			
Firmware version																
Latest firmware version V01.500.104														A		
Firmware version V01.402.203														E		
Function packages																
Cybersecurity Basic - firmware V01.402.203															A	
Cyberscurity Advanced IEC 62443 4-2 Security Level 1 - firmware V01.402.203															B	
Cybersecurity Basic & Advanced Logic Engine - firmware V01.402.203															C	
Cybersecurity Advanced IEC 62443 4-2 Security Level 1 & Advanced Logic Engine - firmware V01.402.203															D	
Settable cybersecurity (Basic or Advanced IEC 62443 4-2 SL1) - firmware V01.500.104															E	
Settable cybersecurity (Basic or Advanced IEC 62443 4-2 SL1) + Advanced Logic Engine - firmware V01.500.104															F	
Languages																
English																A
English - Chinese																B
English - French																C
English - Italian																E
English - Polish																F
English - Portuguese																G
English - Russian																H
English - Spanish																I
English - Tr. Chinese																L
English - English ANSI *																K

* options not available with firmware version V01.303
**** ATTENTION** - slot occupation rules apply, not every I/O board configuration in slots C, D, E is valid. Please refer to Product Selector at www.se.com, User Guide/Ordering information or P5x30 slot occupation rules XLS file.

NOTE: For the applicable slot occupation rules for your PowerLogic P5 protection relay ordered, refer to Slot occupation rules, page 590 to get more details.

Slot occupation rules

The slot occupation rules for PowerLogic P5 protection relay based on your ordering are stated as the table below:

30TE withdrawable HW possible combinations				No. of boards				No. of digital I/O	
	slot D	slot E	slot C	5I5O	arc-flash	6I4O	12I4O	DI	DO
A A * A	cover	cover	cover	0	0	0	0	4	3 + WD
A A * B	cover	cover	6I4O	0	0	1	0	10	7 + WD
B A * B	6I4O	cover	6I4O	0	0	2	0	16	11 + WD
B B * B	6I4O	6I4O	6I4O	0	0	3	0	22	15 + WD
C A * A	arc-flash	cover	cover	0	1	0	0	7	6 + WD
C A * B	arc-flash	cover	6I4O	0	1	1	0	13	10 + WD
C B * B	arc-flash	6I4O	6I4O	0	1	2	0	19	14 + WD
C C * A	arc-flash	arc-flash	cover	0	2	0	0	10	9 + WD
C C * B	arc-flash	arc-flash	6I4O	0	2	1	0	16	13 + WD
A A * D	cover	cover	5I5O	1	0	0	0	9	8 + WD
B A * D	6I4O	cover	5I5O	1	0	1	0	15	12 + WD
B B * D	6I4O	6I4O	5I5O	1	0	2	0	21	16 + WD
C A * D	arc-flash	cover	5I5O	1	1	0	0	12	11 + WD
C B * D	arc-flash	6I4O	5I5O	1	1	1	0	18	15 + WD
C C * D	arc-flash	arc-flash	5I5O	1	2	0	0	15	14 + WD
D A * D	5I/5O	cover	5I5O	2	0	0	0	14	13 + WD
B D * D	6I4O	5I5O	5I5O	2	0	1	0	20	17 + WD
C D * D	arc-flash	5I5O	5I5O	2	1	0	0	17	16 + WD
D D * D	5I5O	5I5O	5I5O	3	0	0	0	19	18 + WD
A A * E	cover	cover	12I4O	0	0	0	1	16	7 + WD
E A * B	12I4O	cover	6I4O	0	0	1	1	22	11 + WD
B E * B	6I4O	12I4O	6I4O	0	0	2	1	28	15 + WD
C A * E	arc-flash	cover	12I4O	0	1	0	1	19	10 + WD
C E * B	arc-flash	12I4O	6I4O	0	1	1	1	25	14 + WD
C C * E	arc-flash	arc-flash	12I4O	0	2	0	1	22	13 + WD
E A * D	12I4O	cover	5I5O	1	0	0	1	21	12 + WD
B E * D	6I4O	12I4O	5I5O	1	0	1	1	27	16 + WD
C E * D	arc-flash	12I4O	5I5O	1	1	0	1	24	15 + WD
D E * D	5I5O	12I4O	5I5O	2	0	0	1	26	17 + WD
E A * E	12I4O	cover	12I4O	0	0	0	2	28	11 + WD
E E * B	12I4O	12I4O	6I4O	0	0	1	2	34	15 + WD
C E * E	arc-flash	12I4O	12I4O	0	1	0	2	31	14 + WD
E E * D	12I4O	12I4O	5I5O	1	0	0	2	33	16 + WD
E E * E	12I4O	12I4O	12I4O	0	0	0	3	40	15 + WD

Accessories

Order code		Description
Communication Modules		
REL51038	☐	Ethernet TP module - slot M
REL51039	☐	Ethernet FO module - slot M
REL51042	☐	Ethernet TP module - slot L
REL51036	☐	RS485 serial line module - slot N
VW3A8306RC	☐	RS485 line termination accessory
LV434211	☐	RJ45 to open 2/4 wire adaptor for Modbus
REL51040	☐	Fiber optic serial line module - slot N
REL51034	☐	Extension module - slot P
REL51041	☐	P2P, Inter-relay module(FO) - slot L
REL51048	☐	Ethernet HSR/PRP RS485 module 2TP- slots M-N
REL51049	☐	Ethernet HSR/PRP RS485 module 2FO - slots M-N
External modules		
59641	☐	8 temperature sensor module (MET148-2)
REL51045	☐	IRIG-B module
59660	☐	0.6m remote module connection cord
59661	☐	2m remote module connection cord
59662	☐	4m remote module connection cord
Sensors		
59635	☐	Core balance CT, Ø=120mm (CSH120)
59636	☐	Core balance CT, Ø=200mm (CSH200)
59637	☐	Core balance CT, Ø=300mm (CSH300)
59634	☐	CSH30 interposing ring CT
EMS59572	☐	VT adapter
EMS59573	☐	LPVT sensor hub
REL52801	☐	Arc accessory VA1DA-20 Arc sensor 20m
REL52802	☐	Arc accessory VA1DA-20S-HF Arc sensor 20m shielded halogen free
REL52803	☐	Arc accessory VA1DA-20S Arc sensor 20m shielded
REL52804	☐	Arc accessory VA1DA-6 Arc sensor 6m connect cable
REL52805	☐	Arc accessory VA1DA-6S-HF Arc sensor 6m shielded halogen free
REL52806	☐	Arc accessory VA1DA-6S Arc sensor 6m shielded
REL52807	☐	Arc accessory VA1EH-20 Arc sensor 20m pipe sensor
REL52808	☐	Arc accessory VA1EH-20S Arc sensor 20m pipe sensor shielded
REL52809	☐	Arc accessory VA1EH-6 Arc sensor 6m pipe sensor
REL52810	☐	Arc accessory VA1EH-6S Arc sensor 6m pipe sensor shielded
Mounting accessories		
REL51032	☐	20TE flush mounting accessory
REL51052	☐	30TE flush mounting accessory
REL51021	☐	19inch rack mounting accessory
REL51018	☐	30TE blanking plate for rack mounting
REL51019	☐	20TE blanking plate for rack mounting
REL51020	☐	10TE blanking plate for rack mounting

Wiring accessories		
REL51054	☐	2-pin comb-busbar for I/O - 100 pcs
REL51055	☐	3-pin comb-busbar for I/O - 100 pcs
REL51056	☐	4-pin comb-busbar for I/O - 50 pcs
REL51057	☐	5-pin comb-busbar for I/O - 50 pcs
REL51058	☐	6-pin comb-busbar for I/O - 50 pcs
REL51059	☐	90° ring wiring terminal red -250 pcs
REL51060	☐	90° ring wiring terminal blue -250 pcs
REL51061	☐	90° ring wiring terminal yellow -250 pcs
Easergy Pro connection cable		
59700	☐	PC cord USB
LPIT accessories		
EMS59572	☐	VT adapter
EMS59573	☐	LPVT hub connector
REL51037[156]	☐	LPIT Test Box
REL51089[156]	☐	LPCT Test Socket with cover
REL51090[156]	☐	LPCT Test Plug
REL51092[156]	☐	LPVT Test Socket with cover
REL51093[156]	☐	LPVT Test Plug
P7M12025	☐	LPVT transducer
REL51095[156]	☐	T-box 3-way RJ45 junction
Spare parts		
REL51077	☐	Spare 2 screw type connectors kit
REL51078	☐	Spare accessories kit for CT/VT
REL51079	☐	Spare accessories kit for LPCT/LPVT
REL51088[156]	☐	Spare cable for LPIT Test Box

156. Please contact Schneider Electric for availability.

Schneider Electric
35 rue Joseph Monier
92500 Rueil Malmaison
France

+ 33 (0) 1 41 29 70 00

www.se.com

As standards, specifications, and design change from time to time, please ask for confirmation of the information given in this publication.

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