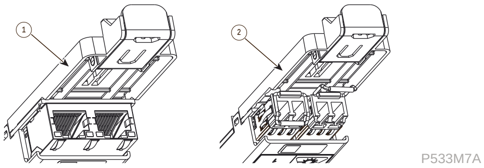
Slot M: Ethernet communication module with RSTP redundancy

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 89 - Example of Ethernet module connection

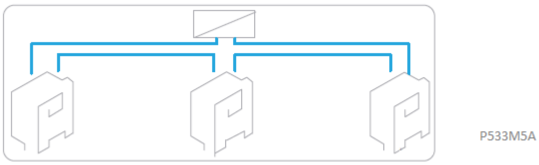
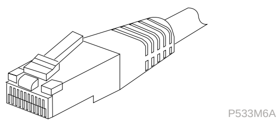


Table 10 - Characteristics of the Ethernet communication module (reference REL51038)

Characteristics	
Location	Slot M
Connection	2 x RJ45 connectors with communication indicators 
Ethernet connection	10/100 Mbps
Protocol	TP or RSTP
Maximum cable length	100 m (328 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.

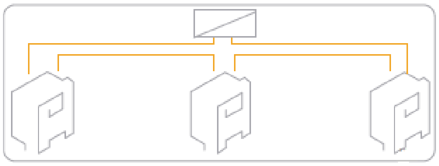
NOTICE
IMPROPER EQUIPMENT OPERATION
• Use only Schneider Electric approved optical transceiver components. • Never replace the optical transceiver components with unauthorised manufactured parts.
Failure to follow these instructions can result in equipment damage.

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").

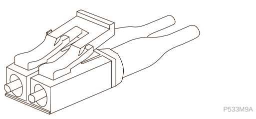
The bending radius of fibres should be especially taken care of, and it is not recommended to use optical shunts, they can decrease the communication performance of the transmission path over time.

Figure 90 - Example of Ethernet module connection



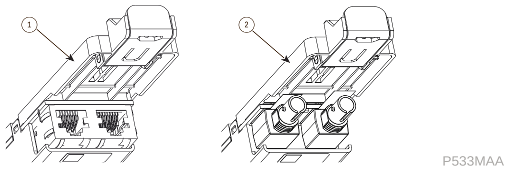
P533M8A

Table 11 - 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	1310 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

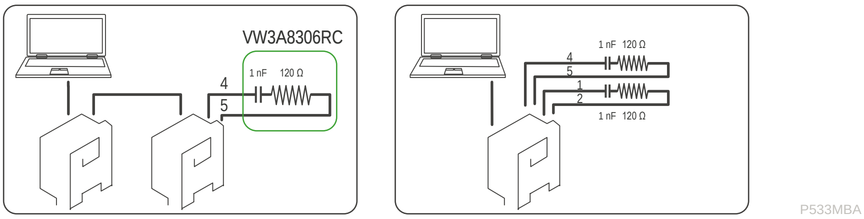
The Serial line communication module is installed in slot N of the device. It is an optional selection when ordering the device or can be purchased after on-site installation. It is available in 2 versions for RS485 ① or fibre optic ② connection.



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 91 - 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 92 - Terminating the transmission line with a RC terminating accessory

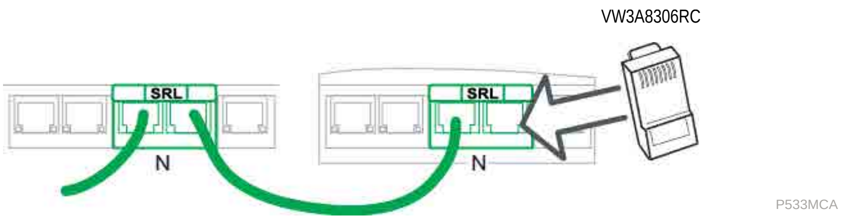


Table 12 - Characteristics of the RS485 serial line module (reference REL51036)

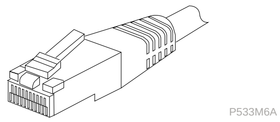
Characteristics	
Location	Slot N
Standard	EIA 2-wires RS485 differential or EIA 4-wires RS485 differential
Connection	2 x RJ45 connectors 
Protocol	TP
Line polarisation	620 Ω
Communication network	Half or full duplex
Maximum cable length	100 m (328 ft)

Figure 93 - RJ45 female connector viewed from front

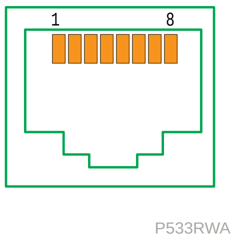


Figure 94 - RJ45 female connector wiring

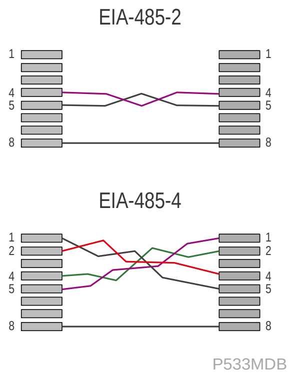
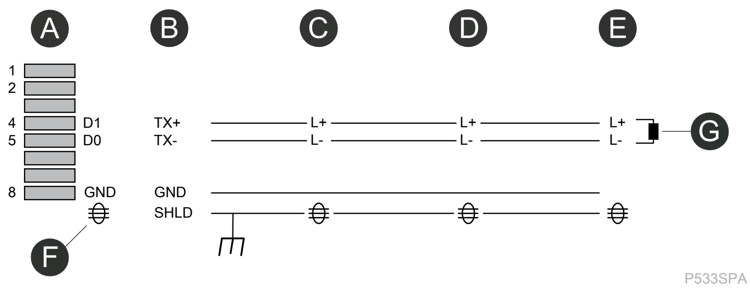


Figure 95 - RJ45 for RS485 interface



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

Figure 96 - Example of fibre optic serial line module connection

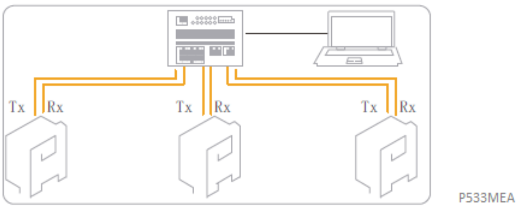
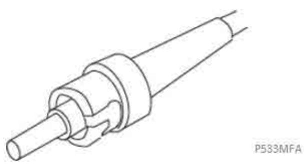


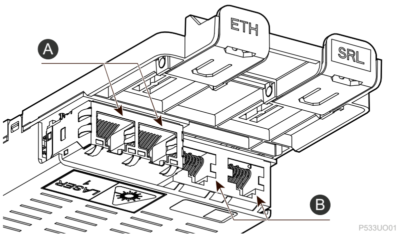
Table 13 - Characteristics of the fibre optic serial line module (reference REL51040)

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 HCS (Hard Clad Silica) fibre diameter 200 µm
Maximum range	2000 m (6561,7 ft)

Slot M & N: Combined Ethernet HSR/PRP 2TP + RS485 module (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.



A	Ethernet RJ45 ports	B	RS485 serial link ports

For the RS485 serial line module, please refer to Slot N: serial line communication modules, page 103.

Figure 97 - Example of Ethernet module connection

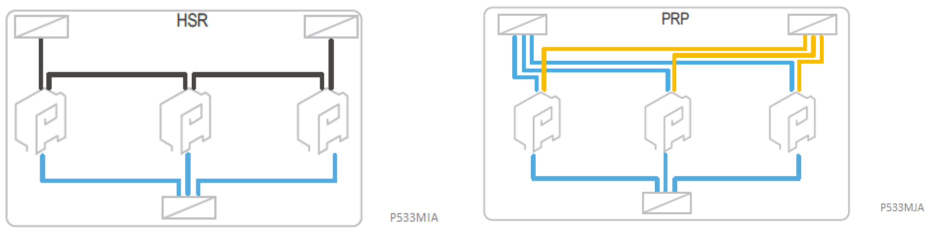
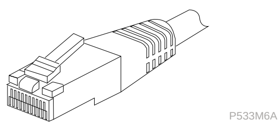


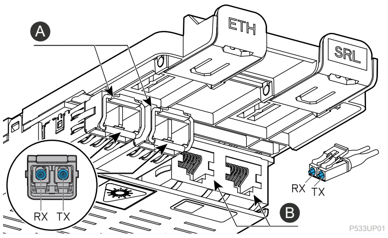
Table 14 - Characteristics of the Combined Ethernet HSR/PRP 2TP + RS485 module (reference REL51048)

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); • 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	100 m (328 ft)

Slot M & N: Combined Ethernet HSR/PRP FO + RS485 module (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.



A	FO ports	B	RS485 serial link ports

⚠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 shall have management of character idle state capability (when the fibre optic cable interface is "Light off").

Specific care shall be taken with the bending radius of the fibres. 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 103.

Figure 98 - Example of Ethernet module connection

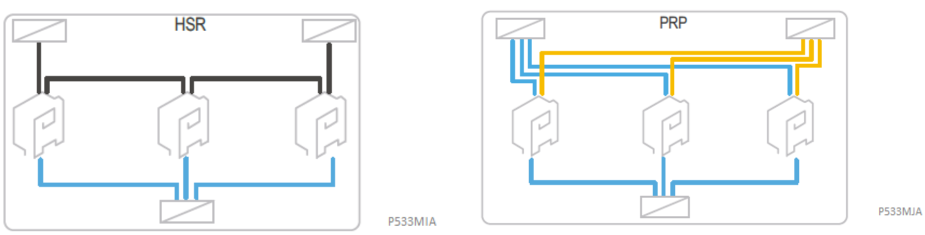
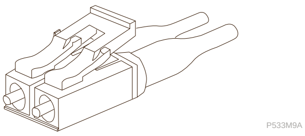
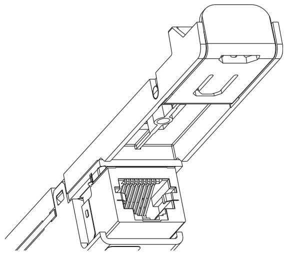


Table 15 - Characteristics of the Combined Ethernet HSR/PRP FO + RS485 module (reference REL51049)

Characteristics	
Location	Both slot M and N
Connection	2 x LC connectors 
Ethernet connection	100 Mbps
Optical wavelength	1310 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)
Maximum range	2 km (1.2 mi)

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.



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.

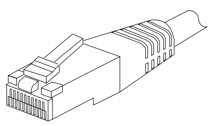
The extension module provides:

- Automatic back-up of data (refer to Backup memory, page 616):
    - 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 135 for more information)
- MET148-2 temperature sensor module (see MET148-2 - temperature sensor module (reference 59641), page 132 for more information)

Table 16 - Characteristics of the extension module (reference REL51034)

Characteristics	
Location	Slot P
Connection	RJ45 connector 
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 P: extension Zigbee module (reference REL51044)

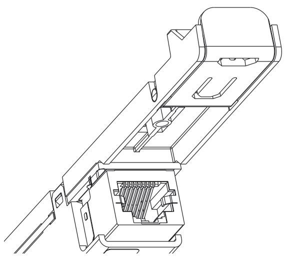
⚠ CAUTION

EXPOSURE TO RADIO FREQUENCY

- Read and understand this guide before performing any installation with the extension Zigbee module (reference REL51044).
- FCC: This device complies with FCC RF radiation exposure limits set forth for general population. This device must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.
- IC: This device complies with Industry Canada RF radiation exposure limits set forth for general population. This device must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.
- Le présent appareil est conforme aux niveaux limites d'exigences d'exposition RF aux personnes définies par Industrie Canada. L'appareil doit être installé afin d'offrir une distance de séparation d'au moins 20 cm avec l'utilisateur, et ne doit pas être installé à proximité ou être utilisé en conjonction avec une autre antenne ou un autre émetteur.

Failure to follow these instructions can result in injury.

The extension Zigbee 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:

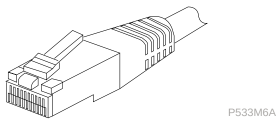
- Automatic back-up of data (refer to Backup memory, page 616):
  - Active configuration file
  - Disturbance records
  - Sequence of events records
  - Power system maintenance data log
- Connection to the external modules through Zigbee Green Power protocol with the sensors located in neighborhood of PowerLogic P5

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

- IRIG-B module (see IRIG-B module (reference REL51045), page 135 for more information)

- MET148-2 temperature sensor module (see MET148-2 - temperature sensor module (reference 59641), page 132 for more information)
- PowerLogic TH110: thermal sensors, connected through Zigbee
- PowerLogic CL110: environmental sensors, connected through Zigbee

Table 17 - Characteristics of the extension Zigbee module (reference REL51044)

Characteristics	
Location	Slot P
Connection	RJ45 connector 
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);

Installation of sensors and connection of modules for Digital Circuit Breaker monitoring

Installation of Zigbee sensors

NOTE: PowerLogic P5 communicates with the Zigbee Green Power sensors through extension module installed in slot P. For the detail of the extension module, refer to Slot P: extension Zigbee module (reference REL51044), page 110.

Installation of PowerLogic TH110

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.

The PowerLogic TH110 is a temperature sensor powered by induced current from monitored conductor. Its measured data are transmitted using Zigbee Green Power protocol. It measures temperature of electrical equipment inside MV cubicle.

The PowerLogic TH110 sensors can be installed on circuit breaker upper arms, circuit breaker lower arms, busbar joints, and cable joints of each phase A/B/C.

The work steps to install the TH110 sensor are:

1. Prepare the metal band, thread the metal band through the gap at the bottom of TH110.
2. Fasten TH110 to the place to be monitored on the equipment by the metal band.
3. Cut-off the excess part of the metal band with dedicated tool.
4. Secure in place the TH110 with Velcro securing strap, cut-off the excess part.

For more detailed information of the installation, please refer to the installation guide (document reference: MFR7945801) of PowerLogic TH110 through this link: https://www.se.com/us/en/download/document/MFR7945801/.

Installation of PowerLogic CL110

⚠CAUTION

EXPOSURE TO HIGH TEMPERATURES

Do not test the temperature beyond the sensor rating, which may cause damage to the sensor.

Failure to follow these instructions can result in equipment damage.

The PowerLogic CL110 is an indoor battery powered and wireless communication thermal and humidity sensor using Zigbee Green Power 2.4GHz protocol according to the IEEE 802.15.4. The PowerLogic CL110 is a mobile device as defined by FCC. It is intended to be used within indoor high and low voltage electrical distribution products or assemblies to monitor temperature and humidity change over a de-energised surface.

Sensors are affixed to magnetic surfaces through four high-strength magnets. The sensor should be used with a Schneider-Electric access point, which can be used for multiple sensors, using Zigbee Green Power wireless communication protocol. If the surface where the CL110 is going to be installed is not of steel, there is another option to fix it on this surface with the help of an installation kit.

For the detailed information of the installation, refer to the user guide (document reference: QGH40088) of PowerLogic CL110 through this link: https://www.se.com/uk/en/download/document/QGH40088/.

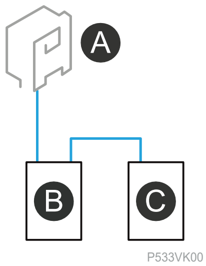
Connection of PowerLogic P5 with EOS-BM100/EOS-MCMx00

NOTE: Before connecting the modules of the Digital Circuit Breaker monitoring, ensure the extension module is installed in slot N or slot M & N. For the details of the extension module, refer to Slot N: serial line communication modules, page 103, Slot M & N: Combined Ethernet HSR/PRP 2TP + RS485 module (reference REL51048), page 106 and Slot M & N: Combined Ethernet HSR/PRP FO + RS485 module (reference REL51049), page 107.

Connect the EOS-BM100/EOS-MCM100/EOS-MCM200 to PowerLogic P5 by Daisy chain with RJ45 cables in the following sequence:

1. Wire the PowerLogic P5 to EOS-BM100.
2. Wire the EOS-BM100 to EOS-MCM100/EOS-MCM200.

Figure 99 - Daisy chain of PowerLogic P5, EOS-BM100 and EOS-MCMx00



A	PowerLogic P5	B	EOS-BM100
C	EOS-MCM100/EOS-MCM200		

The slot used in PowerLogic P5 is Slot N or Slot M+N. One PowerLogic P5 can connect with up to one EOS-BM100 and one EOS-MCM100/EOS-MCM200.

PowerLogic P5 will communicate with EOS-BM100 automatically when the connection is established and Digital CB protocol is configured. A Digital CB icon will be shown on the local HMI of PowerLogic P5. When PowerLogic P5 is connected to eSetup Easergy Pro, a **DIGITAL CB** menu tab will be displayed, it’s both for the monitoring function and the configuration of the Digital Circuit Breaker monitoring.

NOTE: The Modbus slave ID setting ranges of EOS-BM100/EOS-MCM100/EOS-MCM200 are:

- 11 to 19 for EOS-BM100 module, default ID is 11;
- 21 to 29 for EOS-MCM100/EOS-MCM200 module, default ID is 21.

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.

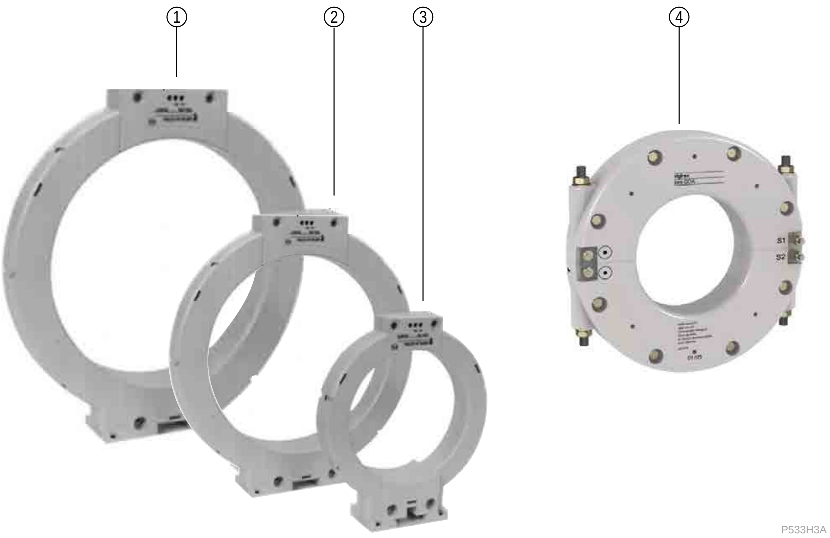
CSH300 ①, CSH200 ② and CSH120 ③ are closed CTs, with different inner diameters:

- 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 71.

Figure 100 - Core balance current transformers (CT)



① CSH300 core balance CT

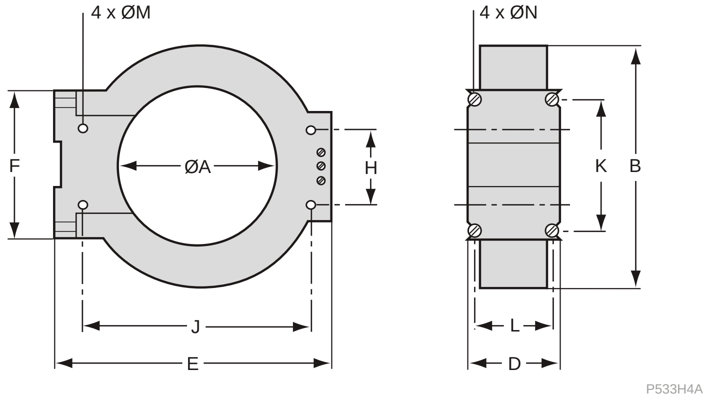
② CSH200 core balance CT

③ CSH120 core balance CT

④ GO110 core balance CT

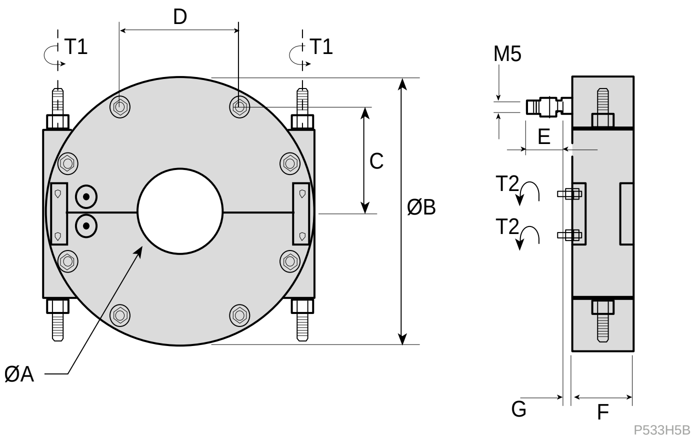
Dimensions

Figure 101 - 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 102 - 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

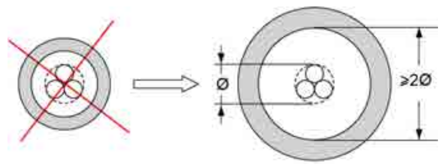
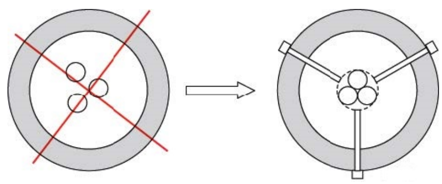
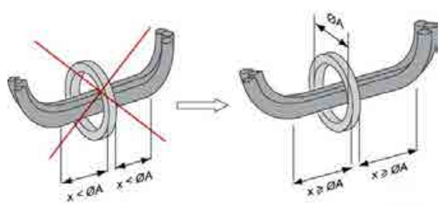
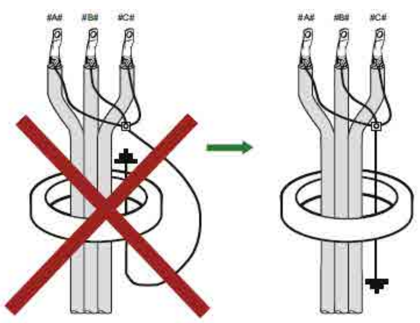
⚠⚠DANGER

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 18 - 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

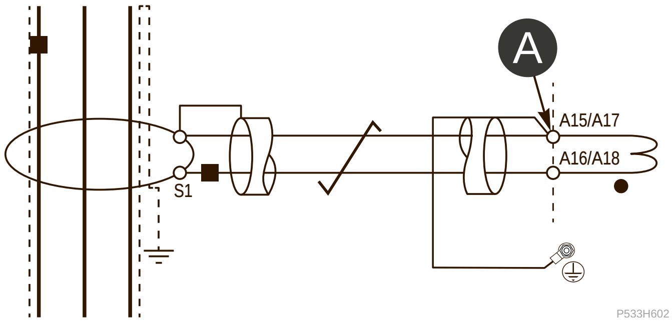
Recommended cable:

- 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 mm^2 (AWG 18 to 14) wire[36] 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 mm^2 (AWG 16 to 10) wire[36] 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 103 - 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.

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

Characteristics

Table 19 - 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 104 - Connection to 5 A secondary circuit: 4 turns

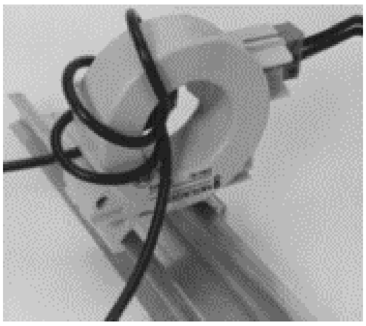
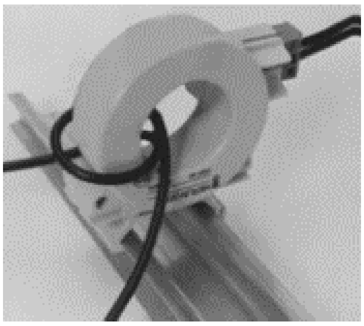


Figure 105 - Connection to 1 A secondary circuit: 2 turns

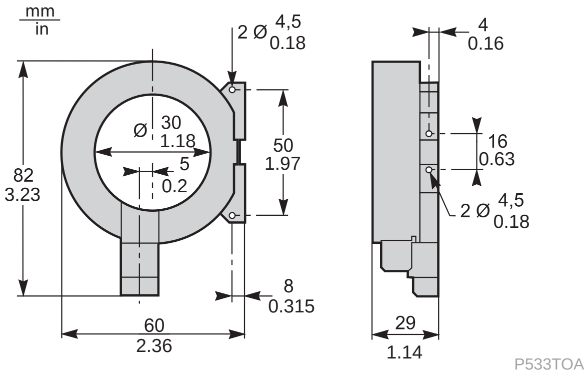


Dimensions

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

Mechanical dimensions are given in the figure below:

Figure 106 - Dimensions for CSH30



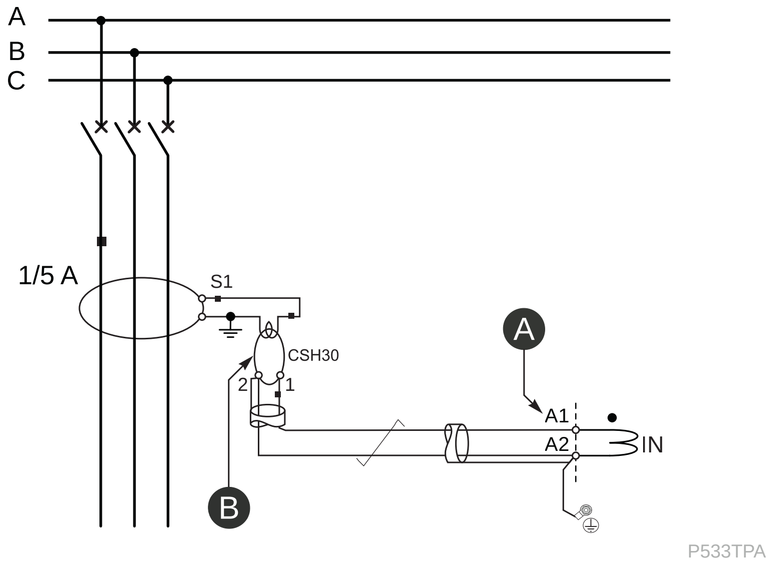
Connection

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 107 - 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

Note that following terminals have to be connected to earth/ground:

- A15, A17 for standards CT/VT board
- A2, A4 for LPIT board

Characteristic

Table 20 - 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.

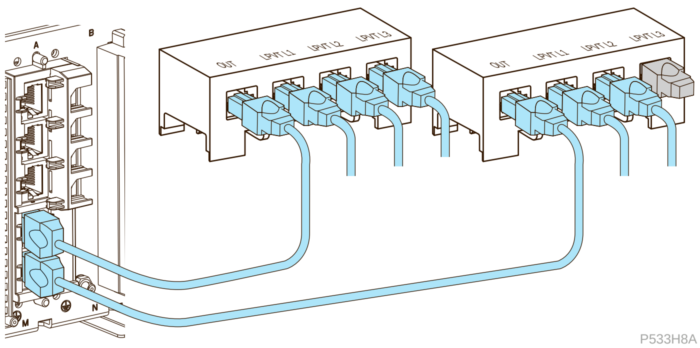
The LPVT hub connector also manages the presence of each LPVT connection thanks to a daisy chain across the three sensors. If at least one LPVT is missing or one cable is damaged, an alarm event is logged and displayed on the local panel.

Figure 108 - 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 109 - LPVT hub connector connected to PowerLogic P5x30 protection relay



Characteristics

Table 21 - 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℃ to 85℃ (-40℉ to 185℉)
Ambient air temperature for storage	-	-40℃ to 85℃ (-40℉ to 185℉)
Fire resistance	IEC 60695-2-11	850℃ (1562℉)
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, consult Schneider Electric.

Failure to follow these instructions can result in measurement error.

Figure 110 - 3 phase to neutral voltages connection

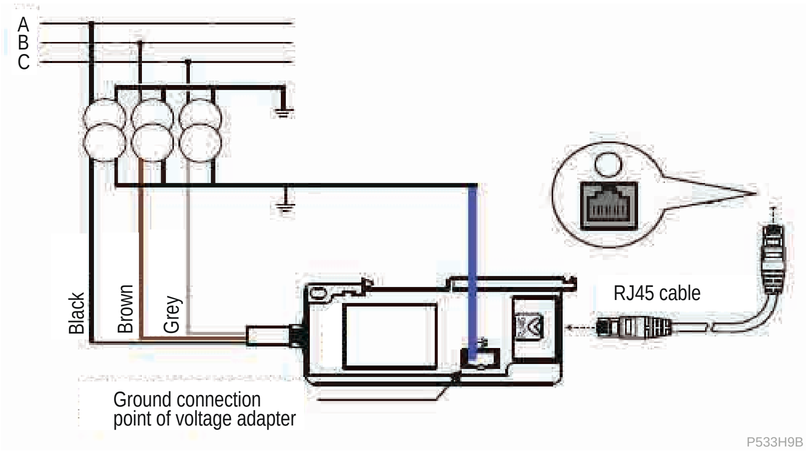


Figure 111 - 2 phase to phase voltages connection

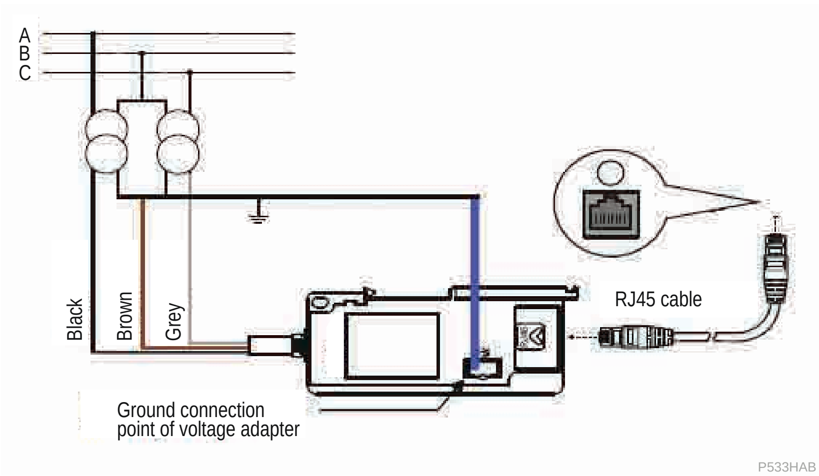


Figure 112 - 1 additional phase to phase voltage connection

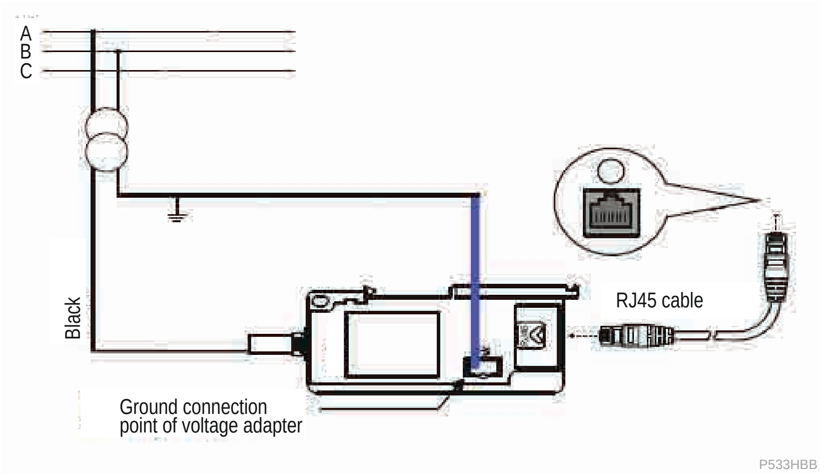
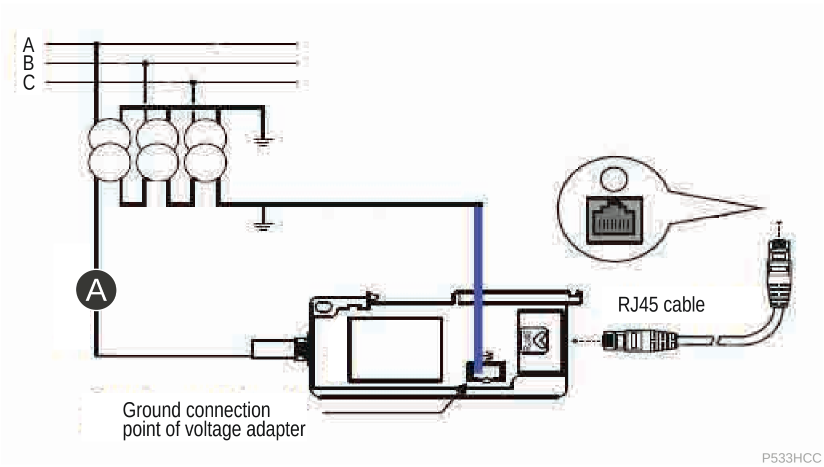


Figure 113 - Open-delta voltage connection



A	Cable: • Black for P5x30 • Brown for P5U20

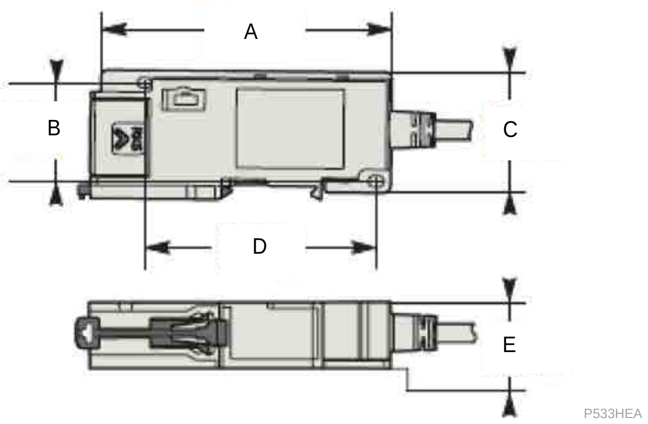
The Ethernet RJ45 cable is connected to the PowerLogic P5 protection relay. Length maximum: 4 m (13.12 ft)

- 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.

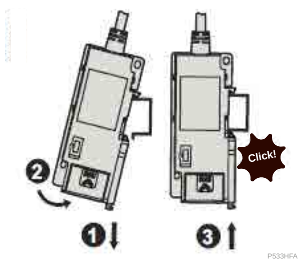
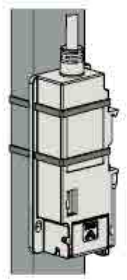
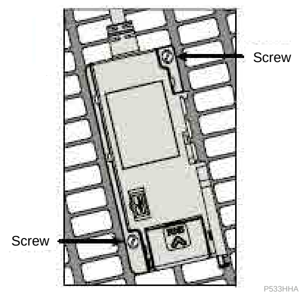
Dimensions

Figure 114 - 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.)

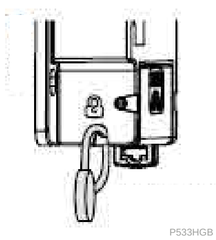
Mounting

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

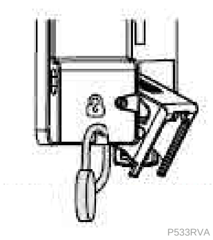
RJ45 terminal locking

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 115 - RJ45 terminal lock



Locked in close position



Locked in open position

Characteristics

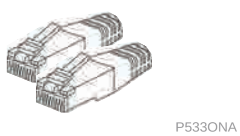
Table 22 - Characteristics of the voltage adapter

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

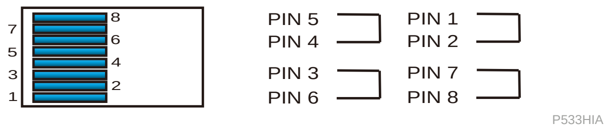
This RJ45 LPCT/LPVT plug is used when a sensor is not present to close the loop of the sensors presence detection (see Connector A cabling kit for LPCT/LPVT analogue inputs (REL51079), page 80). It could be used on LPVT hub inputs or on LPVT or LPCT P5x inputs.

Figure 116 - RJ45 LPCT/LPVT plug



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 117 - 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 118 - Dimensions of the standard arc-flash sensors

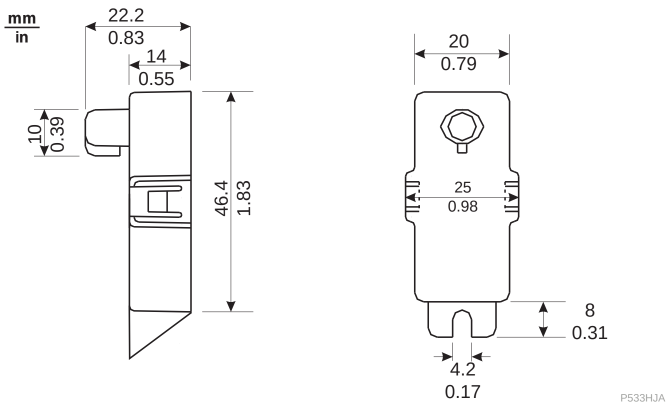
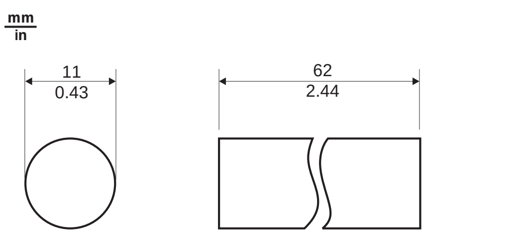


Figure 119 - Dimensions of the pipe type arc-flash sensors



Characteristics

Table 23 - Characteristics of the standard arc-flash sensors

Charac-teristics	REL52801	REL52802	REL52803	REL52804	REL52805	REL52806
Cable length (m) [37]	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
Environ-ment	Pollution Degree 2					
Operation tempera-ture	-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 supervi-sion	Yes					

Table 24 - Characteristics of the pipe type arc-flash sensors

Characteristics	REL52807	REL52808	REL52809	REL52810
Cable length (m)[37]	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

Do not extend the length of arc-flash sensor cables.

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

37. 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 120 - VYX 001 mounting plate for sensor

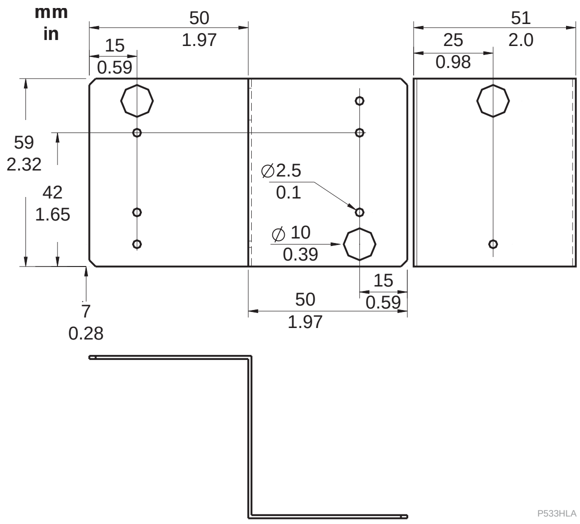


Figure 121 - VYX 002 mounting plate for sensor

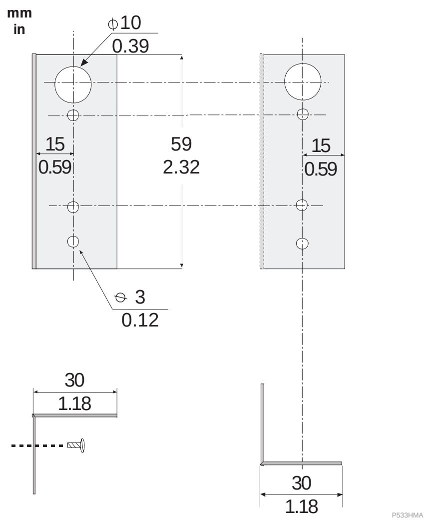
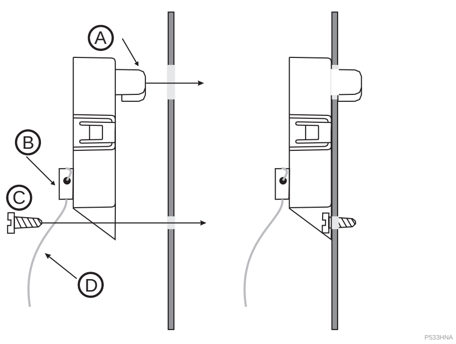


Figure 122 - Mounting the sensor



Ⓐ 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

Do not 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 123 - Point sensor connections

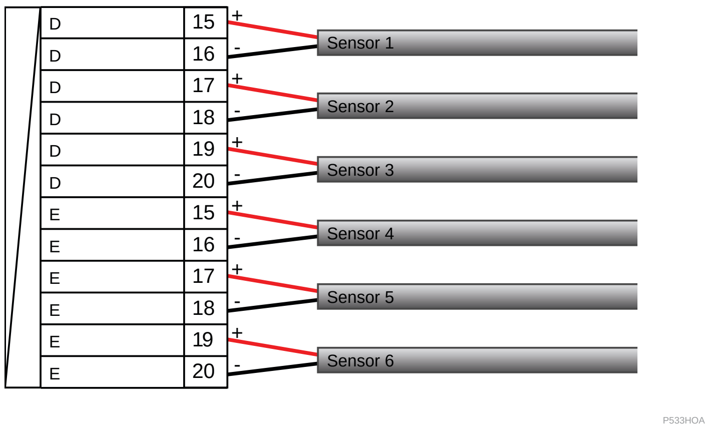
   

   Table 25 - Point sensor connections

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 sensors with shielded cables.

MET148-2 - temperature sensor module (reference 59641)

Up to 2 MET148-2 temperature sensor modules can be connected to PowerLogic P5 protection relay.

DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

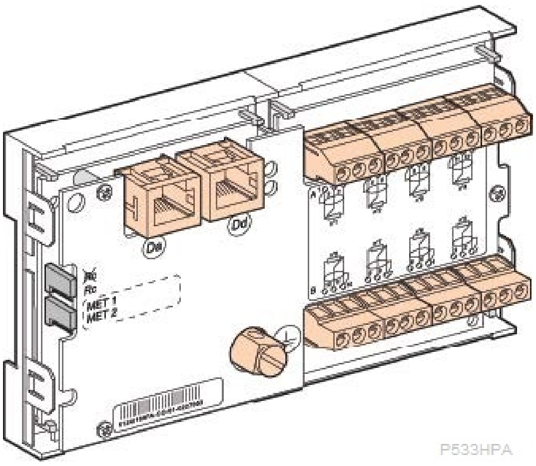
Verify that the temperature sensors are isolated from dangerous voltages.

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 124 - 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 can be connected to a PowerLogic P5 relay 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

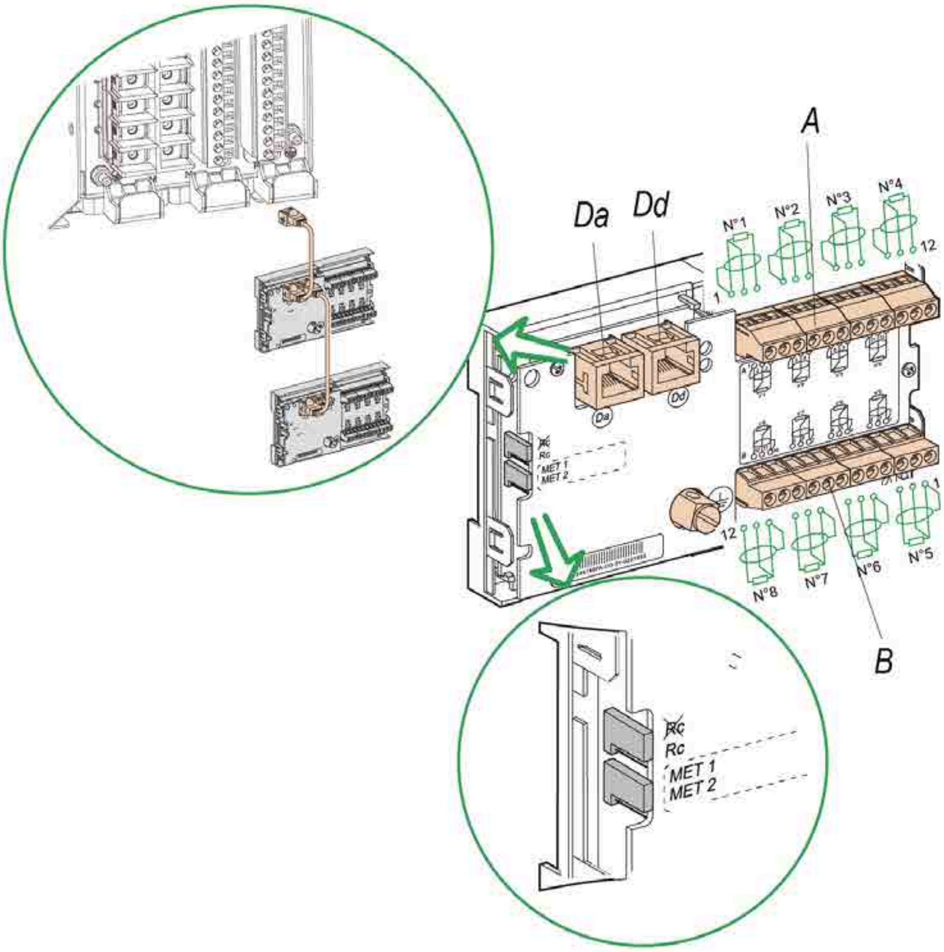
The temperature measurement (for example, in a transformer or motor winding) can be used by the following protection functions:

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

Connection

The MET148-2 temperature sensor module is connected to the extension port P of the PowerLogic P5 protection relay by using the EXT IN port and OUT port of IRIG-B. The cable used for connection must be shielded and of a length not exceeding 10 m (32.8 ft). More details

Figure 125 - 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:

-  - if the module is not the last interlinked module (default position).
-  - 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 26 - 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)[38]	
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)

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

IRIG-B module (reference REL51045)

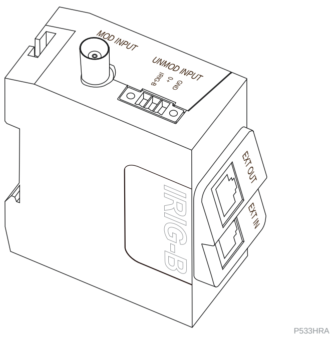
Description

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 automatically detects the type of input. No configuration of input type is needed in the PowerLogic P5 protection relay.

It requires no auxiliary supply.

Figure 126 - IRIG-B module



Characteristics

Table 27 - 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

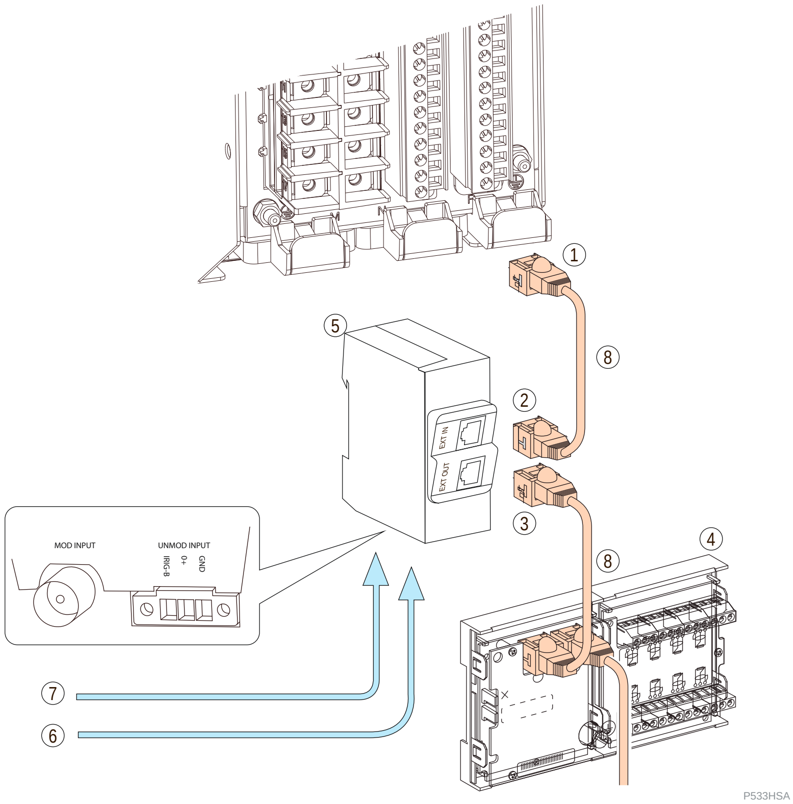
The IRIG-B module is connected to the PowerLogic P5 protection relay at its EXT IN port. The cable used for connection must be shielded and of a length not exceeding 10 m (32.8 ft).

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 127 - Connection of IRIG-B



①	to extension port P of relay	⑤	IRIG-B module
②	to EXT IN port of IRIG-B	⑥	Time source to unmodulated IRIG-B input
③	to EXT OUT port of IRIG-B	⑦	Time source to modulated IRIG-B input
④	MET148-2 module	⑧	CCA77x cord

DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

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

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

CT requirements

⚠ WARNING

UNINTENDED 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 are connected to standard 1 A or 5 A CTs.

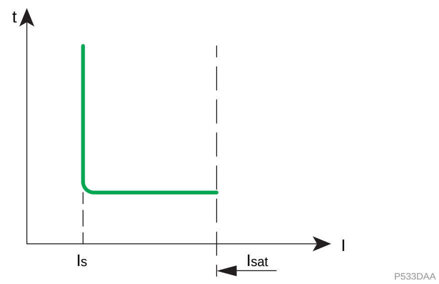
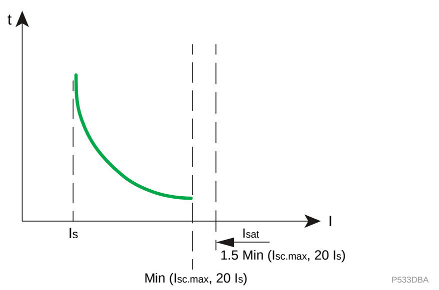
Sizing rules of phase and neutral CTs are specific for each function and depend on which of the following have to be considered:

- Phase overcurrent protection
- Neutral overcurrent protection
- Restricted earth fault protection
- Transformer differential protection
- Line 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 required CT saturation current level (I_{sat}) depends on the setting of the overcurrent protection pick-up level and operating curve settings:

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 applications:

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%
- Bias current 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. $E_{al} \geq 8 \times I_{sr} \times (R_{CT} + R_b)$,

  where:

  - I_{sr} = 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 $V_K \geq 0.85 \times \max(E_{al.int}, E_{al.ext})$.

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_{pr}: Rated primary current (in A)
- I_{sr}: 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 $R_{br} \times I_{sr}^2 = VA_{CT}$, the saturation current is equal to I_{sat} = ALF x I_{pr}.

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_{pr}, where:

$$\textit{Actual ALF} = \text{ALF} \times \frac{R_{CT} \times I_{sr}^2 + VA_{CT}}{(R_{CT} + R_b) \times I_{sr}^2}$$

P533DCA

Hence if the actual CT load is less than its rated burden ($R_b < R_{br}$), 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_{pr} = 2 kA, the load resistance R_b of the CT must be less than:

$$R_{b,max} = \frac{VA_{CT}}{I_{sr}^2} = \frac{2.5\ VA}{(5\ A)^2} = 0.1\ \Omega$$

P533PHA

This represents 12 m (39 ft) of wire with cross-section 2.5 mm² (AWG 13) for a resistance per unit length of 7 mΩ/m (2.1 mΩ/ft) approximately.

For an installation with 50 m (164 ft) of wiring with section 2.5 mm² (AWG 13), the actual resistance is R_b = 0.4 Ω, and hence actual ALF is:

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

P533DEA

Therefore, the saturation current for this CT installation is:
$I_{sat} = 8\ x\ I_{pr}$ = 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 0.019 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} = 20 mΩ) is often negligible compared to the wiring resistance.

Calculating the saturation current in class PX

A class P CT is characterised by:

- I_{pr}: Rated primary current (in A)
- I_{sr}: 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):

$$I_{sat} = \frac{Vk}{R_{CT} + R_b} \times \frac{I_{pr}}{I_{sr}}$$

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 rated secondary current of an inductive CT (ICT) 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 at much higher currents 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[39].

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

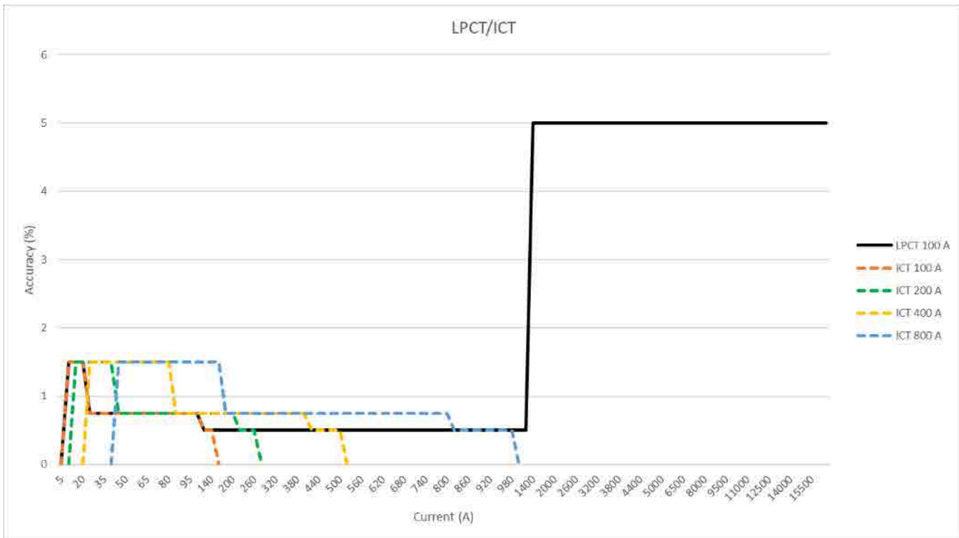
In this example, a multipurpose normalized LPCT with a rated primary current of 100 A and an extended primary current of 1000 A can be used in place of the 10 different ICTs with the following primary currents:
100, (125), 150, 200, (250), 300, (400), 500, (600), 750** (but not 1000**)

39. TPE is a LPIT class defined in 61869-6: Class TPE low-power current transformers are designed for relay protection applications.

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 128 - LPCT measurement accuracies for primary currents

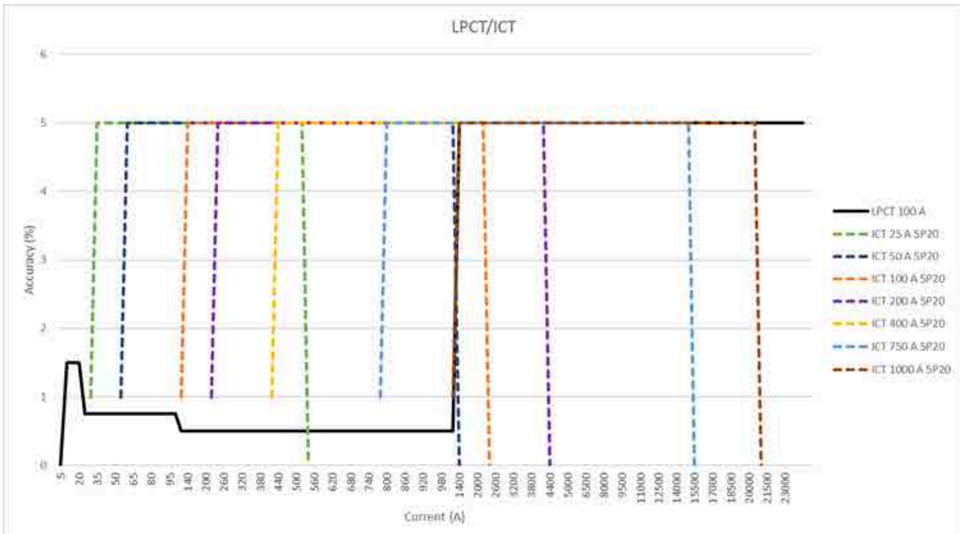


If we know that the initial nominal current to be measured is between 100 A and 750 A, we can take an LPCT of 100 A rated current and with 1000 A extended primary current which will still be flexible to last-minute changes or when load flow may increase subsequently.

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 129 - 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 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.

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. There is no need to wait to wait for CT sizing clarifications, because fewer designs cover the majority of requirements, providing many other benefits.

- Reduced number of order variants
- Simplified and improved quality of project documentation
- In-stock products with fast delivery
- Simplified installation

Compact switchgear with reduced footprint is more sustainable

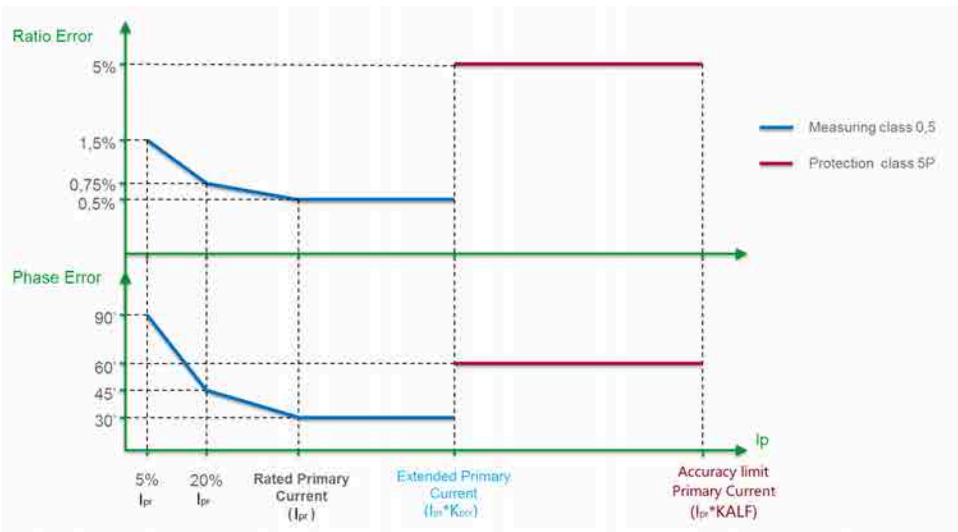
The size and weight of the LPCTs are reduced to less than 10% compared to ICTs. This allows future switchgear designs to be more compact, reducing materials used and the environmental impact. Switchgear handling, transport, installation and replacement are also much simplified.

LPCT characteristics

The multipurpose LPCT is designed to measure from 5% of I_{pr} to KALF x I_{pr} and is defined with a:

- Rated primary current (I_{pr}) (minimum current for measuring accuracy class)
- Rated extended primary current ($I_{e.pr}= I_{pr} \times K_{pcr}$) (maximum current for measuring accuracy class)
- Rated accuracy limit ($I_{sc.pr}= I_{pr} \times$ KALF) (maximum current for protection accuracy class)

Figure 130 - Magnitude and phase errors across the measurement range



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

Table 28 - Characteristics of the LPCT

Characteristics	I_{pr} (A)	$I_{e.pr}$ (A)	$I_{sc.pr}$ (A)
CLV1	100	1250	16000
TLPU1	100	630	25000
TLP130	100	1250	25000
TLP160 or 190	100	2500	40000

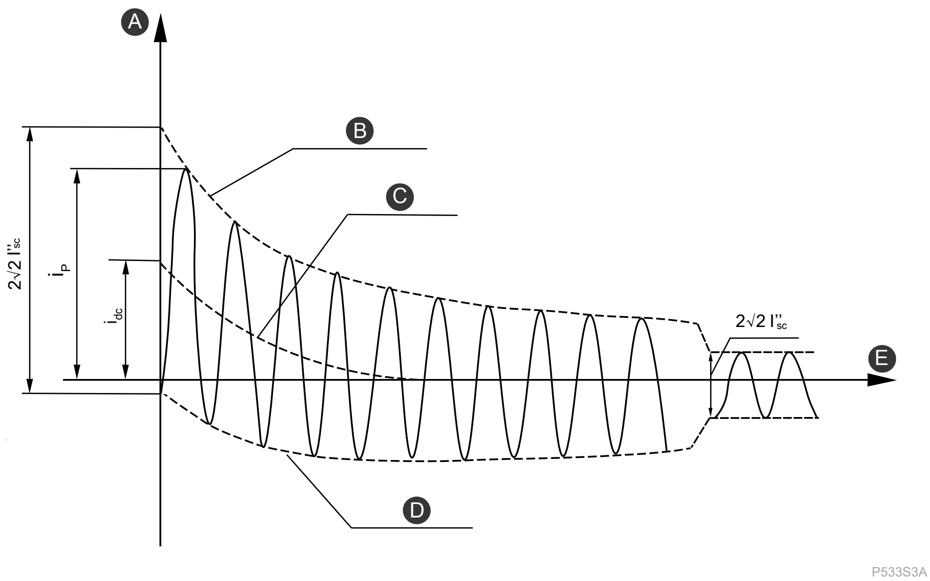
Table 28 - Characteristics of the LPCT (Continued)

Characteristics	I_{pr} (A)	$I_{e.pr}$ (A)	$I_{sc.pr}$ (A)
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 I_r. That means 25 I_r fully offset:

Figure 131 - Fault characteristic



A	Current	B	Top envelope
C	I_{dc}	D	Bottom envelope
E	Time		

NOTE:

- I''_{sc} = initial symmetrical short-circuit current
- i_P = peak short-circuit current
- I_{sc} = steady-state short-circuit current
- i_{dc} = dc component of short-circuit current
- A = initial value of the dc component i_{dc}
- $2\sqrt{2}\ I''_{sc}$ = the peak to peak value of the initial (sub-transient) short circuit current
- $2\sqrt{2}\ I_{sc}$ = 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:

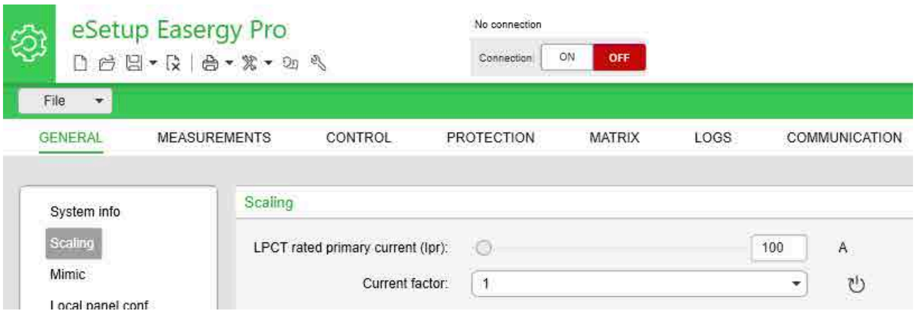
1. Select or check the LPCT suitability

   The maximum short circuit ($I_{sc.max}$) must be below the LPCT protection rated accuracy limit:

   - $I_{sc.max} < I_{sc.pr}$

2. In eSetup Easergy Pro (V3.0.0 or later), under **GENERAL/Scaling** menu, LPCT characteristics can be set.

Figure 132 - LPCT setting



The nominal current In is equal to (I_{pr} x Current factor)

a. For LPCT secondary nominal voltage V_{sec} = 22.5 mV

   i. Set the LPCT rated primary current I_{pr}, for example 100 A

   ii. Then set the "Current factor" to adjust the nominal current, for example, 2 for I_n = 200 A or 4 for I_n = 400 A

b. For other LPCT secondary nominal voltage V_{sec}

   i. For V_{sec}= 150 mV select first "Current factor"= 6.66 or for V_{sec}= 225 mV select first "Current factor"= 10

   ii. Then set the "LPCT rated primary current I_{pr}" = (I_{pr} [of LPCT] / Current factor)

   iii. Then finetune the "Current factor" to adjust the nominal current, for example, 5 instead of 6.66 for I_n = 75 A or 20 instead of 10 for 200 A

The nominal current I_n:

- must be below the LPCT rated accuracy limit divided by 25:
  $I_n < I_{sc.pr} / 25$
- should be below the LPCT rated extended primary current:
  $I_n < I_{e.pr}$ whenever possible
- must be above 20% of the LPCT rated primary current:
  $I_n > 0.2 * I_{pr}$
- should be as close as possible to the nominal load current. It does not need to be among the standardized values.

Three examples for a multipurpose LPCT with a 100 A rated primary current, a 1250 A extended primary current and an accuracy limit of 16 kA:

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

1. The maximum short circuit current must be below the LPCT rated accuracy limit:

   - $I_{sc.max} < I_{sc.pr}$:
     10 kA < 16 kA (= OK)

2. The maximum nominal current:
   - must be below the LPCT rated accuracy limit divided by 25:
     $I_n < I_{sc.pr}$ / 25 = 16 kA / 25 = 640 A (= OK)
   - should be below the LPCT rated extended primary current:
     $I_n < I_{e.pr}$ = 1250 A (= OK)
   - must be above 20% of the LPCT rated primary current:
     $I_n > 0.2 * I_{pr}$ = 0.2 * 100 A = 20 A (= OK)
   - should be as close as possible to the nominal load current. It does not need to be among the standardized values.

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

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

1. The maximum short circuit current must be below the LPCT rated accuracy limit:
   - $I_{sc.max} < I_{sc.pr}$ BUT actually 20 kA is bigger than 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 25 kA.
2. The maximum nominal current:
   - must be below the LPCT rated accuracy limit divided by 25:
     $I_n < I_{sc.pr}$ / 25 = 25 kA / 25 = 1000 A (= OK)
   - should be below the LPCT rated extended primary current:
     $I_n < I_{e.pr}$ = 1250 A (= OK)
   - must be above 20% of the LPCT rated primary current:
     $I_n > 0.2 * I_{pr}$ = 0.2 * 100 A = 20 A (= OK)
   - should be as close as possible to the nominal load current. It does not need to be among the standardized values.

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

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

1. The maximum short circuit current must be below the LPCT rated accuracy limit:
   - $I_{sc.max} < I_{sc.pr}$ BUT actually 50 kA is bigger than 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 50 kA.
2. The maximum nominal current:
   - must be below the LPCT rated accuracy limit divided by 25:
     $I_n < I_{sc.pr}$ / 25 = 50 kA / 25 = 2000 A (= OK)
   - should be below the LPCT rated extended primary current:
     $I_n < I_{e.pr}$ = 1250 A (= OK)
   - must be above 20% of the LPCT rated primary current:
     $I_n > 0.2 * I_{pr}$ = 0.2 * 100 A = 20 A (= OK)
   - should be as close as possible to the nominal load current. It does not need to be among the standardized values.

   So, 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 (V3.0.0 or later).

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

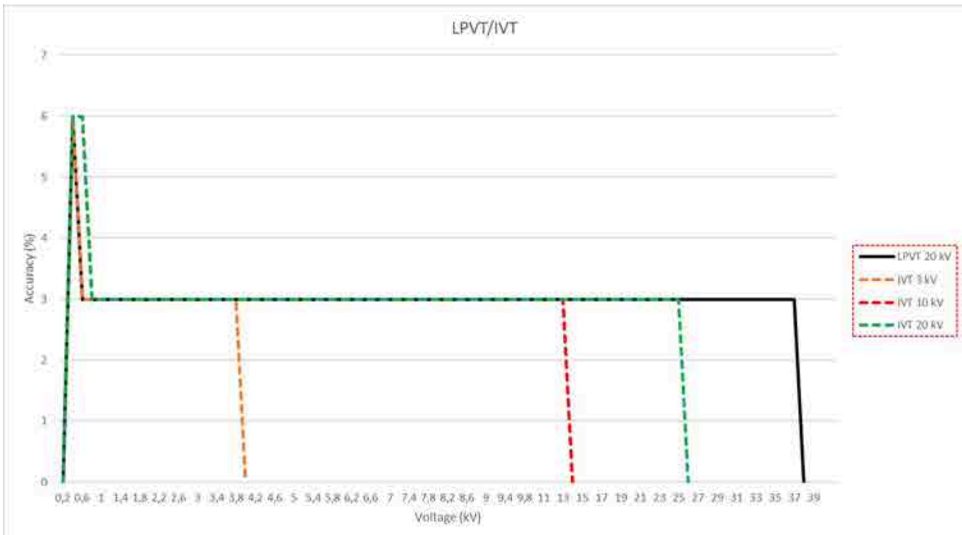
With LPVT technology, there is no risk in the event of touching the secondary circuit as the output is low voltage.

- 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 impact of a 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. Redundant to 3rd bullet point just few lines above.

Figure 133 - 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 V_{pr} (min) to 1.9 x V_{pr} (Max) and is typically defined with a:

- Rated primary voltage V_{pr}
- Range of rated primary voltage ($V_{pr.min}$, $V_{pr.max}$) (minimum and maximum voltage for measuring and protecting accuracy classes)
- Rated secondary voltage V_{sr}

Figure 134 - Magnitude accuracy

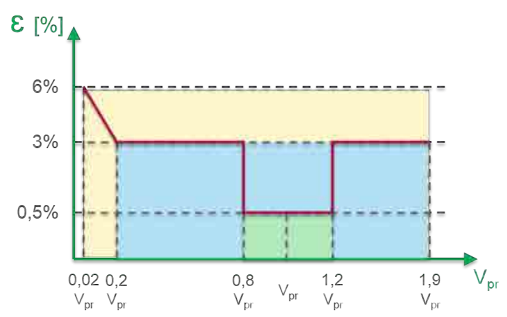
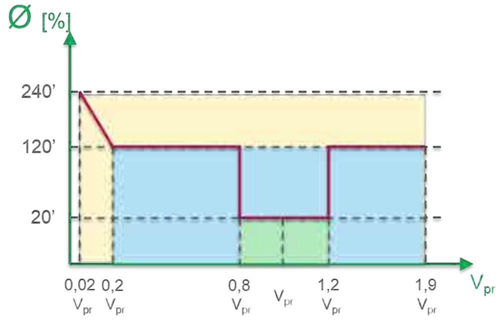


Figure 135 - Phase accuracy



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

Table 29 - Characteristics of the LPVT

Characteristics	V_{pr} (kV)	$V_{pr.min}$ (kV)	$V_{pr.max}$ (kV)	$V_{pr.max}/V_{pr}$
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 121 section for supplementary information on this topic.

Figure 136 - LPVT hub connector

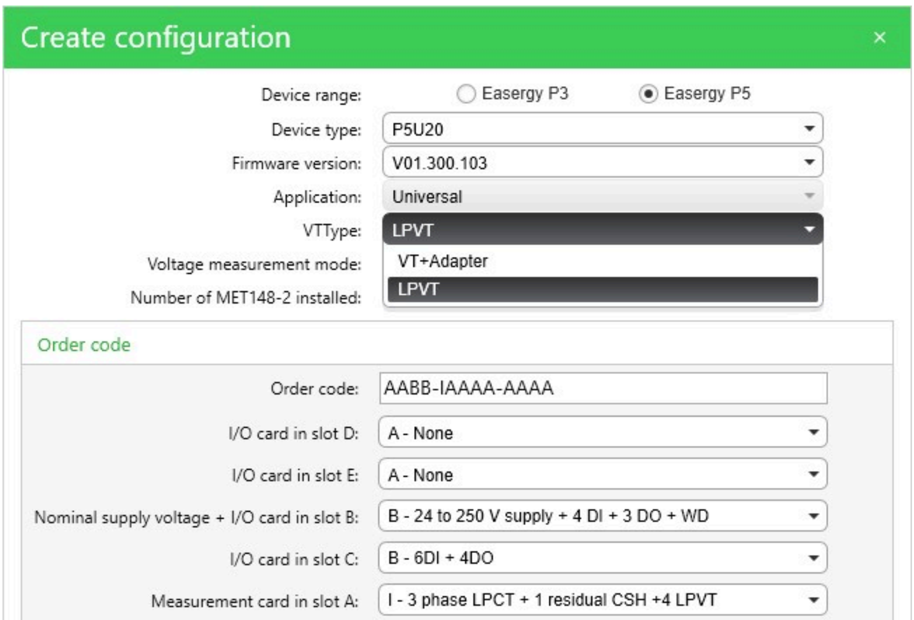
LPVT input characteristics

The PowerLogic P5 LPVT input measuring range is bigger than 1.5 x 1.9 x V_{sr} (with 1.5 as biggest ratio between $V_{pr.max}$ and V_{pr}).

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 (V3.0.0 or later), at the creation of the configuration file once the **Measurement card in slot A** has been set to the LPIT option.

Figure 137 - Selection of the LPIT option

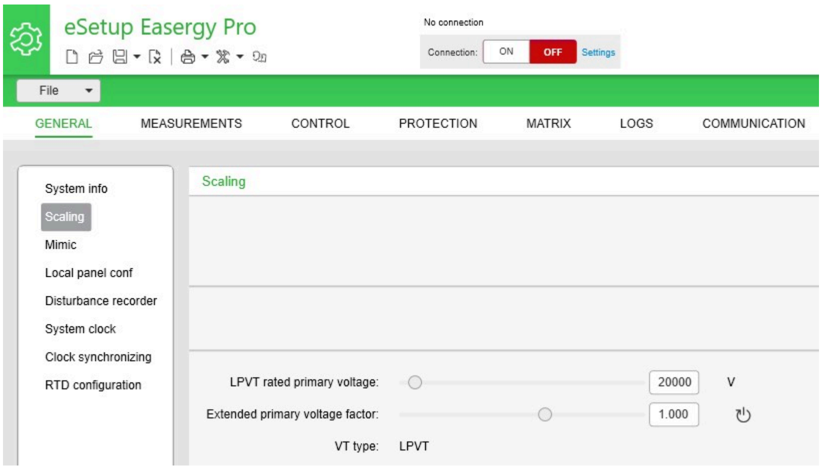


LPVT configuration procedure

Two main simple rules are required to follow:

1. Select or check the LPVT suitability
   The nominal voltage (V_n) must be within the LPVT range of rated primary voltage: $V_{pr.min} < V_n < V_{pr.max}$
2. In eSetup Easergy Pro (V3.0.0 or later), under **GENERAL**/**Scaling** menu, LPVTs are configured to be connected to devices with different measuring input burden.

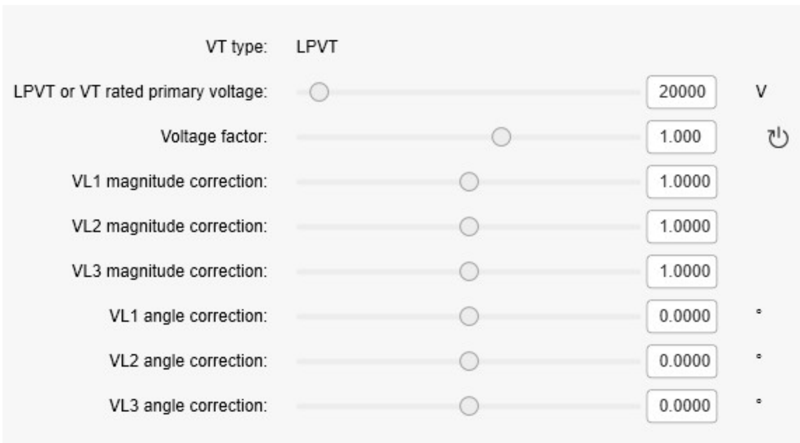
Figure 138 - LPVT settings



a. For both 2 MΩ (IEC 61869-11) and 10 MΩ LPVT output burden
   - Set the LPVT Rated primary Voltage (V_{pr}) in "LPVT rated primary voltage"
   - Set the nominal voltage (V_n) in "Extended primary voltage factor" by adjusting the coefficient to the primary rating (for example, if V_n is 10kV and (V_{pr} is 20 kV then set 0.5)

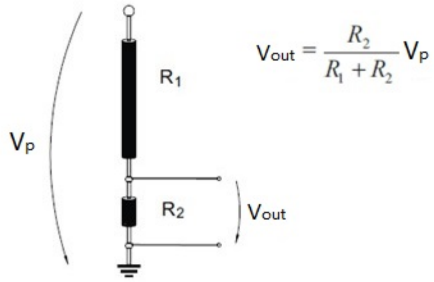
b. Only for 2 MΩ (IEC 61869-11) LPVT output burden, the following additional correction settings are relevant:

Figure 139 - 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 140 - 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 (V3.0.0 or later).

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 123 section for supplementary information on this topic.

Figure 141 - EMS59572 adapter

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

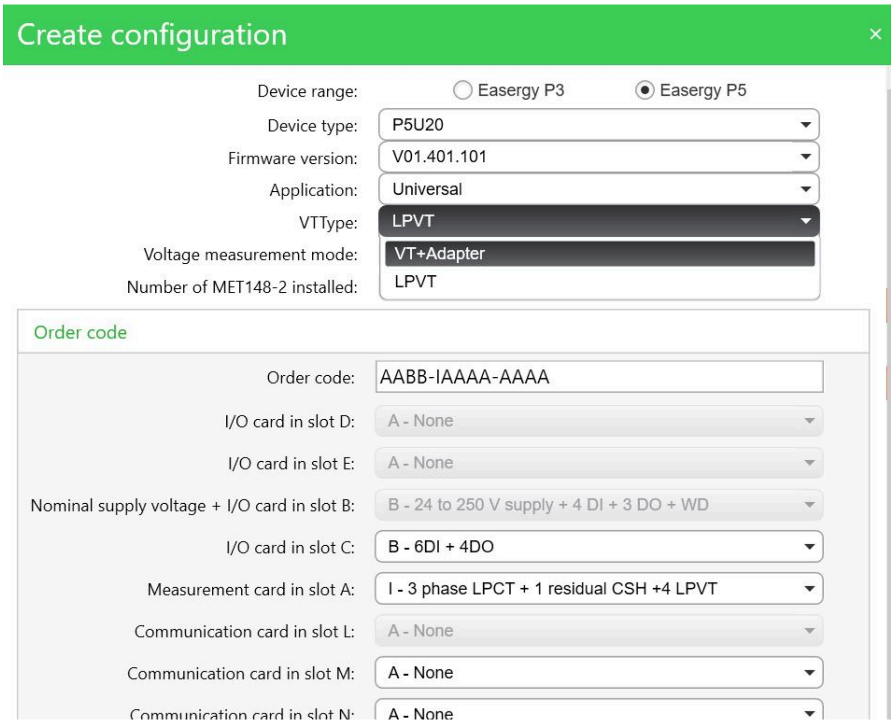
LPVT input characteristics

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

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

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

Figure 142 - Selection of the VT+Adapter option

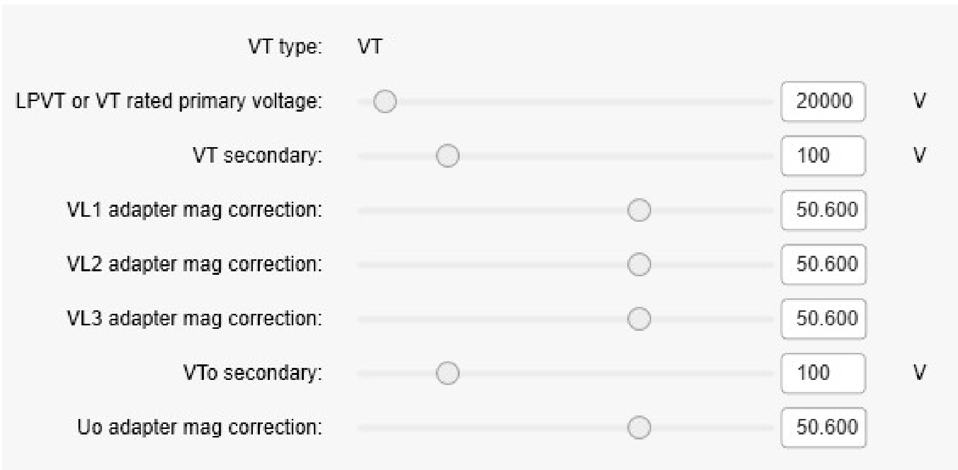


EMS59572 VT adapter configuration

One simple rule is required to follow.

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

Figure 143 - 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 **Vlx 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)

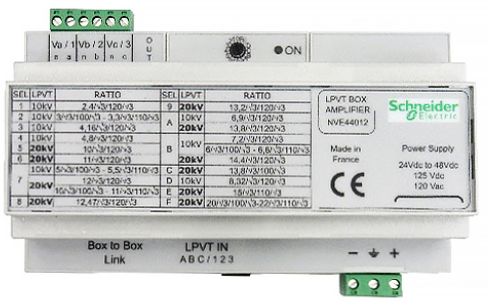
The LPVT Transducer allows an accurate transmission of the low voltage output signal from LPVT sensors (3.25/√3 V) across up to 10 PowerLogic P5 protection relays equipped with LPVT measuring inputs. The low voltage input is provided through a single RJ45 connector that brings the 3 phase LPVT signals 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 30 - Characteristics of LPVT transducer

Characteristics	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)

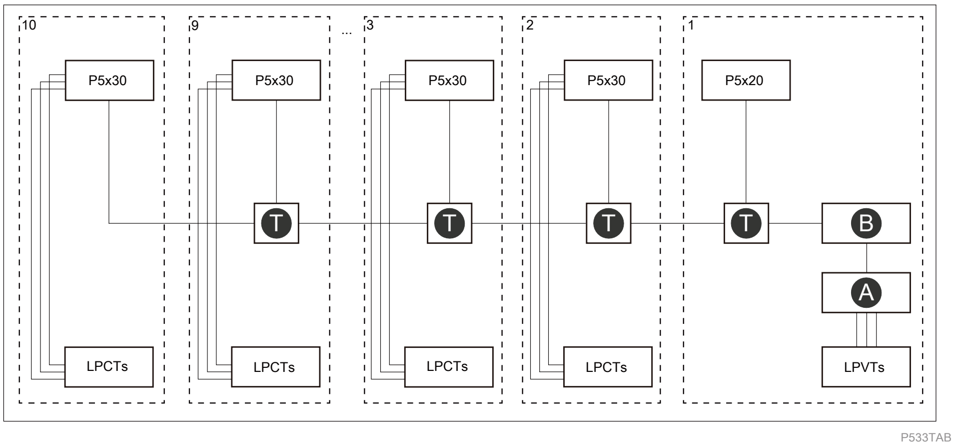
Figure 144 - LPVT transducer



Voltage sharing applications

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

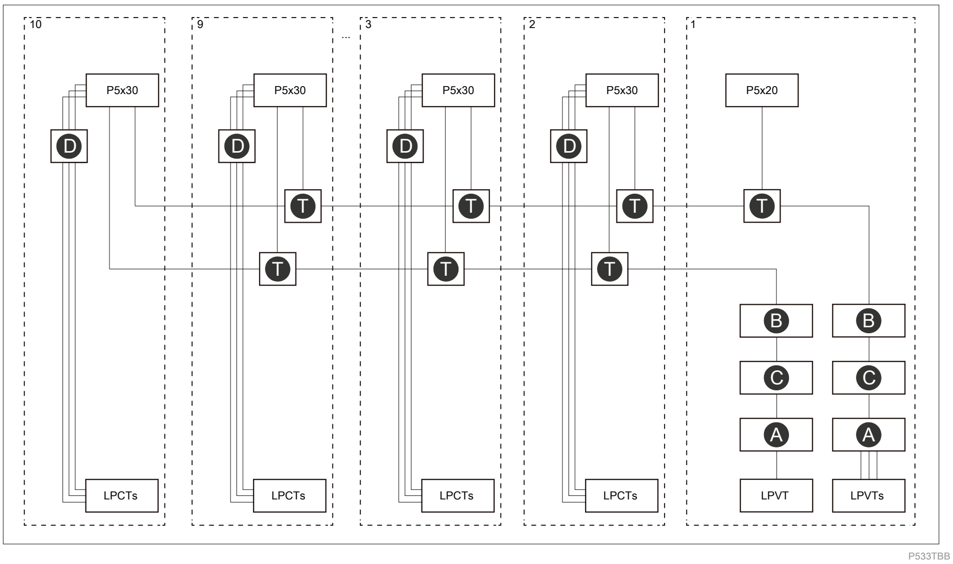
Figure 145 - LPVT sharing application without test sockets/plugs



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 146 - 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.
- 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

UNINTENDED 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 272).

- 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 158.

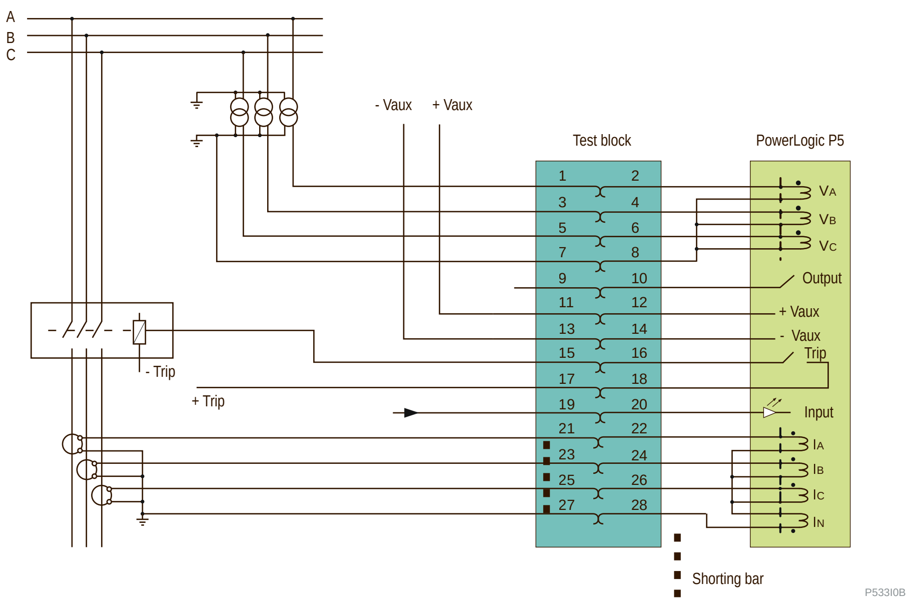
DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Never open-circuit the secondary circuit of a current transformer.
- 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 147 - 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 93).

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 19.2 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 seconds before the power supply module is removed.

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 63 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 63. 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 six 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
- Digital CB

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

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

- IEC 61850
- DNP3
- Modbus
- EtherNet/IP

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 272 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.

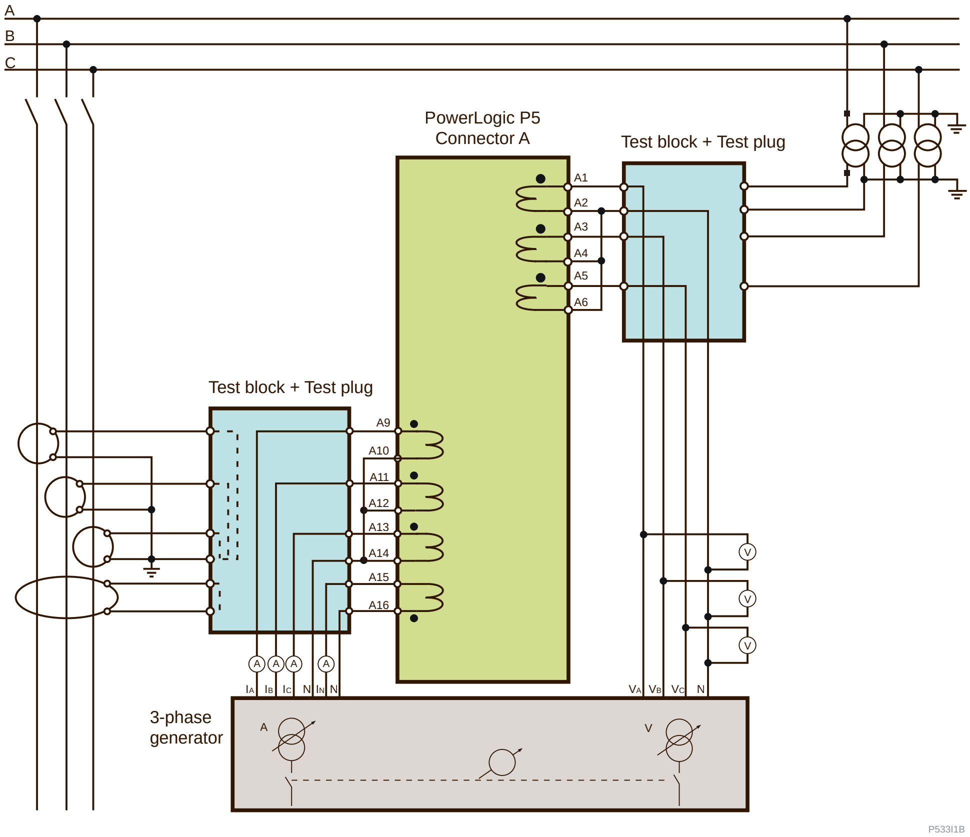
NOTE: Do not try to manually change the mode while using the injector.

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 165.

Figure 148 - 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 through 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 circuit breaker 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								■	■	■
P5L30	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	VCB	-	VN

Mode	U1	U2	U3	U4
2VPP + VN + VPPy	VAB	VCB	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%.

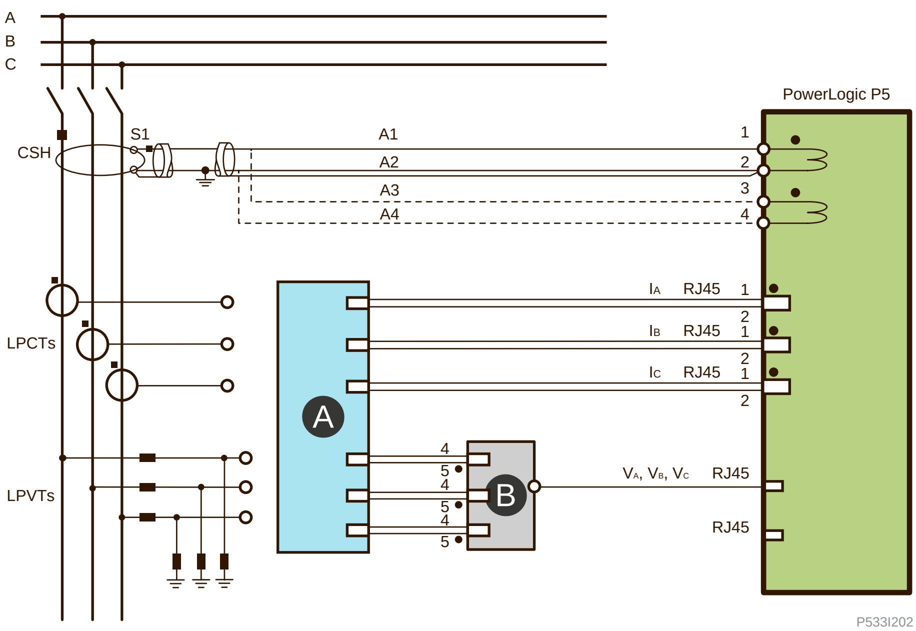
LPCT and LPVT inputs

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 167 shows the connection diagram that includes the PowerLogic P5 protection relay and a low frequency generator as described in Testing tools and equipment, page 157.

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 149 - 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 157.
- 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 157.
- 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 158, Current inputs, page 166, LPCT and LPVT inputs, page 167, and Voltage inputs, page 166 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

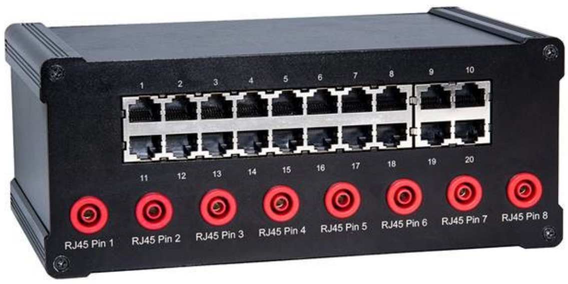
The secondary injection tests can be carried out with the LPIT test box. This test box is an adapter for secondary testing of PowerLogic P5 protection relays with LPCT/LPVT measuring inputs. It is an interface between the OMICRON[40] testing kit's low-power outputs and PowerLogic P5 inputs. Thanks to 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%[41] from 0.71 V to 7.10 V (phase to neutral).

Figure 150 - LPIT test box



For the model number of the LPIT test box, refer to Order codes of LPIT test box and test sockets/plugs, page 176 section for details.

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

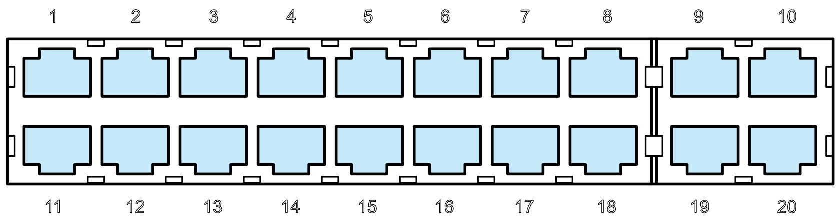
40. Omicron is a trademark of OMICRON Electronics GmbH, Oberes Ried 1, 6833 Klaus, Austria
41. Typical value at 25 °C and variable in range of ultimate operation temperature 0 °C to 50 °C.

Figure 151 - 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 152 - The front panel of LPIT test box

Table 31 - 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 175 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:

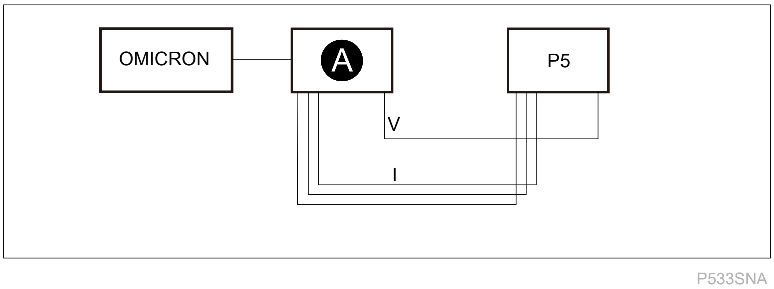
- 2 V OMICRON outputs 1 to 3 to 22.5 mV scaling for outputs 11 to 13 (single phase) and 14 (three phase) LPCT
- OMICRON outputs 4 to 6 with no scaling for outputs 15 to 17 (single phase) and 18 (three phase) LPCT and 19 (three phase) LPVT

LPCT/LPVT testing diagram

There are two cases for LPCT/LPVT testing:

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

Figure 153 - LPCT/LPVT direct testing without test sockets/plugs



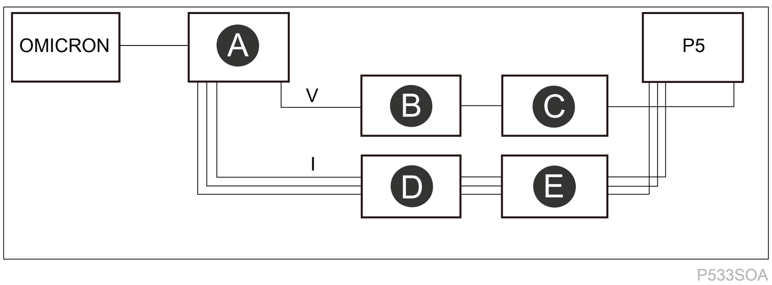
A	LPIT test box	REL51037

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 176 section for details.

.

Figure 154 - LPCT/LPVT testing with test sockets/plugs



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 176 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 32 - 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 emission and radio frequency interferences 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 155 - 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 Model numbers of test sockets/plugs, page 177 for ordering information of test sockets/plugs.

Model numbers for LPCT/LPVT accessories

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

Table 33 - Model numbers 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 34 - Model numbers of test sockets/plugs

Order code	Description
REL51089	LPCT test socket with cover
REL51090	LPCT test plug
REL51092	LPVT test socket with cover
REL51093	LPVT test plug

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 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 the 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. Circuit breaker operation can be controlled by the local or remote-control commands.

Circuit breaker Operation Test:

- Check the actual circuit breaker position and read the circuit breaker position status from the protection relay HMI if the related circuit breaker position (52a, 52b) has been connected to the protection relay opto-isolated inputs.
- Perform a local circuit breaker control command to trip and close the circuit breaker, the circuit breaker shall operate correctly per the control command.
- Read the circuit breaker position status from protection relay HMI after one control command, the circuit breaker position information shall be the same as the actual circuit breaker 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.

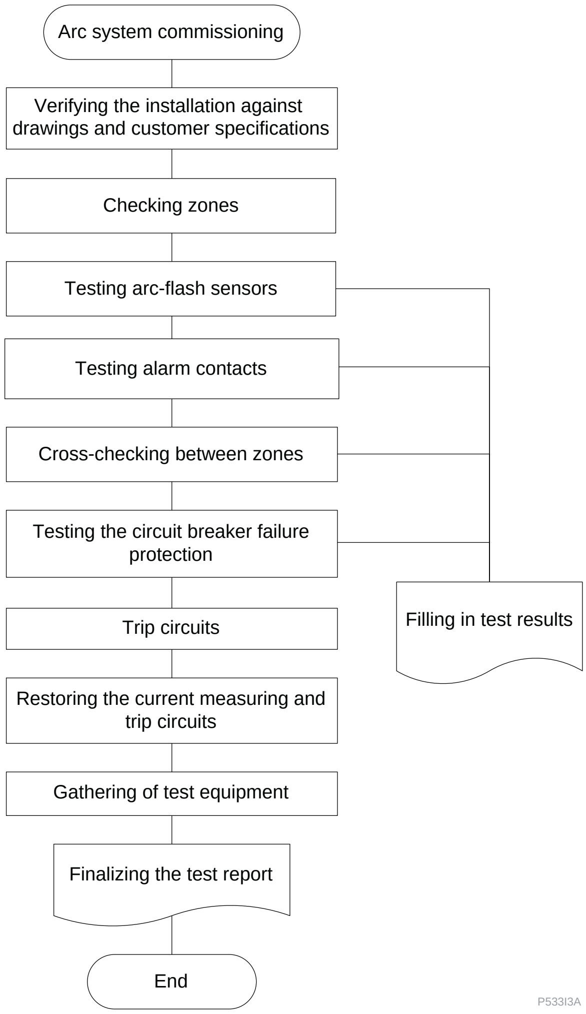
Before setting up the arc flash system:

- 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 156 - 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.

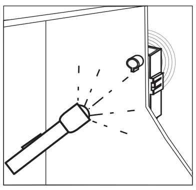
Testing the standard or pipe type sensors

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 157 - 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 158 - 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:		Model number:		
	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 ☐ IN>int	☐		
	2	☐ Light ☐ I>int ☐ IN>int	☐		
	3	☐ Light ☐ I>int ☐ IN>int	☐		
	4	☐ Light ☐ I>int ☐ IN>int	☐		
	5	☐ Light ☐ I>int ☐ IN>int	☐		
	6	☐ Light ☐ I>int ☐ IN>int	☐		
	7	☐ Light ☐ I>int ☐ IN>int	☐		
	8	☐ Light ☐ I>int ☐ IN>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

InterRelay Functional test

The InterRelay 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.

NOTE: Functional test can only be executed when device is in test mode.

There are 2 test types for selection.

Loopback

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 duration 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.

Line differential protection functional test

Different test conditions can be addressed as follows.

Stand-alone relay test

A PowerLogic P5L30 device without communication link to remote end device can be tested by looping the fibre optic send output back to the receive input using a short fibre optic wire and setting the communication address to *00*. With this configuration, the P5L30 line differential protection function is in ready state and accepts message frames from itself. The line differential function can now be tested by activating local test mode.

Inter-connected relay test

In this case, local end relay and remote end relays are connected through communication link and have matching addresses at local & remote relay (1A&1B or 2A&2B and so on.). Without changing this configuration, the line differential function of each P5L30 can now be individually tested by activating its "local test mode" function.

Local test mode

For easy testing of the line differential characteristic a “local test” feature (often so-called “Loopback test”) is provided, which can be enabled in **DEVICE/TEST** menu.

NOTE: Local test mode can only be enabled when the device is already in test mode!

In local test mode,

- The “LocTest” output at the tested P5L30 is set to TRUE (active) for indication.
- This “LocTest” signal is transmitted to the remote P5L30, which then indicates it as “RemTest active” and gets blocked (to prevent false operation).
- The line differential protection function automatically activates high stability operating mode, so that the maximum measured bias current is applied to all 3 phase elements. Upon exiting this local test mode, the user set operating mode gets active again.
- Differential and bias current calculation will not consider the current from remote P5L30. Currents received from remote P5L30 are processed with values “zero”, regardless the data received through communication link. This implies that also their values in **MEASUREMENTS** menu are displayed as *zero*.
- Direct and permissive intertrip signals are blocked:
  - no signal will be sent,
  - received intertrip signals will be forced to inactive/low state.

Loopback test procedure

The following description of the procedure to verify the parameters of the tripping characteristic is illustrated in Illustration of the local test procedure, page 189.

NOTE: PowerLogic P5L30 line differential protection in local test mode processes received data with value zero, so the measured differential current will be equal to the injected current and the bias currents will be half of this value (Id = Itest, Ib = Itest/2).

1. Test of low set pick up value

   Infeed single phase current, starting from zero, until this phase element trips.

2. Test of characteristic within Slope 1

   Feed a certain current in one phase, for example: I_{A1} with a magnitude within [$I_{d.LS}$ and 2 * $I_{b.S2}$].

   This results in measured value $(I_d, I_b)_{A1} = (I_{A1}, ½ I_{A1})$, which is in the tripping area.

   Hence “L-diff trip A” signal gets active (logged in event list, but could also be configured to LED or digital output for monitoring purpose).

   Then, starting from zero, the current in another phase (for example phase B = I_B) is increased, until also “L-diff trip B” signal gets active. This shall happen at a current:

   $I_{B1} = [I_{d.LS} + ½ * s1 * (I_{A1} – I_{d.LS})]$ +/- 5%

3. Test of characteristic within Slope 2

   This is same procedure as for test within Slope 1, just at higher currents.

   For example: I_{A2} with a magnitude within higher than 2 * Ib_{S2}.

   Increase I_B from zero until “L-diff trip B” signal gets active.

   This shall happen at a current:

   $I_{B2} = [I_{d.LS} + s1 * (I_{b.s2} – ½ * I_{d.LS}) + s2 * (½ * I_{A2} – I_{b.s2})]$ +/- 5%

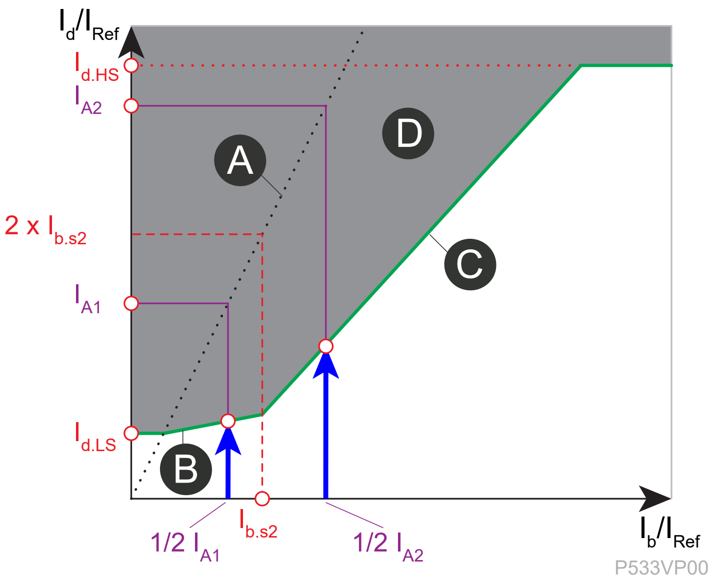
4. Test of unbiased high set pick up value

   This is theoretically same procedure as before, but with even higher currents. Respect thermal limits of CT inputs!

List of abbreviations:

- $I_{d.LS}$: Low set I_d
- $I_{b.S2}$: I_b for start of Slope 2
- s1: Slope 1
- s2: Slope 2

Figure 159 - Illustration of the local test procedure



A	Characteristic for single side fed fault = 200% slope	B	Slope 1
C	Slope 2	D	Trip

Final check

NOTICE

CIRCUIT OVERLOAD

- Remove all test or temporary shorting leads.
- If any external wiring was disconnected 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.
- Circuit breaker 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 194 for details.
- Review assumptions about protected environments. See Protected environment assumptions, page 195 for details.
- Address potential risks and mitigation strategies. See Potential risks and compensating controls, page 196 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

LOSS OF ACCESS

- 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 202).
- 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 55 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.
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 195.

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 [42] 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)[43]	-	■
Change/add/remove user account	-	■
Change password of user account	■[44]	■[42]
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**	_

42. In Advanced Cybersecurity level, changing password of user account can only be done on device HMI.
43. CAE is a free engineering tool software which is used to manage cybersecurity rules for PowerLogic P5.
44. In Basic Cybersecurity level, changing password of user account can only be done on device HMI.

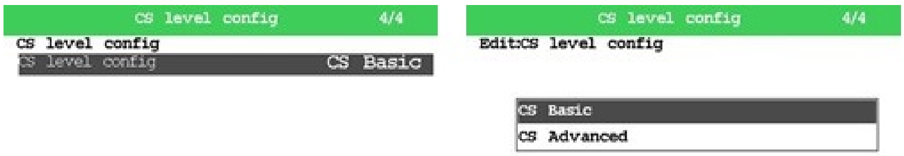
Second last character of reference number	Security features		
	V01.30x.yyy and previous	V01.40x.yyy	V01.50x.yyy and next
A	CS Basic	CS Basic	N/A
B	CS Advanced	CS Advanced	
C	N/A	CS Basic + Advanced logic	
D		CS Advanced + Advanced logic	
E		N/A	Settable CS
F			Settable CS + Advanced logic

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:

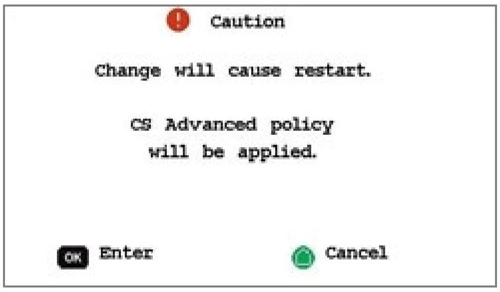
1. With the local panel, enter the **Home menu**/**General** sub-menu/ **Cybersecurity**/**CS level config**, you can upgrade the level from *CS Basic* to *CS Advanced*.



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 200.

This feature is applicable for both Basic and Advanced CS levels.

The Auto-login feature will be disabled:

- For Basic CS level: when the passwords for all three levels are changed from the default ones. More details about the default passwords for all the levels, refer to Default settings, page 209.
- 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 35 - 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 36 - 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				■		