Frequency

PowerLogic P5 protection relay determines the frequency based on the samples of an available voltage or current signal. The frequency determination will be automatically adapted to the availability and quality of the related signal inputs:

- Based on positive sequence voltage V1 or
- Based on any single phase to phase voltage or phase to neutral voltage or
- Based on currents when the voltage is not measured or below 15%Vnom.

The frequency is not measured if:

- The maximum of three phase to phase or phase to neutral voltages or positive sequence voltage V1 is less than 15% Vnom
- The maximum of three currents or positive sequence current (I1) is less than 10%Inom.

The following table provides an overview of the characteristics for frequency measurement:

Table 126 - Characteristics for frequency measurement

Characteristics	Range
Measurement range	10...72 Hz
Units	Hz
Resolution	0.001 Hz
Accuracy	± 0.01 Hz

Voltages

The PowerLogic P5 measures the fundamental and RMS values of phase to phase voltages and phase to neutral voltages.

Table 127 - Measurements of phase to phase and phase to neutral voltages

Value	Description
VA	Fundamental value of the phase to neutral voltage on phase A
VB	Fundamental value of the phase to neutral voltage on phase B
VC	Fundamental value of the phase to neutral voltage on phase C
VAB	Fundamental value of the phase to phase voltage between phase A and phase B
VBC	Fundamental value of the phase to phase voltage between phase B and phase C
VCA	Fundamental value of the phase to phase voltage between phase C and phase A
VA_{rms}	RMS value of the phase to neutral voltage on phase A
VB_{rms}	RMS value of the phase to neutral voltage on phase B
VC_{rms}	RMS value of the phase to neutral voltage on phase C
VAB_{rms}	RMS value of the phase to phase voltage between phase A and phase B
VBC_{rms}	RMS value of the phase to phase voltage between phase B and phase C
VCA_{rms}	RMS value of the phase to phase voltage between phase C and phase A

These voltages are measured with the three analogue voltage inputs VA, VB and VC.

A 4th analogue voltage input V_4 is used to measure an additional phase to phase voltage or phase to neutral voltage, which is usually used as a reference voltage for the synchronisation checking function.

V_y : fundamental value of the additional phase to phase voltage

V_{yrms} : RMS value of the additional phase to phase voltage calculated as follows:

$$V_{RMS} = \sqrt{V_{f1}^2 + V_{f2}^2 + \ldots + V_{f15}^2}$$

P533Z2A

For phase to phase (2VPP) connections, which can be applied for cost reasons in isolated or compensated power systems, the three phase to phase voltages are directly measured and the phase to neutral voltages are calculated taking into account the neutral voltage measurement (VN) when it is measured. Otherwise, the calculation considers a balanced power system.

For phase to neutral (3VP) connections, the three phase to neutral voltages are directly measured and the three phase to phase voltages are calculated.

Table 128 - The voltage modes and the corresponding measurements and calculated values

Voltage mode	Sensors	Voltages measured	Voltages calculated	Additional voltages
3VP	VT, LPVT	VA, VB, VC	VAB, VBC, VCA	
3VP+VN	VT	VA, VB, VC	VAB, VBC, VCA	
3VP/VPy	VT, LPVT	VA, VB, VC, VA_y[134]	VAB, VBC, VCA, VAB_y	VA'
3VP/VPPy	VT, LPVT	VA, VB, VC, VAB_y[134]	VAB, VBC, VCA	VAB'
2VPP+VN	VT	VAB, VBC	VCA, VA, VB, VC	

134. Used for synchro-check function.

Table 128 - The voltage modes and the corresponding measurements and calculated values (Continued)

Voltage mode	Sensors	Voltages measured	Voltages calculated	Additional voltages
2VPP+VN+VPPy	VT	VAB, VBC, VAB_y[135]	VA, VB, VC	VAB'
VPP/VPPy	VT	VAB, VAB_y[135]	VA, VB, VC, VBC, VCA[136]	VAB'

Depending on the phase rotation, the phase to phase values are defined according to A-B-C network: phase to neutral and phase to phase voltages, page 503 and A-C-B network: phase to neutral and phase to phase voltages, page 503:

- For voltage between phases A and B:

$$\vec{V}_{AB} = \vec{V}_A - \vec{V}_B$$

P533Z3A

- For voltage between phases B and C:

$$\vec{V}_{BC} = \vec{V}_B - \vec{V}_C$$

P533Z4A

- For voltage between phases C and A:

$$\vec{V}_{CA} = \vec{V}_C - \vec{V}_A$$

P533Z5A

Figure 318 - A-B-C network: phase to neutral and phase to phase voltages

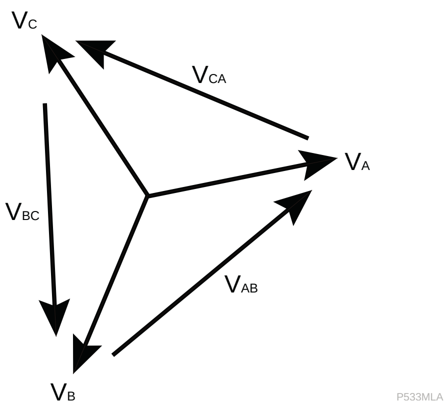


Figure 319 - A-C-B network: phase to neutral and phase to phase voltages

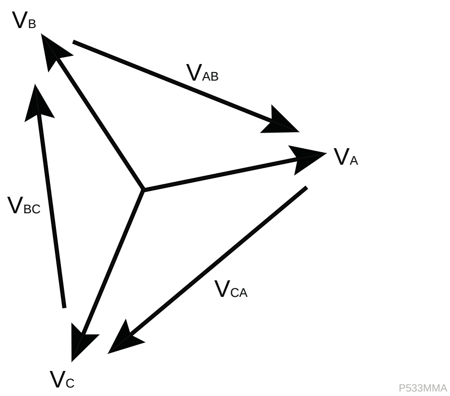


Table 129 - Characteristics for measuring voltage

Characteristics	Measurement range	Unit	Resolution	Accuracy
Magnitude	0.01...1.50 Vnom[137] 0...240 V secondary	V	1 V	±5% for range 1%...10% Vnom[137] ±2% for range 10%...20% Vnom[137] ±1% for range 20%...50% Vnom[137] ±0.5% at 50% Vnom[137] and above
Phase angle	-180°...+180°		0.1°	0.5° with V > 0.1 Vnom[137] and I > 0.1 Inom

135. Used for synchro-check function.
136. Considering a balanced power system.
137. VT Primary nominal

Neutral voltage

The PowerLogic P5 protection relay measures the fundamental value of a neutral voltage VN by an open star/delta voltage transformer. If such a VT is not available, the protection relay is able to calculate VN by taking the internal sum of the three phase to neutral voltages:

$$\vec{V}_N = \vec{V}_A + \vec{V}_B + \vec{V}_C$$

If the calculation method is used, the measurement can only be considered as valid if the power system is balanced.

The following table provides an overview of the measuring options:

Table 130 - Neutral voltage measuring options

Voltage mode	Sensors	Measured/Calculated
3VP	VT, LPVT	VN.calc calculated[138]
3VP+VN	VT	VN.meas measured
3VP/VPPy	VT, LPVT	VN.calc calculated[138]
3VP/VPy	VT, LPVT	VN.calc calculated
2VPP+VN	VT	VN.meas measured
2VPP+VN+VPPy	VT	VN.meas measured
VPP/VPPy	VT	VN not available

The following table lists the characteristics for measuring neutral voltage:

Table 131 - Characteristics for measuring neutral voltage

Measurement range	Unit	Resolution	Accuracy
1...240 V secondary	V	1 V	±5% for range 1...10 V secondary ±2% for range 10...20 V secondary ±1% for range 20...50 V secondary ±0.5% for at 50 V secondary and above

Positive and negative sequence voltages

The positive and negative sequence voltages are calculated as the vector sum of the 3 phase voltages, subject to phase rotating constant.

For standard phase rotation (A – B – C) they are:

$$\vec{V}_1 = \frac{1}{3}(\vec{V}_A + a\vec{V}_B + a^2\vec{V}_C)$$

P533VQA

$$\vec{V}_2 = \frac{1}{3}(\vec{V}_A + a^2\vec{V}_B + a\vec{V}_C)$$

P533VRA

with phasor rotating constant:

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

P533BEB

138. Considering a balanced power system

Table 132 - Characteristics for measuring positive and negative sequence voltages

Signal	Measurement range	Unit	Resolution	Accuracy
V1	0.01...1.50 Vnom	V	1 V	±15% for range 1%...10% Vnom[139] ±6% for range 10%...20% Vnom[139] ±3% for range 20%...50% Vnom[139] ±1.5% at 50% Vnom[139] and above
V2	0.01...1.50 Vnom	V	1 V	±15% for range 1%...10% Vnom[139] ±6% for range 10%...20% Vnom[139] ±3% for range 20%...50% Vnom[139] ±1.5% at 50% Vnom[139] and above

Power and power factor

Active, reactive, apparent power

The PowerLogic P5 protection relay calculates the active, reactive and apparent power values of the power system based on the fundamental or RMS values of the primary three phase currents and voltages.

All power values are determined separately for each phase based on the fundamental or RMS values of related phase current and voltage signal depending on the availability.

Three phase power values can be calculated using phase to neutral voltages and phase currents as follows :

- Active power = 3·V·I·cosφ
- Reactive power = 3·V·I·sinφ
- Apparent power = 3·V·I

According to the transformers used, power calculations are based on the 2 or 3 wattmeter method.

The 2 wattmeter method is only accurate when there is no neutral current (i.e. balanced power system is), but it is not applicable if the neutral is distributed.

The 3 wattmeter method gives an accurate calculation of 3-phase as well as per phase powers in all cases, regardless of whether or not the neutral is distributed.

Table 133 - Power calculation

Voltage measurement mode	Voltage transformer	Voltages used	Currents used (acc. to connected phase CTs)	P, Q, S calculation method	Power per phase (Px, Qx, Sx with x = A,B, C)
3VP 3VP/ VPy 3VP/VPPy 3VP+VN	VT, LPVT	VA, VB, VC	IA, IB, IC	3 wattmeter	Available
			IA, IC	2 wattmeter	Not available
2VPP+ VN 2VPP+ VN + VPPy	VT	VAB,VCB,VN	IA, IB, IC	3 wattmeter	Available
			IA, IC	2 wattmeter	Not available
VPP/VPPy	VT	VAB	IA, IB, IC	3 wattmeter	Available
			IA, IC	2 wattmeter	Not available

139. VT Primary nominal

Power calculation

The power values are calculated in detail as follows:

- By 3 wattmeter method:

$$P = \vec{V_A} \cdot \vec{I_A} \cdot \cos(\vec{V_A} \cdot \vec{I_A}) + \vec{V_B} \cdot \vec{I_B} \cdot \cos(\vec{V_B} \cdot \vec{I_B}) + \vec{V_C} \cdot \vec{I_C} \cdot \cos(\vec{V_C} \cdot \vec{I_C})$$

P533Z6B

$$Q = \vec{V_A} \cdot \vec{I_A} \cdot \sin(\vec{V_A} \cdot \vec{I_A}) + \vec{V_B} \cdot \vec{I_B} \cdot \sin(\vec{V_B} \cdot \vec{I_B}) + \vec{V_C} \cdot \vec{I_C} \cdot \sin(\vec{V_C} \cdot \vec{I_C})$$

P533Z7B

- By 2 wattmeter method:

$$P = \vec{V_{AB}} \cdot \vec{I_A} \cdot \cos(\vec{V_{AB}} \cdot \vec{I_A}) + \vec{V_{CB}} \cdot \vec{I_C} \cdot \cos(\vec{V_{CB}} \cdot \vec{I_C})$$

P533Z8B

$$Q = \vec{V_{AB}} \cdot \vec{I_A} \cdot \sin(\vec{V_{AB}} \cdot \vec{I_A}) + \vec{V_{CB}} \cdot \vec{I_C} \cdot \sin(\vec{V_{CB}} \cdot \vec{I_C})$$

P533Z9B

NOTE: If just one phase to phase voltage is measured (voltage measurement mode “VPP/VPPy”), then a symmetric 3-phase voltage system is assumed to calculate the non-measured voltages.

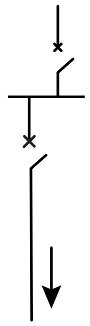
-

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

P533ZAA

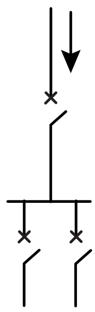
According to standard practice, it is considered that[140]:

- For the outgoing circuit:
  - Power supplied by the busbars is positive
  - Power supplied to the busbars is negative



P533MOB

- For the incoming circuit:
  - Power supplied to the busbars is positive
  - Power supplied by the busbars is negative



P533MNB

Cosφ and power factor

PowerLogic P5 protection relay calculates:

- cosφ, tanφ, the angle φ and power factor values of the power system.

140. Choice to be set in the Scaling view of the General menu.

- cosφ and power factor values of the phase, depending on their availability of phase current and voltages.

cosφ, tanφ and the angle φ express the phase displacement between the phase currents and phase to neutral voltages.

The power factor is defined by:

$$Cos\varphi = P \Big/ \sqrt{P^2 + Q^2}$$

P533ZBA

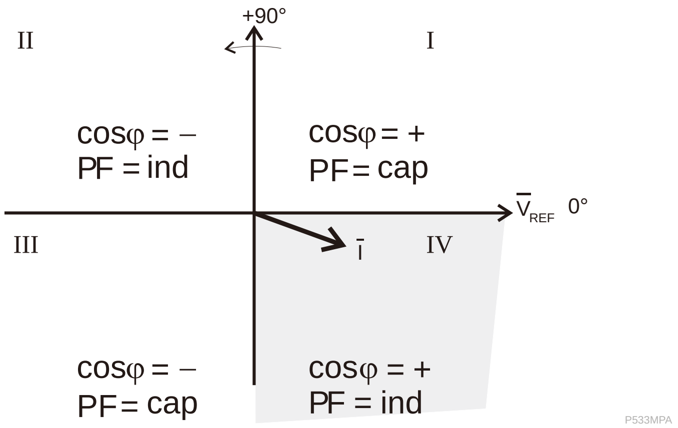
The + and - signs of cosφ give the direction of power flow.

The IND (inductive) and CAP (capacitive) indications of the power factor give type of load.

Power and current direction

This figure shows the concept of three-phase current direction and sign of cosφ and power factor PF (the absolute value is equal to cosφ, and the indication 'IND' means inductive i.e. lagging current and 'CAP' means capacitive i.e. leading current).

Figure 320 - Quadrants of voltage/current phasor plane



I: Forward capacitive power current is leading

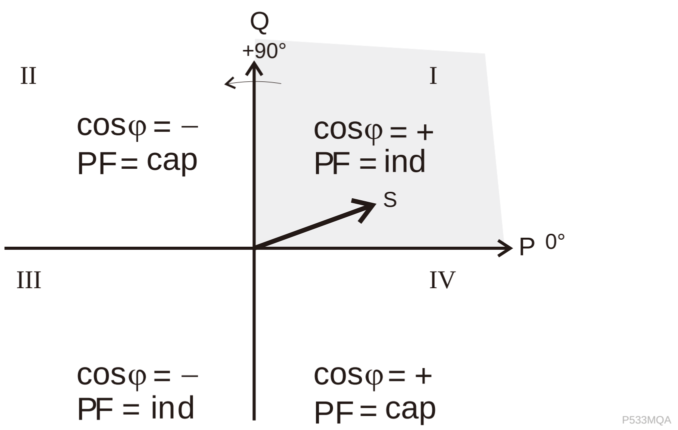
II: Reverse inductive power current is leading

III: Reverse capacitive power current is lagging

IV: Forward inductive power current is lagging

This figure below shows the same concepts on a PQ-power plane.

Figure 321 - Quadrants of power plane



I: Forward inductive power current is lagging

II: Reverse capacitive power current is lagging

III: Reverse inductive power current is leading

IV: Forward capacitive power current is leading

Table 134 - Power quadrants

Power quadrant	Current related to voltage	Power direction	Cosφ	Power factor PF
+ inductive	Lagging	Forward	+	IND
+ capacitive	Leading	Forward	+	CAP
- inductive	Leading	Reverse	-	IND
- capacitive	Lagging	Reverse	-	CAP

Characteristics

The following tables summarise the characteristics for power measuring:

Table 135 - Characteristics for power measuring (part 1)

Characteristics	Active power	Reactive power	Apparent power
Units	kW	kvar	kVA
Resolution	0.1 kW	0.1 kvar	0.1 kVA
Accuracy	±1% Snom typically[141]	±1% Snom typically[141]	±1% Snom typically[141]

Table 136 - Characteristics for power measuring (part 2)

Characteristics	Power factor	Cosφ	Tanφ	Angle φ
Measurement range	0 to 1 IND/CAP	-1 to +1		
Resolution	0.01	0.01	0.01	0.01
Accuracy	0.01[142]	0.01[142]		

141. Snom= √3 Vprim.nom Iprim.nom
142. For measurements at Inom, Vnom, cosφ > 0.8.

Active and reactive energy

The PowerLogic P5 protection relay measures the following active and reactive energy values, calculated on basis of the first three voltages and phase currents IA, IB and IC measured according to the related current flow for an outgoing feeder:

- E+: the accumulated active energy exported
- E-: the accumulated active energy imported
- Eq+: the accumulated reactive energy exported
- Eq-: the accumulated reactive energy imported

It is based on fundamental values or RMS values. The choice is done with the **Energy calculation mode** parameter.

The resolution of each energy counter can be defined by setting from 1 K unit to 1 M unit, by setting the number of decimal places of the value calculated.

When the apparent energy counter reaches 1 TVAh, the active and reactive energy counters reset to zero. To monitor the energy consumption on a feeder, a dedicated energy counter can be set up over a defined time window of between 10 minutes and 24 hours.

All the energy counter settings can be done:

- with eSetup Easergy Pro in the **Energy** view of the **Measurements** menu
- on local panel in the **Measurement** menu

The accumulated energy values are maintained when the PowerLogic P5 protection relay is powered off.

Table 137 - Characteristics of active and reactive energy measuring

Characteristics	Active energy	Reactive energy
Measurement range	999999.999 MWh	999999.999 MVArh
Units	MWh	MVArh
Resolution (self-adaptable)	0.001...1 MWh	0.001...1 MVArh
Accuracy	± 1% typical[143]	

143. At In, Vnp, cosφ > 0.8

Harmonics and Total Harmonic Distortion (THD)

The total harmonic distortion (THD) is calculated as a percentage of all the currents and voltages measured in relation to the base value of the fundamental frequency.

The device calculates the value from the 2nd to the 15th harmonic of each phase current and voltage signal separately and as total value.

The harmonic distortion is calculated as follows:

$$THD = \frac{\sqrt{\sum_{i=2}^{15} h_i^2}}{h_1}$$

P533ZCA

where

h_1 = Fundamental value

h_2 - h_{15} = Harmonics

Example

h_1 = 100A, h_3 = 10 A, h_7 = 3 A, h_{11} = 8 A

$$THD = \frac{\sqrt{10^2 + 3^2 + 8^2}}{100} = 13.15\%$$

P533ZDA

For reference, the RMS value is

$$RMS = \sqrt{100^2 + 10^2 + 3^2 + 8^2} = 100.9\ A$$

P533ZEA

Demand values

The PowerLogic P5 protection relay calculates average demand values of phase currents IA, IB, IC and power values S, P and Q. They are calculated over an adjustable demand time in a range from 10 to 60 minutes.

The parameters used to configure or control the demand values in the **MEASUREMENTS** menu/**Demand values** sub-menu of eSetup Easergy Pro are the following:

Table 138 - Demand value parameters

Parameter	Unit	Description
Demand time	min	Demand time (averaging time)
Fundamental frequency values		
IAda	A	Demand of phase current IA
IBda	A	Demand of phase current IB
ICda	A	Demand of phase current IC
Pda	kW	Demand of active power P
PFda	-	Demand of power factor PF
Qda	kvar	Demand of reactive power Q
Sda	kVA	Demand of apparent power S
RMS values		
IARMSda	A	Demand of RMS phase current IA
IBRMSda	A	Demand of RMS phase current IB
ICRMSda	A	Demand of RMS phase current IC
Prmsda	kW	Demand of RMS active power P
Qrmsda	kvar	Demand of RMS reactive power Q
Srmsda	kVA	Demand of RMS apparent power S

Table 139 - Resetting to zero

Characteristics	Range
Demand time	10...60 min
Currents	see Phase currents, page 499
Powers	see Power and power factor, page 505

Minimum and maximum values

Minimum and maximum values for many measurements are available through the user interfaces (HMI, eSetup Easergy Pro, Web HMI or communications protocols). Each record of minimum or maximum value includes a time stamp. This time stamp is reset either when a clear command (ClrMax) is applied or by a product restart.

The available values are listed in the following table:

Table 140 - Available minimum and maximum values

Min & Max measurement	Description
IA, IB, IC	Phase current, fundamental frequency value
IA_{RMS}, IB_{RMS}, IC_{RMS}	Phase current, RMS value

Table 140 - Available minimum and maximum values (Continued)

Min & Max measurement	Description
IN, IN'	Earth/ground fault overcurrent, fundamental value
VA, VB, VC	Voltages, fundamental frequency values
VA_{RMS}, VB_{RMS}, VC_{RMS}	Phase to neutral voltages, RMS value
VAB, VBC, VCA	Phase to phase voltage
VAB_{RMS}, VBC_{RMS}, VCA_{RMS}	Phase to phase voltage, RMS value
VN	Neutral voltage
f	Frequency
P, Q, S	Active, reactive, apparent power
PF	Power factor

The clearing parameter "ClrMax" is a common reset for all min. and max. values.

Table 141 - Parameters

Parameter	Value	Description	Note
ClrMax	-; Clear	Reset all minimum and maximum values	Settable[144]

A ClrMax command can be initiated as below:

- with "Clear min & max" parameter in the **Measurements** menu in eSetup Easergy Pro
- with "Clear min & max" parameter in the **Measurements** menu in the Web HMI
- from the local panel with the "Clr Max" parameter
- With a suitably configured DI
- with virtual inputs / outputs according to the setting of the "DI to clear min & max" parameter

In addition any action that results in a restart of the PowerLogic P5 protection relay will also clear the min/max values. This includes power cycling and certain configuration updates.

144. An editable parameter (password needed).

Average current

The PowerLogic P5 protection relay calculates the average of the three phase currents IA + IB + IC over a period of time defined by the “Average current window” setting, in the **3_Phase Average current** view of the **Measurements** menu in eSetup Easergy Pro.

Table 142 - 3_Phase Average current

Parameter	Value	Description
Average current window	1 s; 1 min; Demand Time	Time for calculating the average current

If the “Average current window” is set to “Demand Time”, the setting value will depend on the “Demand time” setting, which is configured in the **Demand values** view of the **Measurements** menu.

Table 143 - Demand values

Parameter	Range	Description
Demand time	10...60 min	Demand time (averaging time)

The average current is refreshed each second when the “ Average current window” is set to “1 s”, and it is refreshed each minute when the “Average current window” is set to “1 min” or “Demand Time”.

The average current is available in eSetup Easergy Pro and all communication interfaces.

Voltage sags and swells

The PowerLogic P5 protection platform provides many power quality functions that can be used to evaluate, monitor and alarm on the current power system quality. Two of the most important power quality functions are the voltage sag and swell monitoring.

The PowerLogic P5 protection relay provides separate monitoring logs for sags and swells. The voltage log is triggered if any voltage input either goes under the sag limit (V<) or exceeds the swell limit (V>). There are four registers for both sags and swells in the fault log. Each register will have start time, phase information, duration, minimum, average and maximum voltage values of each sag and swell event. Furthermore, there are total number of sags and swells counters as well as total timers for sags and swells.

The voltage sags and swells monitoring function can be read and set:

- on local panel, through **Measures** menu, under **"Voltages"** sub-menu, in the view of **Voltage sag & swell**
- with eSetup Easergy Pro, under the **Measurements** menu, in the view of **Voltage sag & swell**

Measurement mode

There are 3 selections in drop menu: *Ph-Ph*, *Ph-G* and *Default*, stand for different types of measured voltage.

- Ph-Ph: phase to phase voltage
- Ph-G: phase to ground voltage
- Default: use the setting of “Voltage mode” from system setting.

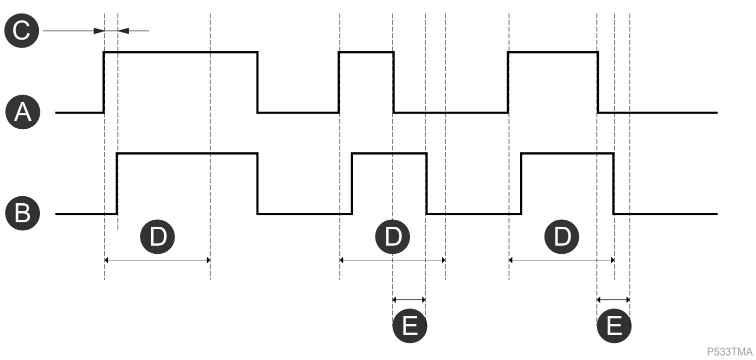
SSW maximum time and SSW gap time

These 2 settings define how to end the Voltage swell signal.

As shown in following chart:

- When Voltage > “Voltage swell limit” is fulfilled, Voltage swell signal will be activated after a delay time. SSW maximum timer starts.
- In case of Voltage > “Voltage swell limit” is continued, Voltage swell signal will also be activated in continue.
- When Voltage > “Voltage swell limit” ends, SSW gap timer starts. Voltage swell signal will be ended either SSW maximum timer or SSW gap timer reaches the set value.

Figure 322 - Example of SSW maximum time and SSW gap time



A	Voltage > "Voltage swell limit"	B	Voltage swell signal
C	Delay time	D	SSW maximum time
E	SSW gap time		

Table 144 - Setting and characteristics of voltage sags and swells monitoring

Setting/characteristics	Values
Measurement mode	
Options	Default (same as the scaling setting); Ph-Ph; Ph-G
Voltage sag limit	
Setting range	10%...120% U_n[145]
Resolution	1% U_n[145]
Accuracy	±0.5 V or 3% of the set value
Reset ratio	103%
Voltage swell limit	
Setting range	10%...150% U_n[145]
Resolution	1% U_n[145]
Accuracy	±0.5 V or 3% of the set value
Reset ratio	97%
DT delay time	
Setting range	0.06...1.00 s
Resolution	0.02 s
Accuracy	±1% or ±30 ms
Low voltage blocking	
Setting range	0...50% U_n[145]
Resolution	1% U_n[145]
Accuracy	±5% of the set value
Maximum time	
Setting range	10...1000 s
Resolution	1 s
Gap time	
Setting range	0.00...5.00 s
Resolution	0.01 s
Characteristic time	
Disengaging time	< 60 ms

145. VT Primary nominal

Temperature

Operation

This function gives the temperature value measured by Resistance Temperature Detectors (RTDs):

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

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

The function also indicates RTD faults:

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

In the event of a fault, the display of the value is inhibited.

The associated monitoring function generates a maintenance alarm.

Readout

The measurements may be accessed via:

- **RTD** view of the **Measures** menu on the local panel of the PowerLogic P5 protection relay
- **Temperature** view of the **MEASUREMENTS** menu in eSetup Easergy Pro
- The communication link

Characteristics

Table 145 - Characteristics of temperature measuring

Characteristics	Values
Range	-30...+200°C (-22...+392°F)
Resolution	1°C (1°F)
Accuracy	±1°C for +20...+140°C (±1.8°F for +68...+284°F); ±2°C for -30...+20°C (±3.6°F for -22...+68°F); ±2°C for +140...+200°C (±3.6°F for +284...+392°F)
Refresh interval	5 seconds (typical)

Accuracy derating according to wiring (connection in 3-wire mode)

The deviation Δt is proportional to the length of the connector and inversely proportional to the connector cross-section:

$$\Delta t\,(^\circ C) = 2 \times \frac{L\,(km)}{S\,(mm^2)}$$

P533ZFA

- ±2.1°C/km for a cross-section of 0.93 mm^2 (AWG 18)
- ±1°C/km for a cross-section of 1.92 mm^2 (AWG 14)

Control functions

Digital outputs

Description

Digital outputs are available for control and signalling purposes.

The number of available outputs depends on the number and type of board options ordered.

The following digital output contact relays are available:

- **Slot B**

  The digital output DO1 is normally opened (NO) contact (and high speed high break contact for P5x30 only) used for control. The digital output DO2 (Change Over contact) is usually used for control.

  The digital output DO3 (Normal Open) is usually used for control.

  The digital output DO4 (change over contact) is dedicated to the watchdog (signalling).

  Both the tripping DO2 relay and the watchdog relay have normally open (NO) or normally closed (NC) contacts. Refer to Selecting the trip command and examples of use, page 555.

- **Slot C, D, E (6I4O option)**

  The digital outputs DO1 to DO4 (Normal Open single pole single throw) are for signalling only.

  Slot C, D, E (5I5O option)

  The digital outputs DO1 and DO2 (Change Over contact single pole double throw) are usually used for control.

  The digital outputs DO3 (Normal Open single pole single throw) are for control.

  The digital outputs DO4 and DO5 are normally opened (NO) contact and high speed high break contact used for control.

  Slot C, D, E (12I4O option)

  The digital outputs DO1 to DO4 are independently controlled normally open signalling contacts with DO1 & DO2 and DO3 & DO4 having a common connection point.

- **Slot D, E (Arc-flash option)**

  The digital output DO1 (Normal Open) is usually used for control.

  The digital output DO2 (Change Over contact single pole double throw) is usually used for control.

  The digital output DO3 (Normal Open single pole single throw) is usually used for signalling.

  The contacts are (SPST) normal open (NO) type, except signal relay DO2 and DO4 (watchdog) which has a changeover contact (SPDT).

  The digital outputs can be set in Normal Open or Normal Close position with eSetup Easergy Pro and Web HMI in the **Relays polarity** view of the **Control** menu.

The status of the digital outputs can be read:

- with eSetup Easergy Pro in the **Relays** view of the **Device/Test** menu
- by the local panel in the **digital output Slot x** view under the menu option **DO** of the **Device/Test** sub-menu
- EcoStruxure Power Device application
- Web HMI

Label and description texts can be edited with eSetup Easergy Pro or the Web HMI in **Names for output relays** view according to the demand. Labels are the short parameter names used on the local panel display and descriptions are the longer names used by eSetup Easergy Pro (the **Names of the output relays** view in the **Control** menu).

Any internal signal can be connected to the output relays using the output matrix. An output relay can be configured as latched or non-latched. (see **Output Matrix** view in the **Matrix** menu of eSetup Easergy Pro and Web HMI).

Forced control of digital outputs

For tests purposes, first set the **IED Mode** to **Test:**

- with eSetup Easergy Pro in the **System info** setting view of the **General** menu
- by local panel in the **Device/Test** menu under the **Test** menu option

See Mode of use for testing purposes, page 272 for more information.

Default numbering of digital outputs

Every option card and slot has default numbering. Below is an example of PowerLogic P5x30 showing default numbering of DOs.

Figure 323 - Default numbering of digital outputs for PowerLogic P5x30

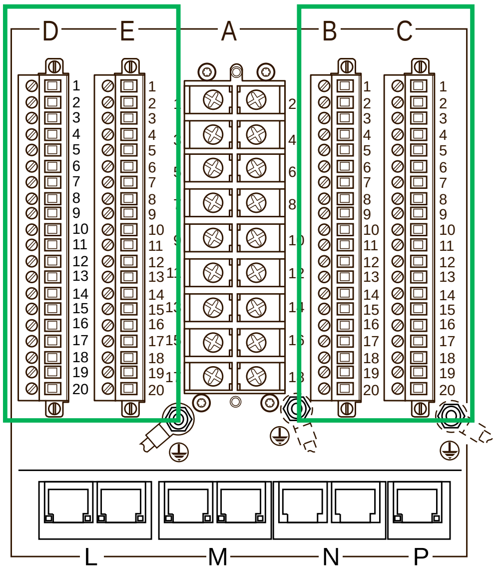


Table 146 - Example of digital outputs numbering

Option boards	Slot B	Slot C	Slot D[146]	Slot E[146]
No option	DO1...DO3 + WD			
1 x 6I/4O	DO1...DO3 + WD	DO1...DO4		
2 x 6I/4O	DO1...DO3 + WD	DO1...DO4	DO1...DO4	
3 x 6I/4O	DO1...DO3 + WD	DO1...DO4	DO1...DO4	DO1...DO4

146. For PowerLogic P5x30 only

Table 146 - Example of digital outputs numbering (Continued)

Option boards	Slot B	Slot C	Slot D[147]	Slot E[147]
1 x 6I/4O +1 x Arc-flash	DO1...DO3 + WD	DO1...DO4	DO1...DO3	
2 x 6I/4O +1 x Arc-flash	DO1...DO3 + WD	DO1...DO4	DO1...DO3	DO1...DO4
1 x 6I/4O +2 x Arc-flash	DO1...DO3 + WD	DO1...DO4	DO1...DO3	DO1...DO3

Characteristics

Table 147 - Characteristics of the digital outputs

Parameter	Value	Description	Note
DO1...DOn	0; 1	Status of the digital outputs: • 0 = Digital output not energised • 1 = Digital output is set active The available parameter list depends on the number and type of the I/O cards.	Editable when IED mode is set to "Test".
Mode	NO NC	Normal open Normal close	Editable when IED mode is set to "Test".
IED mode	Normal Test Test-block	In **Test** mode, digital output forcing is enabled for test purposes.	Editable parameter (password needed)
Name of output relays			
Label	String of max. 16 characters	Short name for digital outputs on the local display. Default is "DO1...DOx". x is the maximum number of the digital outputs.	Editable parameter (password needed)
Description	String of max. 32 characters	Long name for digital outputs. Default is "Digital output 1...Digital output x". x is the maximum number of the digital outputs.	Editable parameter (password needed)

147. For PowerLogic P5x30 only

Digital inputs

⚠WARNING

RISK OF FIRE

Do not connect power greater than 0.5 W to each digital input for ambient temperature lower than 70°C (158°F), or 0.8 W for lower than 45°C (113°F).

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

Digital inputs are available for control purposes. For example, the digital inputs can provide the position of the circuit breaker and make it possible to change setting group, block/enable/disable functions, program logic, and indicate object status.

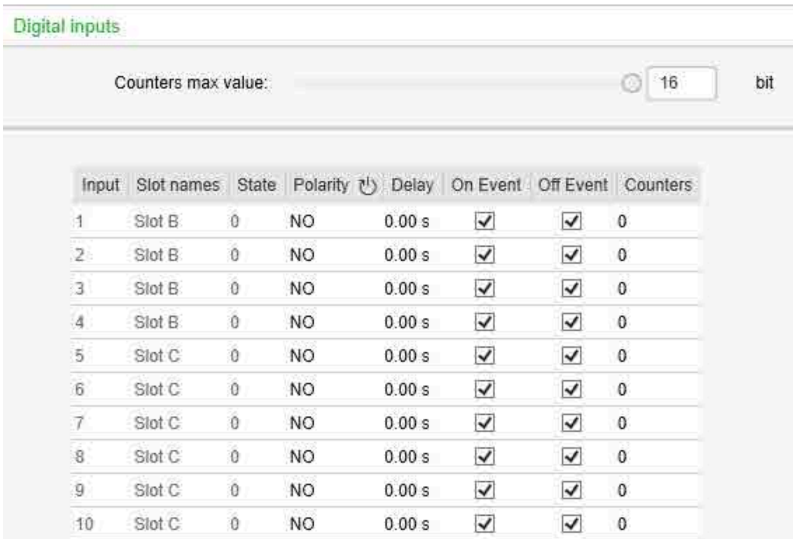
The number of available inputs depends on the number and type of option boards.

The digital inputs require an external control voltage (AC or DC) and are activated after the voltage exceeds the pick-up threshold. Deactivation follows when the voltage drops below the drop-off threshold limit.

Configuring the digital inputs

The digital inputs are set with eSetup Easergy Pro and Web HMI in the **Digital Inputs** view of the **Control** menu. They are not settable on the local panel.

Figure 324 - The Digital inputs setting section in the Digital inputs view



Digital inputs

Counters max value: 16 bit

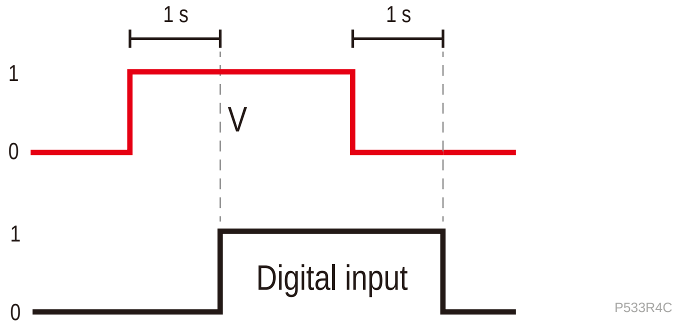
Input	Slot names	State	Polarity	Delay	On Event	Off Event	Counters
1	Slot B	0	NO	0.00 s	☑	☑	0
2	Slot B	0	NO	0.00 s	☑	☑	0
3	Slot B	0	NO	0.00 s	☑	☑	0
4	Slot B	0	NO	0.00 s	☑	☑	0
5	Slot C	0	NO	0.00 s	☑	☑	0
6	Slot C	0	NO	0.00 s	☑	☑	0
7	Slot C	0	NO	0.00 s	☑	☑	0
8	Slot C	0	NO	0.00 s	☑	☑	0
9	Slot C	0	NO	0.00 s	☑	☑	0
10	Slot C	0	NO	0.00 s	☑	☑	0

The settable items includes:

- Polarity
- Delay
- On event
- Off event
- Counter

Digital input delay determines the activation and de-activation delay for the digital input. It is used for both On and Off transitions. Digital inputs behaviour when delay is set to 1 second, page 522 shows how the digital input behaves when the delay is set to 1 second.

Figure 325 - Digital inputs behaviour when delay is set to 1 second



Digital inputs on/off events and alarm pop-up message display can be enabled and disabled in **Digital inputs** setting view of eSetup Easergy Pro or Web HMI.

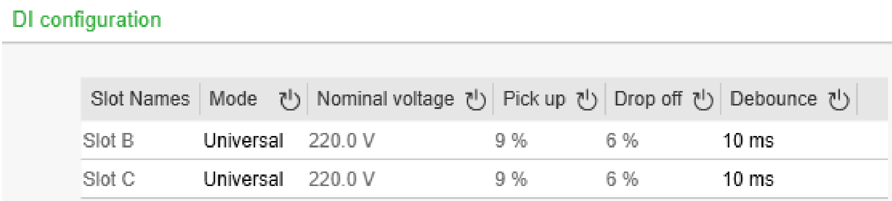
Individual operation counters are located in the same view as well. The maximum value of the counters is settable and is the same for all counters.

The status of the digital inputs can be read:

- with eSetup Easergy Pro and Web HMI in the **Digital inputs** view of the **CONTROL** menu
- by local panel in the **Digital inputs** view of the **DI** menu option in the **Control** menu
- EcoStruxure Power Device application
- Communication according to the protocol

The configuration of the digital inputs in eSetup Easergy Pro is common for all digital inputs on the same board.

Figure 326 - The DI Configuration section in the Digital inputs view



DI configuration

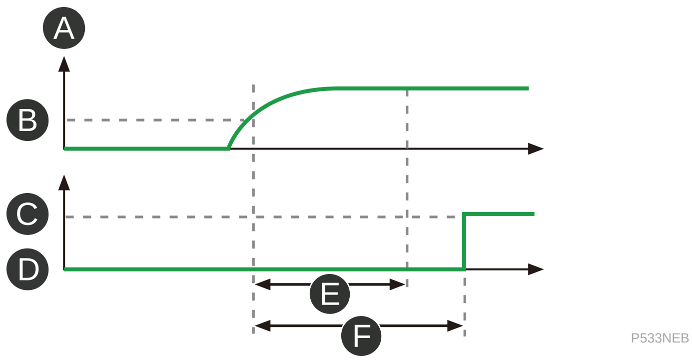
Slot Names	Mode	Nominal voltage	Pick up	Drop off	Debounce
Slot B	Universal	220.0 V	9 %	6 %	10 ms
Slot C	Universal	220.0 V	9 %	6 %	10 ms

The digital inputs can be set for the following voltage values with pre-defined setting values or settable values:

- Universal (by default)
- Standard AC or DC voltages (24 V DC, 48 V DC, 110 V DC, 220 V DC, 220 V AC, and 250 V DC)
- Customisable AC (settable from 90 V AC to 230 V AC), customisable DC (settable from 24 V DC to 250 V DC)

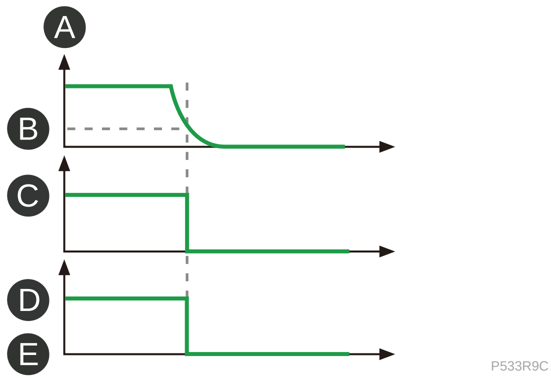
Timing diagram of a digital input during pick-up, page 523 and Timing diagram of a digital input during a drop-off, page 523 below illustrate the timing diagrams of a digital input during pick-up and drop-off:

Figure 327 - Timing diagram of a digital input during pick-up



A	Nominal voltage	B	Pick up value
C	Input seen as high level	D	Input seen as low level
E	Inrush time	F	Debounce time

Figure 328 - Timing diagram of a digital input during a drop-off



A	Nominal voltage	B	Drop-off value
C	Holding current	D	DI high
E	DI low		

Label and description texts can be edited with eSetup Easergy Pro according to the demand. Labels are the short parameter names used on the local panel and descriptions are the longer names used by eSetup Easergy Pro.

The digital input signals can be connected to the different outputs of the **Output matrix**, **Block matrix**, **Object block matrix**, **Auto-recloser 79 matrix** views in the **MATRIX** menu of eSetup Easergy Pro and Web HMI or used in the custom logic function.

Default numbering of digital inputs

Every option card and slot has default numbering. After making any changes to the numbering, read the settings from the relay after the relay has rebooted.

Below is an example of PowerLogic P5x30 showing default numbering of digital inputs.

User can change the numbering of the following option cards - slot B, C, D, E.

Figure 329 - Default numbering of digital inputs for PowerLogic P5x30

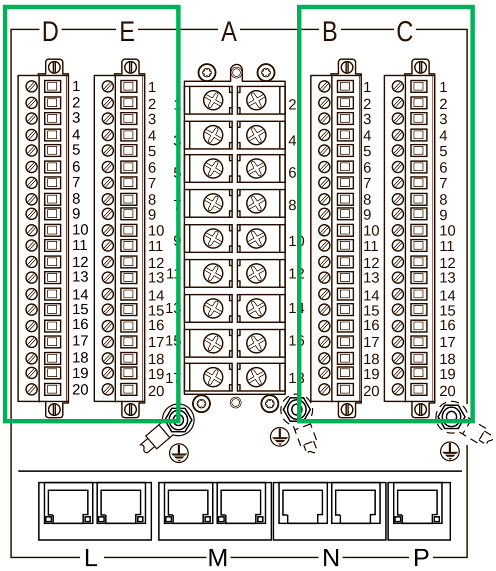


Table 148 - Example of digital inputs numbering

Option boards	Slot B	Slot C	Slot D[148]	Slot E[148]
No option	DI1...DI4			
1 x 6I40	DI1...DI4	DI1...DI6		
2 x 6I40	DI1...DI4	DI1...DI6	DI1...DI6	
3 x 6I40	DI1...DI4	DI1...DI6	DI1...DI6	DI1...DI6
1 x 6I40 +1 x Arc-flash	DI1...DI4	DI1...DI6	DI1...DI3	
2 x 6I40 +1 x Arc-flash	DI1...DI4	DI1...DI6	DI1...DI3	DI1...DI6
1 x 6I40 +2 x Arc-flash	DI1...DI4	DI1...DI6	DI1...DI3	DI1...DI3

Characteristics

Table 149 - Characteristics of the digital inputs

Parameter	Value		
	Universal	Standard voltage	Customisable voltage
Mode	Universal (value by default)	24 V DC; 48 V DC; 110 V DC; 220 V DC; 220 V AC; 250 V DC	Custom 24 V DC to 250 V DC; Custom 90 V AC to 230 V AC
Pick-up ratio	> 19 V	70%	40%...80%, 154 V max.
Drop-off ratio	< 12 V	60%	20%...60%, 12 V min.
Holding current	1.3 mA	2.3 mA (V ≤ 110 V) 1.3 mA (V > 110 V)	1...27 mA
Debounce time	0...100 ms		
State	0; 1		
Polarity position	NO; NC		
Power maximum	0.5 W for ambient temperature less than 70°C (158 °F); 0.8 W for ambient temperature less than 45°C (113 °F);		
Delay	0.00...60.00 s		

148. For PowerLogic P5x30 only

Table 149 - Characteristics of the digital inputs (Continued)

Parameter	Value		
	Universal	Standard voltage	Customisable voltage
On event	No; Yes		
Off event	No; Yes		
Counters	0 to 255 - 511 - 1023 - 2047 - 4095 - 8191 - 16383 - 32767 - 65535 Reset automatically to 0 if the limit is exceeded.		
Counter max value	Setting range is 8 to 16 bit counter		
Name of digital inputs	Label: short name for display on the local panel. String of max. 10 characters. Default is "DI1...DIx".		
	Description: long name for display in eSetup Easergy Pro or HMI String of max. 32 characters. Default is "Digital input 1...Digital input x".		

NOTE: Digital inputs can be assigned to a signal with normal state or inverted state.

Virtual inputs and virtual outputs

There are virtual inputs and virtual outputs that can, in many places, be used like their hardware equivalents except that they are located in the memory of PowerLogic P5. Virtual inputs can be used in many operations act like normal digital inputs such as: enable changing setting groups, block/enable/disable functions, program logics, and so on.

Virtual inputs can be selected to operate by the function buttons on local panel, the local mimic, communication or simply by using the **Virtual input** menu of eSetup Easergy Pro or Web HMI.

The activation and reset delay of virtual inputs/outputs is about 5 ms.

The status of virtual inputs and outputs can be read:

- with eSetup Easergy Pro in the **Virtual inputs** views of **CONTROL** menu and **Virtual outputs** views of **Device/Test** menu
- by local panel in **Virtual inputs** or **Virtual outputs** view of **Control** menu
- EcoStruxure Power Device application
- web HMI
- communication depending on the protocol

The virtual inputs and virtual outputs can be named through eSetup Easergy Pro or Web HMI in the Names for virtual inputs and Names for virtual outputs views of **CONTROL** menu.

The virtual input signals can be connected to different outputs of the **Output matrix**, **LED matrix**, **Block matrix**, **Object block matrix**, **Auto-recloser 79 matrix** views in the **MATRIX** menu of eSetup Easergy Pro and Web HMI or used in the custom logic function.

The virtual outputs can be controlled through output matrix (see **Output matrix** view in the **Matrix** menu of eSetup Easergy Pro and Web HMI).

Table 150 - Characteristics of the virtual inputs and outputs

Parameter	Value	Description	Note
Number of Virtual Inputs	50		
Number of Virtual Outputs	20		
VI1-VI50	0 1	Virtual input status is set to inactive. Virtual input status is set to active.	Editable when IED mode is set to "Test".
VO1-VO20	0 1	Virtual output status is set to inactive. Virtual output status is set to active.	Editable when IED mode is set to "Test".
Refresh period	5 ms	The activation and reset delay of the virtual inputs/outputs	
Event enabling	No Yes	Active edge event disabled. Active edge event enabled.	
Check L/R selection	No Yes	disabled enabled	
Name of virtual inputs and virtual outputs			
Label	String of max. 10 characters	Short name for virtual inputs and virtual outputs on the local display. Default is "VI1...VIn" and "VO1...VOn". n is the maximum number of the digital inputs or outputs.	Editable parameter (password needed)
Description	String of max. 32 characters	Long name for virtual inputs and virtual outputs. Default is "Virtual input 1 (or Virtual output 1)...Virtual input n (or Virtual output n)". n is the maximum number of the virtual inputs or virtual outputs.	Editable parameter (password needed)

Virtual input pulse time operation

VI1 to VI10 are configurable virtual inputs, they can operate on pulse mode, which is achieved by a settable VI pulse length.

When the VI pulse length is set to "0 = infinite", it keeps actual operation; and with any setting > 0 s, the VI state gets automatically reset to 0 (low/ inactive), once the pulse timer expires.

The pulse timer can be re-started while running when a command with value “1” is received, and can be reset instantaneously when a command with value "0" is received.

Matrix

General information

The PowerLogic P5 protection relay has several matrices that are used for linking the hardware and software elements together to create a protection chain:

- **Output matrix**

  Used to link various inputs, outputs, statuses and signals to send a command to the contact relays and virtual outputs, to activate disturbance recording, and to provide SOL status.
- **Block matrix**

  Used to block protection stages
- **LED matrix**

  Used to control LEDs on the local panel
- **Object block matrix**

  Used to inhibit object control
- **Auto-recloser matrix**

  Used to control auto-recloser
- **Arc-flash matrix**

  Used for Arc-flash detection functions
- **Event matrix**

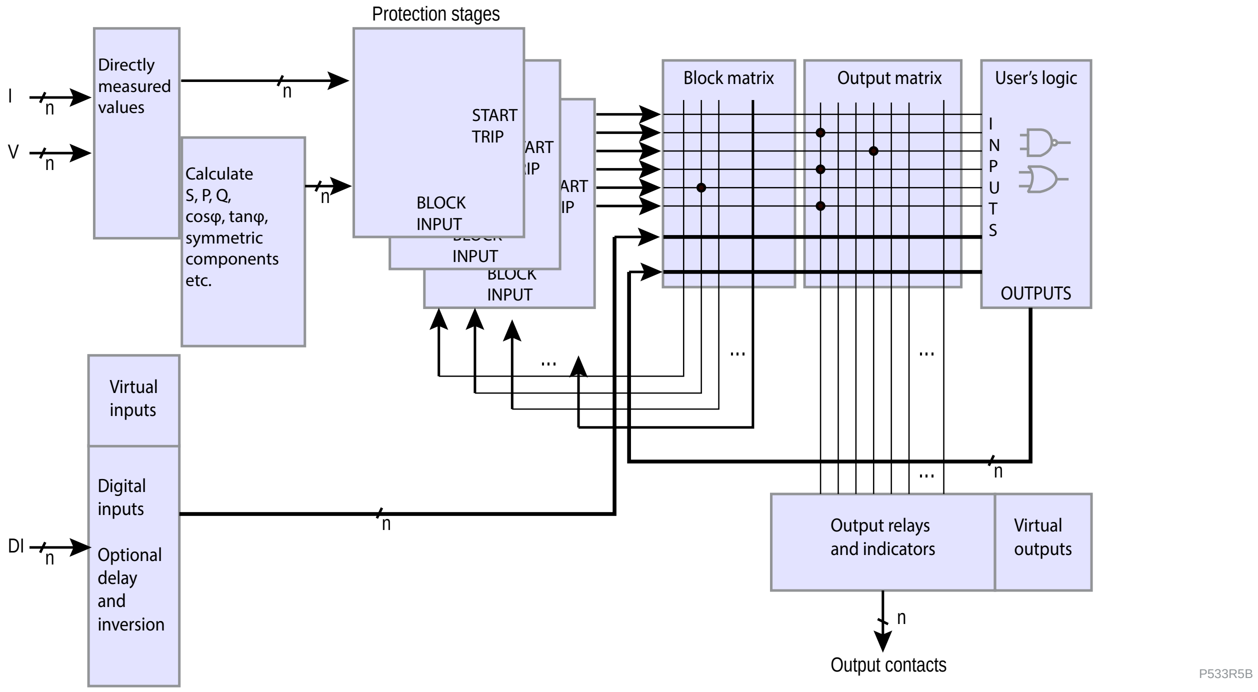
  See Logging and recording functions, page 559.
- **Goose matrix**

  Used in association with IEC61850 (see the Goose matrix view in the communication menu).

  It allows to associate up to 250 Goose messages (NIx) to a virtual input or a Goose message (NI).
- **General signals matrix**

  User configurable general trip signals with configuration of a dedicated matrix

Figure 330 - Blocking matrix and output matrix



Output matrix

The output matrix is used for connecting signals issued by different functions to the output relays (DO), virtual outputs (VO) and disturbance record trigger (DR).

The connecting signals to the outputs are the following:

- Protection signals from the different stages including setting changes
- Auto-recloser information
- Digital inputs
- Virtual inputs and outputs
- Object control command
- Function keys
- Goose
- Voltage sag/swell and interrupt
- Timers
- InterRelay signals

The **Output matrix** setting view of eSetup Easergy Pro and Web HMI represents the state (de-energised/energised) of the digital output's coil. For example, an orange vertical line in the **Output matrix** and a logical "1" in the **Relays** view represent the energised state of the coil. The same principle applies for both NO and NC type digital outputs. The actual position (open/closed) of the digital outputs' contacts in coil's de-energised and energised state depends on the type (NO/NC) of the digital outputs. De-energised state of the coil corresponds to the normal state of the contacts.

A digital output can be configured as latched or non-latched. The releasing latches procedure is described in Releasing latches, page 534.

Programming matrix

Matrix connection without latch

The connection is shown as a single bullet.

- When the input signal is activated, the output is activated
- When the input signal is released, the output is released

Latched matrix connection

The latched connection is shown as a single bullet surrounded by a circle.

- When the input signal is activated, the output is activated
- When the input signal is released, the output will remain active until cleared manually (refer to Releasing latches, page 534).

No connection

The line crossing is empty.

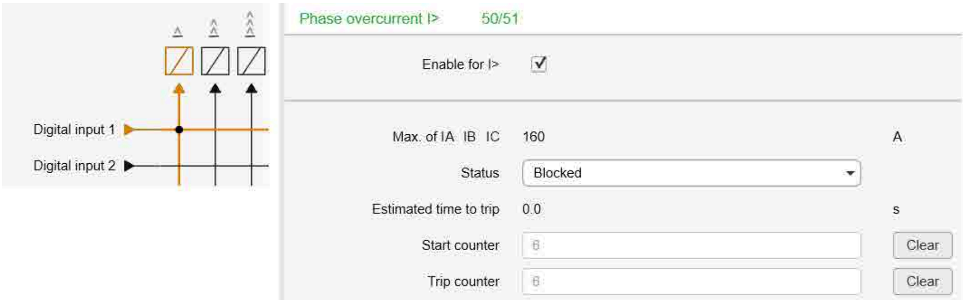
> **NOTE:** Logic outputs (see Logic functions, page 542) are also assigned automatically in the output matrix when defined in any user programmable logic scheme.

Blocking matrix

The operation of any protection stage can be blocked using the blocking matrix in the **MATRIX** menu/**Block matrix** sub-menu. The blocking signal can originate from the digital inputs or it can be a start or trip signal from a protection stage or an output signal from the user's programmable logic.

The Blocked status becomes visible only when the stage is about to activate.

Figure 331 - A view from the setting tool showing a DI input blocking connection (left picture) and the result for the I> stage when the DI is active and the stage exceeds its current start value



NOTICE

UNINTENDED AND NUISANCE TRIPPING

- In the online mode, the blocking matrix is dynamically controlled by selecting and deselecting protection stages.
- Activate the protection stages first, then store the settings in the protection relay. After that, refresh the blocking matrix before configuring it.

Failure to follow these instructions can result in unwanted shutdown of the electrical installation.

LED matrix

The LED matrix defines the use of the Alarm LED , the trip LED , and the configurable LEDs on the local panel of PowerLogic P5 protection relay. A lot of functions can be assigned to each LED.

Table 151 - Inputs for LEDs

Input	LED mapping	Latch	Description	Note[149]
Protection, arc and programmable stages	green or red	Normal/ Latched/ BlinkLatch	Different type of protection stages can be assigned to LEDs	Set
Digital/virtual inputs and function buttons	green or red	Normal/ Latched/ BlinkLatch	All different type of inputs can be assigned to LEDs	Set
Object open/close, object final trip and object failure information	green or red	Normal/ Latched/ BlinkLatch	Information related to objects and object control	Set
Local control enabled	green or red	Normal/ Latched/ BlinkLatch	While remote/local state is selected as local the "local control enabled" is active	Set
Logic output 1-20	green or red	Normal/ Latched/ BlinkLatch	All logic outputs can be assigned to LEDs at the LED matrix	Set
Manual control indication	green or red	Normal/ Latched/ BlinkLatch	When the user has controlled the objectives	Set
Setting error, self diagnostic alarm, pwd open and setting change	green or red	Normal/ Latched/ BlinkLatch	Self diagnostic signal	Set
GOOSE NI 1-250	green or red	Normal/ Latched/ BlinkLatch	IEC 61850 goose communication signal	Set
GOOSE error	green or red	Normal/ Latched/ BlinkLatch	IEC 61850 goose communication signal	Set
InterRelay signals	green or red	Normal/ Latched/ BlinkLatch	IRInx signal	Set

All the LEDs (6 for PowerLogic P5x20; 10 for PowerLogic P5x30) can be assigned as green or red in the **MATRIX** menu/**LED matrix** sub-menu of eSetup Easergy Pro. The selection of green and red at the same time will result in yellow.

The connection can be normal, latched or blink-latched (flashing).

NOTE: It is not possible to control LEDs directly from logics.

Normal connection

When the connection is normal, the assigned LED is active when the control signal is active. After deactivation, the LED turns off. LED activation and deactivation delay when controlled is approximately 10 ms.

Latched connection

A latched LED activates when the control signal activates but remains lit even when the control signal deactivates. Latched LEDs can be released by pressing the R key on the local panel.

149. Set = an editable parameter (password needed)

Blink-latched connection

When the connection is "BlinkLatch", the assigned LED is active and blinking as long as the control signal is active. After deactivation, the LED remains latched and blinking. The latch can be released by pressing the key on the local panel.

Object block matrix

The object block matrix is used to link digital inputs, virtual inputs, function buttons, protection stage outputs, object statuses, logic outputs, alarm signals, InterRelay signals and GOOSE signals to inhibit the control of objects, that is, circuit breakers, isolators and earthing/grounding switches.

Typical signals to inhibit controlling of the objects like circuit breaker are protection stage activation, statuses of the other objects, interlocking made in logic or GOOSE signals. These and other signals are linked to objects through the object block matrix.

Auto-recloser matrix

The auto-recloser matrix is used to link digital inputs, virtual inputs, protection stage outputs, object statuses, logic outputs, alarm signals and GOOSE signals to control the auto-recloser. For more information, see Auto-recloser function (ANSI 79), page 439.

Arc-flash matrix

The arc-flash detection matrix uses three types of matrix:

- **Arc-flash light matrix**

  The arc-flash light matrix is used for connecting light signals detected by sensors or Goose or any virtual inputs to the different stages of the Arc-flash detection function.

- **Arc-flash current matrix**

  The arc-flash current matrix is used for connecting current signals and any virtual inputs to the different stages of the Arc-flash detection function.

- **Arc-flash output matrix**

  The arc-flash output matrix is used for connecting the different arc stage signals to the digital outputs.

See Arc-flash (ANSI 50ARC), page 388 for more information on the arc-flash protection function of the PowerLogic P5 protection relay.

General signals matrix

In some applications, not all enabled protection functions are used to trip the circuit breaker but just to generate signal, for example, a phase overcurrent protection stage sends a “high load current” alarm to the operation system to initiate re-dispatch actions, the “Global trip” signal will not be generated. One solution of the user-defined signals is to set up by programmable logic, which is the application specific OR combination of start or trip signals, with the use of a logic timer element for the minimum trip command time. The drawback is that these signals have no standardised correspondence with existing dedicated signals in communication protocols, especially in IEC 61850.

The general signals matrix provides user configurable general trip signals with configuration of a dedicated matrix which allows user to configure general trip signals by configurable connections with input trip signals..

The configuration of the general signals matrix is made in eSetup Easergy Pro/**MATRIX**/**General signals matrix**. The timer is configured in **CONTROL**/**Global trip timer**.

The inputs of the general signals matrix are all trip/DI/VI/ Function Key/InterRelay input signals. Global trip signal is kept as an input of the general signals matrix for backward compatibility.

There are 2 output signals: General trip 1 and General trip 2. They can be inputs of other matrix. Each input signal can be linked/connected to one or both of the general trip signals. The protection signals and the global trip have a linkage effect, it means when the global trip connects/disconnects for example General Trip 1, the protection functions that trigger the global trip will automatically connect/disconnect General Trip 1.

When connecting the trip signal of a protection to General trip 1 or General trip 2, the related general start and direction signals with all “attributes” (as required in the LN PTRC) will be automatically adapted.

The output signals of general signals matrix can be transferred by the communication protocols, namely in additional IEC 61850 LN PTRC instances, but also in legacy protocols, for example IEC 60870-5-103.

Releasing latches

According to the matrix configurations different outputs and indicators can be latched or non-latched. A non-latched output or indicator follows the controlling signal. A latched output or indicator remains active after the controlling signal releases.

There is a common "release all latches" signal to release all the latched relays. This release signal resets all the latched digital outputs and indicators.

Each digital output can be latched or not independently through the output matrix.

The release of the latches can be done:

- Directly with the key on the local panel
- With a digital input/output or virtual input/output set in the **CONTROL** menu/ **Release latches** sub-menu of eSetup Easergy Pro or Web HMI
- With eSetup Easergy Pro, click **Device** button in the toolbar and select **Release all latches**
- With Web HMI
- Through communication

Mimic display

The PowerLogic P5 protection relay can display multiple mimic screens (up to 5) on the local panel. The mimic screen can be entered from the main screen/default screen.

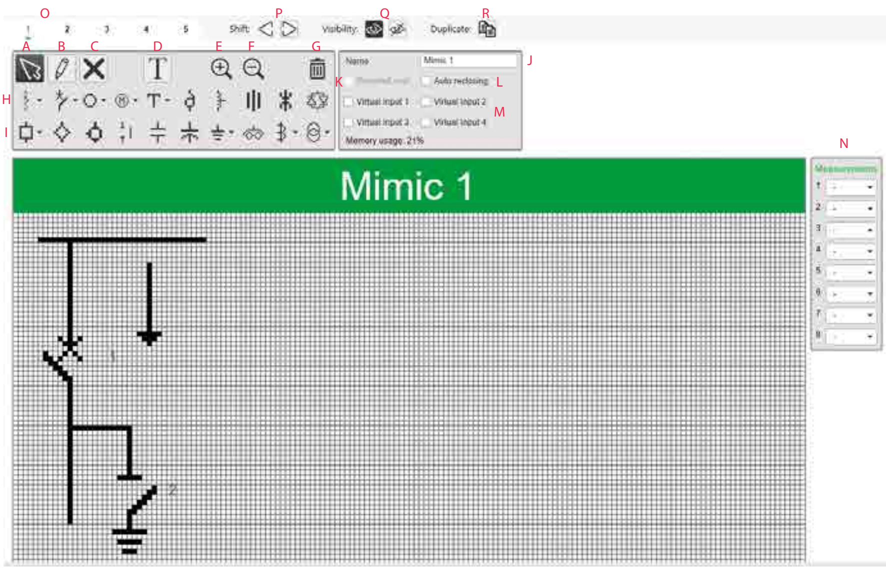
When pressing the mimic entry, the first mimic is shown on the local panel. The user can use the left/right navigation keys to switch between mimics. If the first mimic is currently displayed, only right navigation key is functional. If the 5th mimic is currently displayed, only left navigation key is functional. It is not possible to add or remove any mimic, but it can be hidden by clicking the **Visibility** button in the mimic configuration screen.

There are two ways to configure a mimic screen, from scratch, or from one existing mimic by clicking the **Duplicate** button located in the mimic configuration screen. The name and the content of each individual mimic can be edited. The content of each mimic is independent of the others. The user can click the left/right shift button to switch between mimic screens. The mimics can be configured in online mode (connected to the PowerLogic P5 by mini-USB port or Ethernet port) or offline mode.

Each mimic can display a single-line diagram, which can be created in eSetup Easergy Pro through the Mimic view of the **GENERAL** menu. Up to 8 analogue measurements (voltage, current, power...) based on the selection and up to 5 digital signals with fixed assignment can be displayed in one mimic. In order to display all the required information, the user can spread the information across multiple mimics.

Considering checking all the five mimics on default screen scenario, the user can use the up/down navigation keys to switch between mimics, and use the left/right navigation keys to view the **Main measurements**, firmware version and the **Alarm list** screens from the PowerLogic P5.

Figure 332 - Set up the Mimic view



A **Cursor**: used to move an object
To move an existing object, select the tool, point the cursor to the object until the object turns green and then drag and drop the object to the new position.

B **Draw line**: used to draw lines in the view
To draw a line, select the tool, click the left mouse button at the start point and then move the cursor to the second point and click again.

J Provides the PowerLogic P5 protection relay's location. The text comes from the **System info** view of the **GENERAL** menu

K **Remote / Local** state
Depending on the state, some settings and actions are not allowed
The remote / Local state can be changed in the **Objects** view of the **CONTROL** menu.

C	**Delete object**: used to delete an existing object from the view To delete an object, select the tool, point the cursor to the object until the object turns red and click.
D	**Text**: used to insert text in the view To insert text, select the tool, click at the position to place the text and then, in the pop-up dialog box, type in the text and click the **OK** button. Use the Cursor tool to move the text if necessary.
E	**Zoom in**: used to increase the size of the view To zoom in, click the tool until the view reaches the desired size.
F	**Zoom out**: used to decrease the size of the view To zoom out, click the tool until the view reaches the desired size.
G	**Clear view**: used to remove all objects from the view To clear the view, click the tool and select **OK** to confirm.
H	Different choice of configurable objects The object's number corresponds to the number in the **Object** menu.
I	Some predefined drawings for use in the view.
L	**Auto reclosing** check box To show or hide the Auto-reclosing state in the view
M	**Virtual input x** check boxes To show or hide the specified virtual inputs states in the view
N	Up to 8 freely selectable measurements To select the measurements to be shown in the view
O	The sequence number of the mimic
P	**Shift key**: used to switch between different mimics
Q	**Visibility key**: used to hide/unhide the mimic
R	**Duplicate key**: used to copy the current mimic

Table 152 - Mimic functionality

Parameter	Value	Description
Sublocation	Text field	Up to 20 characters. Fixed location.
Object 1–8	1–8	Double-click on top of the object to change the control number between 1 and 8. Number 1 corresponds to object 1 in **CONTROL** menu/ **Objects** sub menu.
Auto-reclosing	0 1	Possible to enable/disable auto-reclosing locally in local mode (L) or remotely in remote mode (R). Position can be changed.
Measurement display 1–8	Select the measurements from the drop down list	Up to 8 freely selectable measurements.
Virtual input 1–4	0 1	Change the status of virtual inputs while the password is enabled. Position can be changed.

Local panel configuration

The display and behaviour of the PowerLogic P5 protection relay's local panel can be configured in the **GENERAL** menu/**Local panel conf** sub-menu of the eSetup Easergy Pro.

Table 153 - Local panel configuration

Parameter	Value	Note
Contrast of LCD screen	0–15	For PowerLogic P5x20 only.
Display backlight control	Selection of digital inputs (DI), one virtual inputs (VI), one virtual outputs (VO), or one function key (Fx).	
Backlight off timeout	0.0–2000.0 min	Configurable delay for backlight to turns off when the protection relay is not used.

Table 153 - Local panel configuration (Continued)

Parameter	Value	Note
		Default value is 60 minutes. When value is zero (0.0) backlight stays on all the time.
Display evt time not sync	Checked unchecked	Event time shown normally if relay is synchronised, or otherwise in brackets.
Object for control buttons	Object 1 - Object 6	
Mode for control buttons	Selective Direct	Two different ways of controlling the object using the control buttons (I/O) (see Controllable objects, page 537)
Fault value scaling	PU Primary	PU: analogue values displayed in % or x rated value; Primary: analogue values displayed directly in primary units.
Date style	yy-mm-dd dd.mm.yy mm/dd/yy	
Clear events	- Clear	
Default screen		Used to set the default home screen of the local panel.

Controllable objects

The PowerLogic P5 protection relay allows the control of six objects, that is, circuit-breakers, disconnectors and earthing/grounding switches by the "select before operate" or "direct control" principle.

The object block matrix and logic functions can be used to configure interlocking to help ensure the control before the output pulse is issued. The objects 1 - 6 are controllable whilst the additional objects 7 - 8 are only able to show the status.

Controlling of objects 1–6 is possible in the following ways:

- through the object control buttons (I/O)
- through the local panel and display using single line diagram
- through the function key
- through a digital input
- through a remote communication
- through eSetup Easergy Pro setting tool
- through Web HMI
- through the EcoStruxure Power Device application

The connection of an object to specific controlling outputs is done via an output matrix (object 1 – 6 open output, object 1 – 6 close output). There is also an output signal "Object failed" that is activated if the control of an object is not completed.

Object states

Each object has the following states:

Setting	Value	Description
Object state	Undefined (00)	Actual state of the object
	Open	
	Close	

Setting	Value	Description
	Undefined (11)	

Basic settings for controllable objects

Each controllable object has the following settings:

Setting	Value	Description
DI for "obj open"	None, any digital input, virtual input or virtual output	Open information
DI for "obj close"		Close information
DI for "obj ready"		Ready information
Max ctrl pulse length	0.02...600 s	Pulse length for open and close commands. Control pulse stops once object changes its state
Completion timeout	0.02...600 s	Timeout of ready indication
Object control	Open/Close	Direct object control

If changing the states takes longer than the time defined by the "Max ctrl pulse length" setting, the object is inoperative and the "Object failure" matrix signal is set. Also, an undefined event is generated. "Completion timeout" is only used for the ready indication. If the "DI for 'obj ready'" is not set, the completion timeout has no meaning.

NOTE: The Object can only be controlled when its position is in a known state.

Output signals of controllable objects

Each controllable object has two control signals in the matrix:

Output signal	Description
Object x Open	Open control signal for the object
Object x Close	Close control signal for the object

Settings for read-only objects

Each read-only object has the following settings:

Setting	Value	Description
DI for "obj open"	None, any digital input, virtual input or virtual output	Open information
DI for "obj close"		Close information
Object timeout	0.02...600 s	Timeout for state changes

If changing states takes longer than the time defined by "Object timeout" setting, an "Object failure" matrix signal is set, and an undefined-event is generated.

Local or remote control

In Local mode, the digital outputs can be controlled via the local panel, but they cannot be controlled via a remote communication interface.

In Remote mode, the digital outputs cannot be controlled via the local panel, but only via a remote communication interface.

The Local or Remote mode is selected by one selectable digital input or using the local/remote button on local panel. When digital input is configured to switch between Local and Remote mode, the local/remote button will not take effect and so when it is pressed an alarm message appears, to remind the user that a digital input is applied to switch the Local or Remote mode. It is in Local mode when the digital input is OFF, and it is in Remote mode when the digital input is ON.

The selection of the L/R digital input is done in the **CONTROL** menu/**Objects** sub-menu of the eSetup Easergy Pro or Web HMI.

Object control with digital inputs

Objects can be controlled with digital inputs, virtual inputs or virtual outputs. There are four settings for each controllable object:

Setting	Active
DI for remote open / close control	In remote state
DI for local open / close control	In local state

If the protection relay is in a local control state, the remote control inputs are ignored and vice versa. An object is controlled when a rising edge is detected from the selected input. The length of digital input pulse should be at least 60 ms.

Object control with function keys

Each function key toggles an internal signal. This internal signal is available as an input of the output matrix, the block matrix, the auto-reclose matrix, the LED matrix and the object block matrix.

The function keys can also be used:

- To clear the minimum and maximum of current, voltage and power
- To clear the minimum and maximum of demand values and RMS demand values
- To select a setting group
- To select the IED modes (Normal / Test / Test-blocked)
- To enable / disable the auto-recloser
- To bypass the synchro-check
- As an input in the programmable logic

  NOTE: If the backlight for the LCD display is switched off, pressing a function key for the first time will only light up the LCD display. The function assigned to the function key will only be triggered when this function key is pressed a second time. This configuration is also valid for the other local panel keys.

Depending on the model of the PowerLogic P5 protection relay, there are different number of available function keys on the local panel:

- F1 for PowerLogic P5 x20
- F1 to F7 for PowerLogic P5 x30

The selection of the function keys for the objects is made in the **CONTROL** menu/**Objects** sub-menu of the eSetup Easergy Pro or Web HMI.

The function keys are configured to control objects in the **CONTROL** menu/**Function buttons** sub-menu of the eSetup Easergy Pro.

Setting function buttons

In the **CONTROL** menu/**Function buttons** sub-menu of the eSetup Easergy Pro, function buttons can be set to different type of functions:

- Fx (F1 to F7): work as function button. Status value will be changed between 0 and 1 on each pressing. The setting of pulse length is valid only when the function key is set to Fx type. When pulse length = 0, status value changes with each pressing of Fx, when length > 0, status value becomes to 1 when press, and change back to 0 after the delay time of pulse length setting.

- VI1...VI50: control the status of VI1 to VI50. VI value changes on each pressing.
- Object control: after set the function button to this value, you will have to make further settings in the **CONTROL** menu/**Objects** sub-menu of the eSetup Easergy Pro, in the section of Control object X, for example Control object 1, select Fx in **DI for local open control** or **DI for local close control**.
- Change test mode: if the function button is set to this function, when the button is pressed, you will be asked to set **Mode of use** (please refer to Mode of use for testing purposes, page 272) of the device.

Table 154 - Parameters for the function keys

Parameter	Value	Description
Status	0	Disabled
	1	Enabled
Selected control	V1...V50	Virtual input
	ObjCtrl	Object control
	Fn	Function key n
	ChgTstMod	Change the IED mode
Selected objects	-	No object selected
	xLocOpen; xLocClose	Shown when ObjCtrl is selected in the Selected control field.
Fn pulse length (0 = infinite)	0.00...600 s	Time delay common to all programmable function keys

Object control with I and O buttons

The PowerLogic P5 protection relay also has dedicated control buttons for objects. (I) stands for object closing and (O) controls object open command internally. **Object for control buttons** and **Mode for control buttons** are configured in the **CONTROL** menu/**Objects** sub-menu of the eSetup Easergy Pro or Web HMI.

Table 155 - Parameters of control buttons

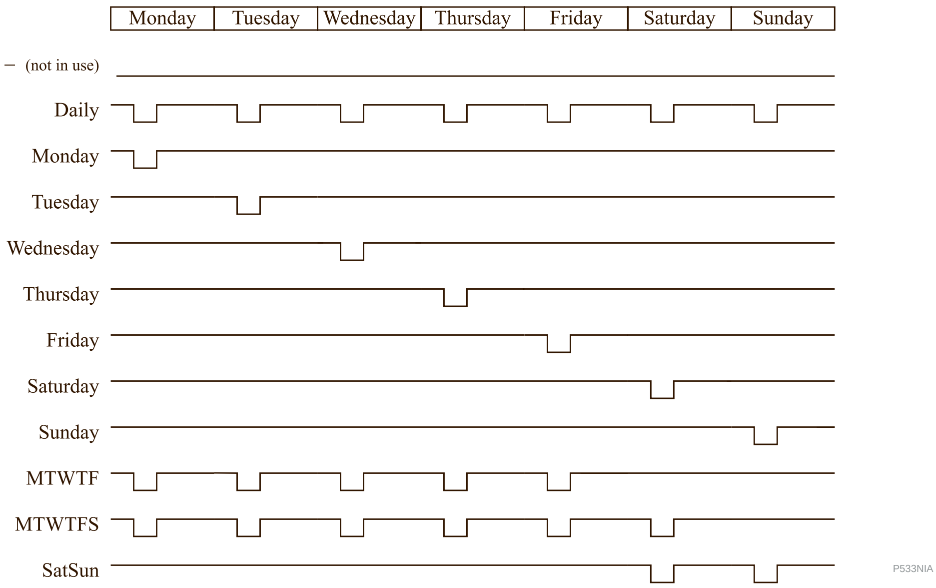
Parameter	Value	Unit	Description	Set
Object for control buttons	-		Disabled: the control buttons do not control any object.	Set
	Obj1...Obj6		Button I closes selected object if password is enabled. Button O opens selected object if password is enabled.	
Mode for control buttons	Selective		Control operation needs confirmation (select before operate)	
	Direct		Pressing the control button directly leads to action of the controled object.	

Timers

Description

The PowerLogic P5 protection platform includes four settable timers that can be used together with the user's programmable logic or to control setting groups and other applications that require actions based on calendar time. Each timer has its own settings. After setting the selected on-time and off-time you can then select whether the timer is activated every day or just selected days of the week (See the setting parameters for details). The timer outputs are available for logic functions and for the block and output matrices.

Figure 333 - Timer output sequence in different modes



You can force any timer, which is in use to on or off. The forcing is done by writing a new status value. Unlike the digital inputs no forcing flag is needed.

The forced timer status remains as forced until the next forced change or the next time the timer automatically changes status.

The status of each timer is stored in the non-volatile memory when the auxiliary power is switched off. At startup, the status of each timer is recovered.

Setting parameters

Table 156 - Setting parameters of timers

Parameter	Value	Description
Status	- 0 1	Not in use Output is inactive Output is active
On	hh:mm:ss	Activation time of the timer
Off	hh:mm:ss	De-activation time of the timer
Mode		For each four timers there are 12 different modes available:
	-	The timer is off and not running. The output is off, i.e. 0 all the time.
	Daily	The timer switches on and off once every day.
	Monday	The timer switches on and off every Monday.
	Tuesday	The timer switches on and off every Tuesday.

Table 156 - Setting parameters of timers (Continued)

Parameter	Value	Description
	Wednesday	The timer switches on and off every Wednesday.
	Thursday	The timer switches on and off every Thursday.
	Friday	The timer switches on and off every Friday.
	Saturday	The timer switches on and off every Saturday.
	Sunday	The timer switches on and off every Sunday.
	MTWTF	The timer switches on and off every day except Saturdays and Sundays
	MTWTFS	The timer switches on and off every day except Sundays.
	SatSun	The timer switches on and off every Saturday and Sunday.

Logic functions

PowerLogic P5 protection relay supports user-defined programmable logic for boolean signals. User-configurable logic can be used to create functionality that is not provided by the protection relay as a default. You can see and modify the logic in the **Logic** setting view of the **Control** menu in the eSetup Easergy Pro or Web HMI.

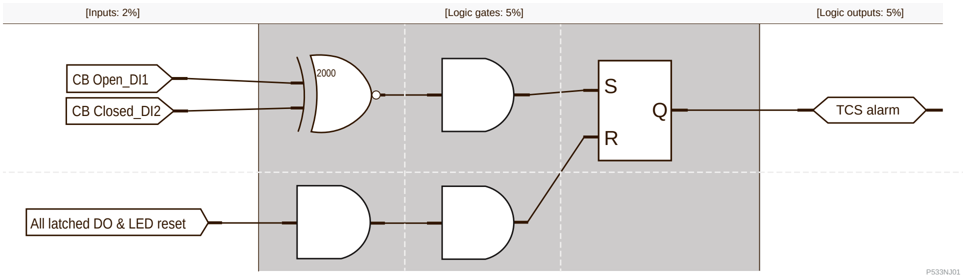
Table 157 - Available logic functions and their memory use

	Number of gates reserved	Maximum capacity	Maximum number of logic outputs
AND	1	Maximum number of logic gates = 120 Maximum number of signals per input = 120 Maximum number of signals = 120	20
OR	1		
XOR	1		
AND+OR	2		
CT (count + reset)	2		
INVAND	2		
INVOR	2		
OR+AND[150]	2		
RS (set + reset)	2		
RS_D (set + D + load + reset)	4		

The consumed memory is dynamically shown on the configuration view in percentage. The first value indicates the memory consumption of inputs, the second value the memory consumption of gates, the third value the memory consumption of logic outputs, and the fourth value the memory consumption of outputs. The logic is operational as long as the memory consumption of the inputs, gates, logic outputs and outputs remains individually below or equal to 100%.

150. by selecting “AND+OR” and ticking “Reverse”

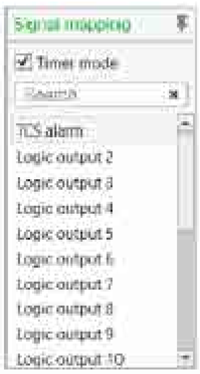
Figure 334 - Logic and memory consumption



Logic timer feature

PowerLogic P5 protection relay logic function can be used to manage accurate breaker control and alarms with flexibility thanks to the logic timer feature included. Logic timer feature offers the possibility of assigning a freely configurable time characteristic to the output signal of each Boolean equation. The logic timer can be displayed and modified in the eSetup Easergy Pro, the Web HMI, or through IEC 61850.

The logic timer feature could be configured by clicking on any Logic output in the logic diagram, a window of **Signal mapping** will be pop up:



On **Signal mapping** window, make **Timer mode** setting checked, a Logic output (t) will be shown. By clicking on the Logic output(t), requested timer mode could be selected together with the dedicated time configured.

The protection relay's HMI screen could display a countdown logic timer pop-up window. It could be enabled in the **Logic timers** view of the **Control** menu of eSetup Easergy Pro or the local panel. The popup window could be closed by pressing any key.

Table 158 - Settings and characteristics of the logic timer

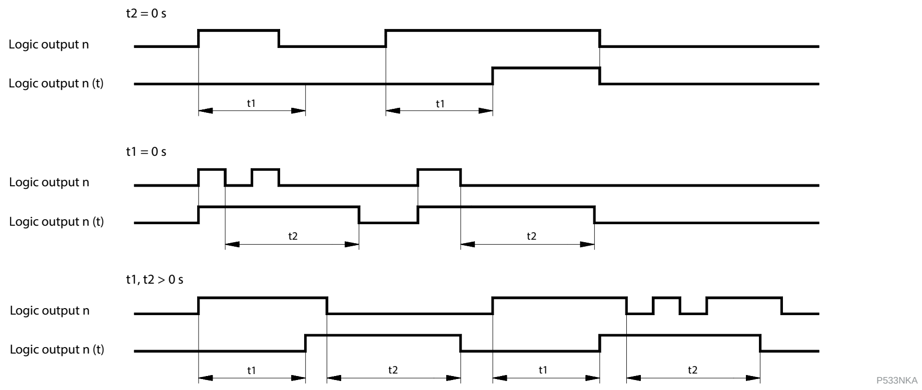
Settings/characteristics	Value
Timer mode	
Setting range	Op./Rel.delay; Op.delay/Pulse; Op./Rel.retrig; Op./Pulse.retrig; Minimum time
t1	
Setting range	0...60,000.00 s
Resolution	0.01 s
Accuracy	±1% or ±20 ms

Table 158 - Settings and characteristics of the logic timer (Continued)

Settings/characteristics	Value
t2	
Setting range	0...60,000.00 s
Resolution	0.01 s
Accuracy	±1% or ±20 ms

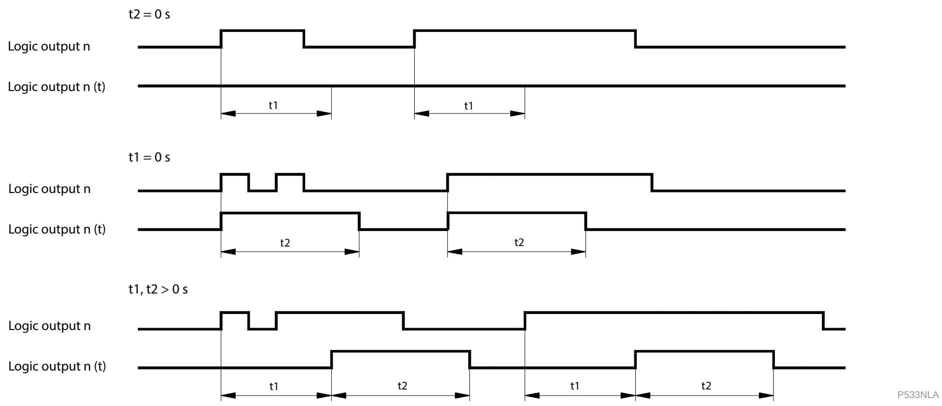
The following figures show the time characteristics for the various timer stage operating modes.

Figure 335 - Timer mode: Pickup/reset delay, non-triggerable (Op./Rel.delay)



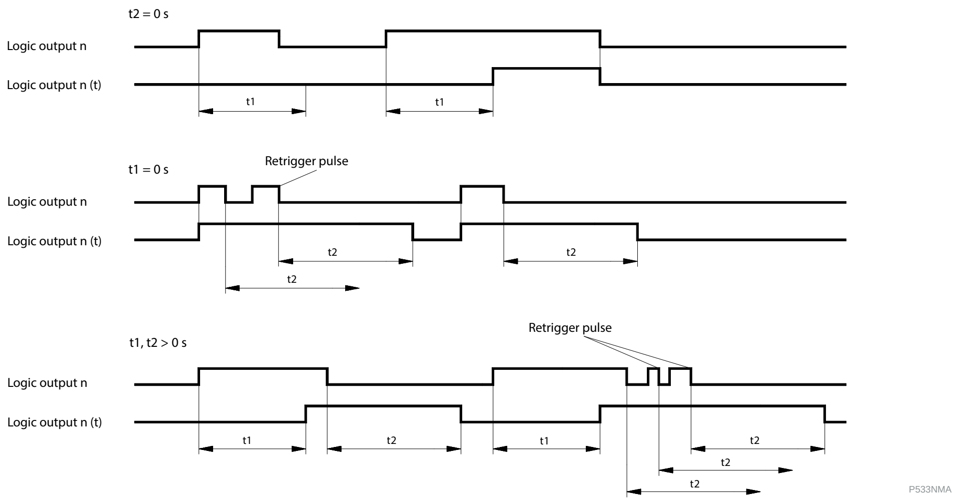
t1	operate delay	t2	release delay

Figure 336 - Timer mode: Pulse, delayed pickup, non-triggerable (Op.delay/ Pulse)



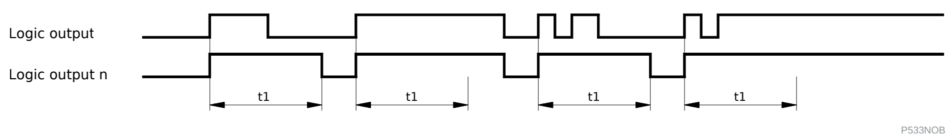
t1	operate delay	t2	pulse delay

Figure 337 - Timer mode: Pickup/reset delay, retriggerable (Op./Rel.retrig)



t1	operate delay	t2	release delay

Figure 338 - Timer mode: Minimum time (Minimum time)



t1	minimum time

Figure 339 - Timer mode: Pulse, delayed pickup, retriggerable (Op./Pulse. retrig)

t1	operate delay	t2	pulse delay

Table 159 - Logic gates

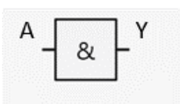
<table>
<tr><th>Logic gate</th><th>Symbol</th><th>Truth table</th></tr>
<tr><td>AND</td><td></td><td>
<table>
<tr><td>In</td><td>Out</td></tr>
<tr><td>A</td><td>Y</td></tr>
<tr><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td></tr>
</table>
</td></tr>
</table>

Table 159 - Logic gates (Continued)

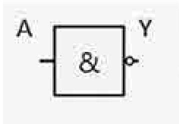
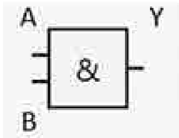
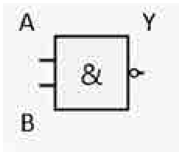
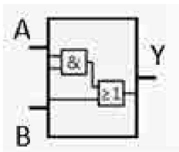
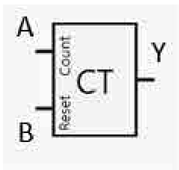
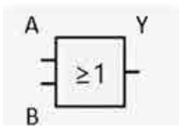
<table>
<tr><th>Logic gate</th><th>Symbol</th><th>Truth table</th></tr>
<tr><td></td><td></td><td><table><tr><td>In</td><td>Out</td></tr><tr><td>A</td><td>Y</td></tr><tr><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td></tr></table></td></tr>
<tr><td></td><td></td><td><table><tr><td colspan="2">In</td><td>Out</td></tr><tr><td>A</td><td>B</td><td>Y</td></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td></tr></table></td></tr>
<tr><td></td><td></td><td><table><tr><td colspan="2">In</td><td>Out</td></tr><tr><td>A</td><td>B</td><td>Y</td></tr><tr><td>0</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>1</td></tr></table></td></tr>
<tr><td>AND+OR</td><td></td><td><table><tr><td colspan="2">In</td><td>Out</td></tr><tr><td>A</td><td>B</td><td>Y</td></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>1</td></tr></table></td></tr>
<tr><td>CT
(count+reset)</td><td></td><td><table><tr><td colspan="2">In</td><td colspan="2">Out</td></tr><tr><td>A</td><td>B</td><td>Y</td><td>Y</td></tr><tr><td>Cont</td><td>Reset</td><td>Setting</td><td>New</td></tr><tr><td>1</td><td></td><td>3</td><td>0</td></tr><tr><td>1</td><td></td><td>3</td><td>0</td></tr><tr><td>1</td><td></td><td>3</td><td>1</td></tr><tr><td></td><td>1</td><td>3</td><td>0</td></tr></table></td></tr>
<tr><td>OR</td><td></td><td><table><tr><td colspan="2">In</td><td>Out</td></tr><tr><td>A</td><td>B</td><td>Y</td></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>1</td></tr></table></td></tr>
</table>

Table 159 - Logic gates (Continued)

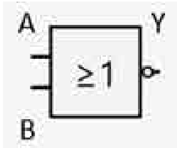
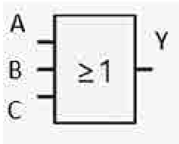
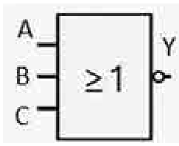
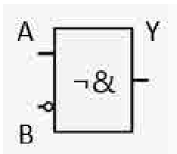
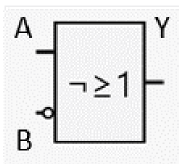
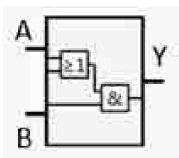
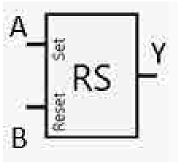
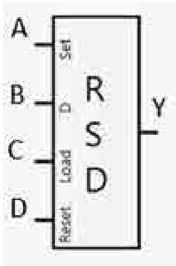
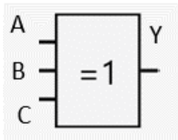
<table>
<tr><th>Logic gate</th><th>Symbol</th><th>Truth table</th></tr>
<tr><td rowspan="3"></td><td>
</td><td><table><tr><th colspan="2">In</th><th>Out</th></tr><tr><td>A</td><td>B</td><td>Y</td></tr><tr><td>0</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td></tr></table></td></tr>
<tr><td>
</td><td><table><tr><th colspan="3">In</th><th>Out</th></tr><tr><td>A</td><td>B</td><td>C</td><td>Y</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>1</td><td>1</td></tr></table></td></tr>
<tr><td>
</td><td><table><tr><th colspan="3">In</th><th>Out</th></tr><tr><td>A</td><td>B</td><td>C</td><td>Y</td></tr><tr><td>0</td><td>0</td><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>1</td><td>0</td></tr></table></td></tr>
<tr><td>INVAND</td><td>
</td><td><table><tr><th colspan="2">In</th><th>Out</th></tr><tr><td>A</td><td>B</td><td>Y</td></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td></tr></table></td></tr>
<tr><td>INVOR</td><td>
</td><td><table><tr><th colspan="2">In</th><th>Out</th></tr><tr><td>A</td><td>B</td><td>Y</td></tr><tr><td>0</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>0</td></tr></table></td></tr>
<tr><td>OR+AND
(AND+OR
reversed)</td><td>
</td><td><table><tr><th colspan="2">In</th><th>Out</th></tr><tr><td>A</td><td>B</td><td>Y</td></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td></tr></table></td></tr>
</table>

Table 159 - Logic gates (Continued)

<table>
<tr><th>Logic gate</th><th>Symbol</th><th>Truth table</th></tr>
<tr><td>RS
(set+reset)</td><td>
</td><td>
<table>
<tr><th>A</th><th>B</th><th>Y</th></tr>
<tr><td>Set</td><td>Reset</td><td>Y</td></tr>
<tr><td>1</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>0 if last value of Y = 0
1 if last value of Y = 1</td></tr>
<tr><td>0</td><td>1</td><td>0</td></tr>
</table>
</td></tr>
<tr><td>RS_D
(set+D+load+reset)</td><td>
</td><td>
<table>
<tr><th>A</th><th>B</th><th>C</th><th>D</th><th>Y</th></tr>
<tr><td>Set</td><td>D-input</td><td>Load</td><td>Reset</td><td>Y</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>x</td><td>x</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>x</td><td>x</td><td>x</td><td>1</td><td>0</td></tr>
</table>
</td></tr>
<tr><td>XOR</td><td>
</td><td>
<table>
<tr><th colspan="3">In</th><th>Out</th></tr>
<tr><td>A</td><td>B</td><td>C</td><td>Y</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td></tr>
</table>
</td></tr>
</table>

Advanced logic

PowerLogic P5 protection relay can also support an advanced programming tool (ISaGRAF™ Workbench of Rockwell Automation) for developing user-defined programmable logic. The advanced logic can be used in conjunction with the programmable logic to create a very flexible and strong logic capability. The programmable logic is optimised for execution speed whilst the advanced logic of ISaGRAF™ provides flexibility. Typically, high speed interlocks and tripping functions should use the programmable logic whilst less time demanding functions such as complex control functions are more suited to the advanced logic. ISaGRAF™ offers a solution compliant to the IEC 61131 and IEC 61499 standards.

To know whether the PowerLogic P5 protection relay supports the advanced logic function or not, check the second last bit of the model number. For PowerLogic P5 with V01.40x.yyy firmware version C stands for Advanced logic and CS Basic. D stands for Advanced logic and CS Advanced. For PowerLogic P5 with V01.500.101 firmware version and next ones, F stands for Advanced logic and CS Settable (CS Basic or CS Advanced).

P 5 x 2 0 - _ _ _ _ - _ _ _ _ _ - _ _ **C** _

P 5 x 3 0 - _ _ _ _ - _ _ _ _ _ - _ _ **D** _

P 5 x 3 0 - _ _ _ _ - _ _ _ _ _ - _ _ **F** _

ISaGRAF™ Workbench including text and graphics editors is used to develop specific custom applications in the following programming languages :

- SFC: Sequential Function Chart
- ST: Structured Text
- LD: Ladder Diagram
- FBD: Function Block Diagram
- SAMA: Scientific Apparatus Makers Association

PowerLogic P5 with ISaGRAF™ Runtime capability supports maximum 2048 boolean digital inputs and 128 boolean digital outputs. There is no limit on the number of gates and timers.

Table 160 - Settings and characteristics of the advanced logic

Settings/characteristics	Value
Inputs	
Number	2048 All boolean signals available in matrix.
Outputs	
Number	128 These outputs can be configured through matrix according to the application usage and can be used in the Programmable logic.
Execution rate	
Value	40 ms
Timer	
Accuracy	±1% or ±40 ms

The eSetup Easergy pro provides several parameters about the advanced logic function. **Project files CRC** is Cyclic Redundancy Check for project files, which is to check whether the content of the logic is changed. **Project name**, **Project comment**, **Configuration name** and **Configuration comment** can be customised in the ISaGRAF™ Workbench.

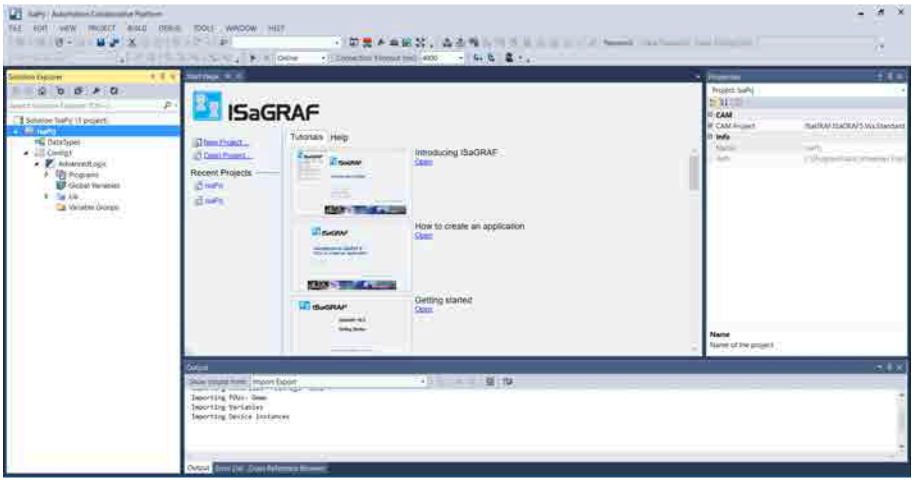
In order to create an advanced logic, the ISaGRAF™ Workbench software of Rockwell Automation needs to be installed on the computer and a license for activating the ISaGRAF™ is needed. For more information on the license, please contact RAisagraf_sales@ra.rockwell.com or local Rockwell Automation Sales Office.

Creating an advanced logic offline

1. When ISaGRAF™ Workbench with an active license is installed on the computer, the logic can be created by clicking the **Edit advanced logic** in the **CONTROL** menu/**Advanced logic** sub-menu via the eSetup Easergy Pro. Then a default project will be opened in the ISaGRAF™ Workbench automatically. Whilst editing using the ISaGRAF™ Workbench, Easergy Pro will be locked out.

   NOTE: Only PowerLogic P5 products with the correct order option will have the **Advanced logic** sub-menu.

   Figure 340 - View of ISaGRAF™ Workbench of Rockwell Automation



2. To create an advanced logic (in FBD as an example), double click **Demo**, which is under **IsaPrj**/**Config1**/**AdvancedLogic**/**Programs** at the left side of the ISaGRAF™ Workbench. To create an advanced logic in other programming languages, right click **Programs** and choose **add**. For more information on those properties and on building a logic in the ISaGRAF™ Workbench, click **HELP** on the title bar.

   The boolean signals of the PowerLogic P5 can be used as the variables in the ISaGRAF™ Workbench. The user can link the PowerLogic P5 signals to the variables in the ISaGRAF™ Workbench, by double clinking the variables in the logic diagram. The available signals include NI, DI, VI, VO, protection start or trip signals, and program logic output signals.

   PowerLogic P5 ISaGRAF™ logic supports a maximum of 128 boolean digital outputs. These outputs can be configured through matrix according to the application usage and can be used in the Programmable logic.

   When creating an advanced logic, in order to keep its performance, the following suggestions are recommended:

   - Try to create all the logic in one diagram. Logic is executed from top to bottom and from left to right in the ISaGRAF™ Workbench, thus follow this principle when creating logic.
   - If the logic is in multiple diagrams, pay attention to the order of those diagrams. Set the value of **Order** of the diagram, to be executed first, to 1 in the **Properties** panel, and so on.

NOTICE

IMPROPER OPERATION

The property **resource name** should not be modified in the ISaGRAF™ Workbench.

Failure to follow these instructions can result in improper operation.

3. When the logic is built, click **Save** and close the ISaGRAF® workbench. A pop-up window showing the information “Do you want to attach advanced logic project (ISaGRAF™) to the configuration?” appears on the screen of the eSetup Easergy pro. Click **Yes**.
4. In the eSetup Easergy pro, click **Save as** to save the complete configuration file, which includes the created advanced logic, locally.
5. Connect the P5 device through the eSetup Easergy pro, and open the saved configuration file. Then **Write** the configuration file to the P5 device.

eSetup Easergy Pro is the only way to download ISaGRAF™ logic into P5 device. In the process of downloading, if there are invalid signals, an alarm window will pop-up (while the ISaGRAF™ program continues to run).

Updating an advanced logic online

1. Connect the P5 device through the eSetup Easergy Pro.

2. Click the **Edit advanced logic** in the **CONTROL** menu/**Advanced logic** sub-menu via the eSetup Easergy Pro.
3. Update the advanced logic in the ISaGRAF™ Workbench.
4. After updating, click **Save** and close the ISaGRAF™ Workbench. Then A pop-up window appears on the screen of the eSetup Easergy pro. Click **Yes**.
5. **Write** the configuration file to the P5 device via the eSetup Easergy Pro.

eSetup Easergy Pro is the only way to download ISaGRAF™ logic into P5 device.

Commissioning

NOTICE

CYBER SECURITY

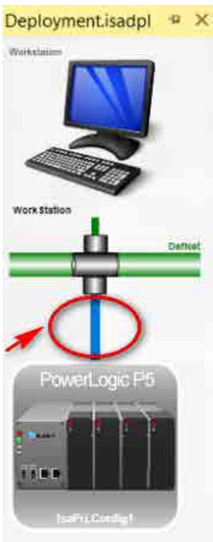
The ISaGRAF™ debugging protocols do not include security capabilities, the data transmission is in plain text. For this reason, this function must be used in secured communication networks only.

It is strongly recommended to disable this function in normal operation mode, as with default settings.

Failure to follow these instructions can result in improper operation.

PowerLogic P5 supports the online commissioning function of the advanced logic. To enable the online debug, please: in eSetup Easergy Pro, go to the **Communication** menu, in the section **Protocol configuration**, uncheck the setting **Disable advanced logic port**.

1. Click **IsaPrj**. Then click **VIEW** on the title bar, and choose **Deployment View**.
2. Select part of the wire connecting the PowerLogic P5 in the deployment window.



3. Enter the IP address of the mini-USB port or the Ethernet port of the PowerLogic P5 in the **Properties** panel at the right side of the ISaGRAF™ Workbench.
4. **Save** the configuration, click **BUILD** and choose **Build Solution the logic**.
5. Download the advanced logic via the ISaGRAF™ Workbench to the P5 device by right clicking **IsaPrj**, and then select **Download**.

6. Select **Online** and click **Start Debugging button**.

The commissioning includes:

- Users can commission the logic in the ISaGRAF™ Workbench to highlight which part of the logic is being activated.
- Users can assign different values to the input to simulate the output to check the correct behaviour of the logic.

For more information on how to assign the values to the inputs in the simulation mode, please refer to the **HELP** on the title bar of the ISaGRAF™ Workbench.

NOTE: To commission an advanced logic, download it via the ISaGRAF™ Workbench (see Commissioning, page 552). After the commissioning, to execute the logic, **Write** it to the P5 device via the eSetup Easergy Pro.

Switchgear control and monitoring

Switchgear control and fail-safe position

For the PowerLogic P5 protection relay, operational reliability helps ensure the safety and availability of the installation.

This means avoiding the following 2 situations:

- Nuisance tripping of the protection

  Continuity of the electrical power supply is as vital for a manufacturer as it is for an electricity distribution company. Nuisance tripping caused by the protection can result in considerable financial losses. This situation affects the availability of the protection.

- Failure of the protection to trip

  The protection relay must detect faults in the electrical power system as quickly as possible.

  Power network systems consist of a set of components (cables, switchgear, protection relays, measurement transformers, MV/LV transformers, etc.) whose correct operation may be affected by failures. The consequences of failure of one of the power system components are varied and depend on factors specific to each power system.

  These include:

  - Power system topology
  - Type of connected users
  - Load types
  - Position of each component in the power system
  - Failure mode for each component, etc.

  In case a power system fails, it is the responsibility of the user to prioritise either continuity of the electricity supply, or shutdown of part of the power system. While designing the power system and its protection plan, knowledge of the failure modes for each element can be used to steer the failure into a particular state. This requires the failure mode for the power system elements to be as deterministic as possible.

  To comply with this approach, the PowerLogic P5 protection relay is equipped with self-tests that continuously check all its electronics and embedded software are operating correctly. The purpose of the self-tests is to put the PowerLogic P5 protection relay into a deterministic position, called the fail-safe position, in the event of failure or malfunction of one of its internal components. In the fail-safe position the PowerLogic P5 protection relay is no longer operational. All its output relays are forced into the default position and the power system is no longer protected. If the auxiliary power supply disappears, the PowerLogic P5 protection relay's contact relays are also in the off-position.

  The table below indicates the possible types of behaviour in the event of PowerLogic P5 protection relay failure. Use in standard mode or in custom mode is described in the sections below.

Circuit Breaker with Shunt Trip Coil	Circuit Breaker with Undervoltage Trip Coil
The circuit breaker stays closed if PowerLogic P5 protection relay goes into the fail-safe position. Monitoring is required to detect whether the protection is no longer operational.	The circuit breaker opens automatically if PowerLogic P5 protection relay goes into the fail-safe position. The circuit breaker opens if the substation auxiliary voltage disappears.

Selecting the trip command and examples of use

NOTICE

RISK OF UNPROTECTED ELECTRICAL INSTALLATION

Always connect the watchdog output to a monitoring device to mitigate and take appropriate action when the selected trip command does not result in the installation tripping or when the PowerLogic P5 protection relay fails.

Failure to follow these instructions can result in unprotected electrical installation.

An analysis of the operational reliability of the whole installation should determine whether availability or safety of this installation should be prioritised if PowerLogic P5 protection relay is in the fail-safe position. This information is used to determine the choice of trip command as outlined in Selecting the trip command, page 555.

Table 161 - Selecting the trip command

Dia-gram	Control	Event	Trip	Advantage	Disadvantage
1	Shunt trip breaker or mechanical latching contactor	Internal failure or loss of the auxiliary power supply	No	Availability of the installation	Installation not protected until remedial intervention
2	Breaker with undervoltage trip coil (fail-safe)	Internal failure or loss of the auxiliary power supply	Yes	Safety of the installation	Installation not available until remedial intervention
3	Breaker with undervoltage trip coil (not fail-safe)	Internal failure	No	Availability of the installation	Installation not available until remedial intervention
		Loss of auxiliary power supply	Yes	Safety of the installation	Installation not available until remedial intervention
4	Contactor without coil latching (permanent order)	Internal failure or loss of the auxiliary power supply	Yes	Safety of the installation	Installation not available until remedial intervention

Figure 341 - Example of use with shunt trip coil (diagram 1)

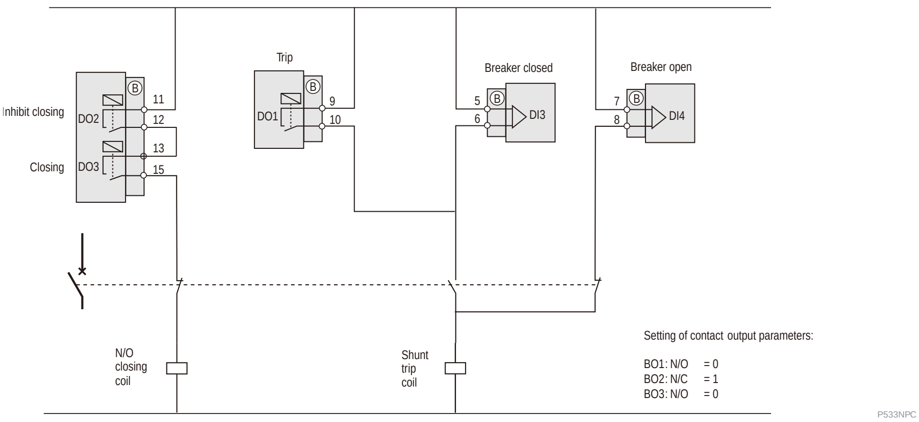


Figure 342 - Example of use with undervoltage trip coil with fail-safe condition (diagram 2)

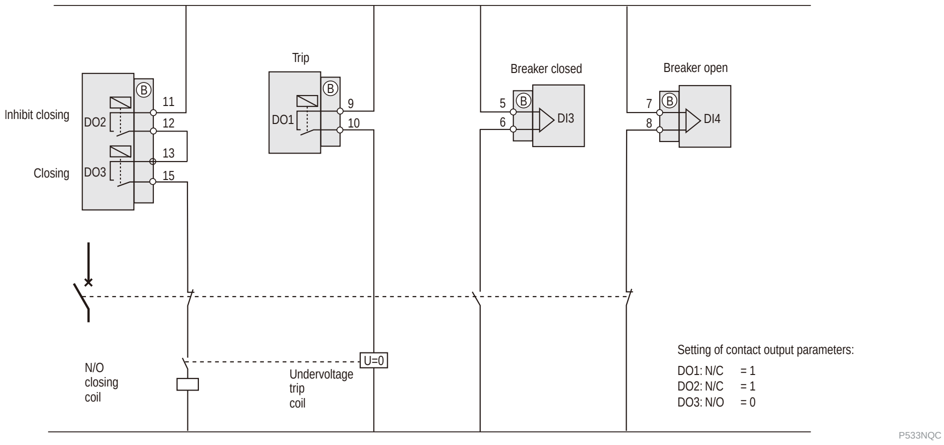
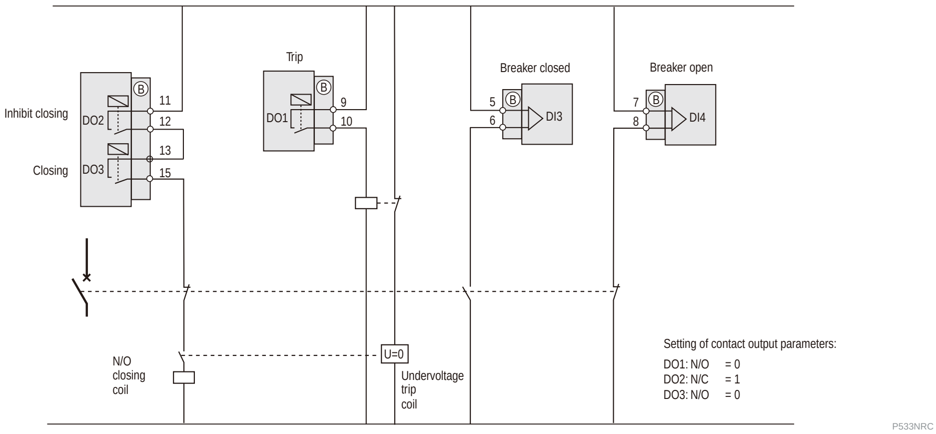
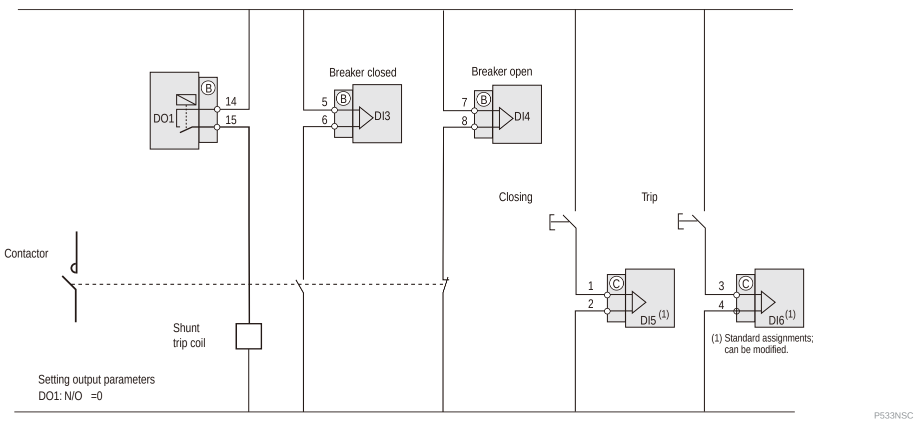


Figure 343 - Example of use with undervoltage trip coil without fail-safe condition (diagram 3)



NOTE: When using an undervoltage trip coil, it is recommended to install a free wheel diode in parallel to the opening coil in order to slow down its operation in the event of a microbreak on its power supply.

Figure 344 - Example of use with contactor under permanent order command (diagram 4)



Programmable switchgear interlocking

Switchgear interlocking can be easily done using the object matrix.

For example, if object 1 is the circuit breaker, object 2 the isolating switch, and object 4 the ground switchgear, the blocking scheme could be configured as below:

1. When CB is closed, the isolating switch open operation is blocked.
2. When ground switchgear is closed, the CB close operation is blocked.

Local control on single-line diagram

The objects can be controlled directly on the local panel in the mimic screen that includes the single-line diagram.

1. Press the OK key.
2. With the ◁ and ▷ arrow keys, select the object, or one of the four virtual inputs, or the auto-reclosing (if they are displayed in the mimic).
3. Press the OK key to bring up the menu list.
4. Select Open or Close and then press the OK key.

   NOTE: Only the objects configured connected in Output matrix can be selected in Mimic screen.

Logging and recording functions

Time tagging

For operations and fault analysis all data are logged with an accurate date and time.

The items that are time tagged and logged are:

- Events
- Disturbance recording
- Fault data logging
- Voltage interruptions
- Maximum and minimum values of the last 31 days or last 12 months

The PowerLogic P5 protection relay time stamp resolution is 1 ms.

Event buffer

The PowerLogic P5 protection relay provides a logging and recording of all important events that happen during operation. All “operationally relevant” signals, each fully tagged with date and time at signal start and signal end, are registered and stored in chronological order. For example, an event can be, start-on, start-off, trip-on or trip-off of any protection stage, alarm-on or alarm-off, a digital input change, etc. Each event is associated with a unique code. The selection of signals to be considered in the event logging and recording can be configured by the user.

As an example, a typical trip event is shown in Example of I>1 trip-on event and its visibility in local panel and communication protocols, page 559.

Table 162 - Example of I>1 trip-on event and its visibility in local panel and communication protocols

Event	Description	Local panel	Communication protocols
Code CHENN: 01E02	CH = event channel, channel 1 NN = event code, event 2	No	Yes
A-B-C	Fault type	Yes	No
Event desc: I>1 trip on 2 pu	Event text and fault value	Yes	No
yyyy-mm-dd: 2018-01-31 hh:mm:ss:nnn: 08:35:13.413	Date Time	Yes	Yes

Timestamp is truncated to 1 ms in event list. The logged events can also be read using:

- Local panel (see the **Events list** view under the **Events** option of the **Logs** menu)
- eSetup Easergy Pro or Web HMI (see the **Event buffer** view in the **LOGS** menu)
- Communication: In this case, only the latest event can be read.

On the local panel, the code is replaced by a ranking number.

With eSetup Easergy Pro, the events can be stored to a file, which is very helpful if the PowerLogic P5 protection relay is not connected to a SCADA system.

SCADA systems are reading events using any of the available communication protocols.

Event configuration

To configure which events are recorded the event enabling matrices are used (see the Event enabling views in the **LOGS** menu of eSetup Easergy Pro). This allows the optimisation of reporting by selecting the most useful events and deselecting the ones of no interest. This prevents them from being written to the event buffer.

- Event enabling - stages 1

  This matrix is used to activate an event when there is a change of the Start and Trip status of a protection function/ stage. Select **On**, **Off** or **both**.
- Event enabling - stages 2

  This matrix is similar to the Event enabling - stages 1 matrix but dedicated to functions which provide more information than start and trip signals (e.g. thermal image protection).
- Event enabling - objects

  This matrix is dedicated to generate events associated to the defined objects such as circuit breaker status and controls.
- Event enabling - AR

  This matrix is dedicated to the auto recloser function and is used to generate events associated with auto reclose states and status.
- Event enabling - logic

  This matrix is used to generate events when one of the logic equations (up to 20) gets true or false.
- Event enabling - other

  This matrix is dedicated to system monitoring including setting group change.

The maximum size of the buffer is 2000 events and can be exported as a PDF file via eSetup Easergy Pro **Print** menu. 300 events can be displayed by eSetup Easergy Pro. Only the latest 300 events, or the oldest 300 events, can be read on the local panel according to the scroll order parameter.

All events are stored in non-volatile memory inside the PowerLogic P5 protection relay and can be saved every 150 ms in the backup memory if available (Extension board option).

When the buffer is filled the oldest event will be overwritten when a new event occurs. The shown resolution of a time stamp for an event is one millisecond, but the actual resolution depends on the particular function creating the event. For example, most protection stages create events with a 5 ms, 10 ms or 20 ms resolution. The absolute accuracy of all time stamps also depends on the protection relay's time synchronisation.

Event buffer overflow

The normal procedure is to poll events from the PowerLogic P5 protection relay all the time. If this is not done, the event buffer could reach its limits. In that case, the oldest event is deleted and the newest is displayed with an OVF (overflow) code on the local panel.

The Event setting parameters can be configured in **Logs**/**Event logs**/**Counter** of the local panel .

Characteristics

Table 163 - Setting parameters for events

Parameter (description/label)	Value	Description
Clear events/Clear events	-	
	Clear	Clear the buffer of events
Fault value scaling/Fault value		Scaling of event fault value
	PU	Per unit scaling
	Primary	Primary scaling
Display evt time not in sync/Event synchro.	On (check mark)	Event time shown normally if relay is synchronised
	Off	Event time is shown in brackets if relay is not synchronised

Table 164 - Measured and monitored parameters for events

Parameter (description/label)	Value	Description
Event buffer size/ Counter	2000	Event buffer size

Disturbance recording

Description

The PowerLogic P5 protection relay provides for fault events a disturbance recording with the sampled analogue values of pre-selected analogue currents and voltages before, during and after a fault event. Additionally, the calculated frequency, the states of digital inputs (DI) and output (DO) signals are provided for detailed fault analysis. The complete list of provided signals is shown in Disturbance recording parameters (measurements and monitored values), page 563.

Triggering the recording

The recording can be triggered by any start or trip signal from any protection stage, by a digital input, logic output or GOOSE signals. The triggering signal is selected in the output matrix (vertical signal DR). The recording can also be triggered manually. All the recordings are time stamped. The recording can be made at 48 samples/cycle or 24 samples/cycle rate.

Reading recordings

The recordings can be downloaded with eSetup Easergy Pro. The recording is in COMTRADE format. This also means that other programs can be used to view and analyse the recordings made by the PowerLogic P5 protection relay.

PowerLogic P5 disturbance records can be read as well thru IEC 61850 and DNP3 ethernet protocols and DNP3 and IEC 60870-5-103 serial communication protocols. In case disturbance record is downloaded with sFTP, PowerLogic P5 generate and compress disturbance recorder COMTRADE data file with DEFLATE format (rfc1950) by using public domain zlib functions. To decompress the COMTRADE data file, please follow inflate API process defined in Zlib specification. For detail, please visit home page of zlib (http://www.zlib.net/).

Number of channels

A maximum of 30 records can be stored with a mix of analogue and digital signals:

- 14 Analogue signals
- 124 Digital Signals (40 Digital inputs; 20 Digital outputs; 32 Start signals; 32 Trip signals)

A pre-selection of the channels and their order in the fault recording is made per default and can be changed by the user with the parameters shown in Disturbance recording parameters (measurements and monitored values), page 563.

Table 165 - Examples of disturbance recording durations

Selected signals	Maximum time setting
4 analogue input signals, up to 40 digital input signals , up to 20 digital output signals , start and trips signals[151][152]	48/cycle: 6.06 s 24/cycle: 12.12 s
4 analogue inputs and trip signals	48/cycle: 10.92 s 24/cycle: 21.86 s
4 analogue inputs, start and trip signals	48/cycle: 9.10 s 24/cycle: 18.20 s
8 analogue signals, up to 20 digital input signals, up to 20 digital output signals and trip signals	48/cycle: 4.96 s 24/cycle: 9.92 s
8 analogue signals, up to 20 digital input signals, up to 20 digital output signals, start and trip signals	48/cycle: 4.55 s 24/cycle: 9.10 s
9 analogue input signals, frequency, up to 40 digital input signals, up to 40 digital output signals, all start and trip signals	48/cycle: 3.41 s 24/cycle: 6.82 s

151. Digital input signal means digital inputs (DI), virtual inputs (VI), etc.
152. Digital output signal means digital outputs (DO), virtual output (VO), etc.

NOTE: eSetup Easergy Pro provides directly the maximum recording length when the signals to record are selected (see the bottom section of the Disturbance recording view in the General menu).

NOTE: If the disturbance record is not correctly displayed in eSetup Easergy Pro, please try to change the setting of Encoding in Wavewin. You can find the .exe file from ...\Easergy Pro\Wavewin\Wavewin.exe. Double click **wavewin32.exe**, click on **Options**/**Display** from the menu bar, in pop-up **System Settings** window, select **Language** tab, then change the setting of **Encoding:** to UTF8, click **Ok** button.

Parameters

Table 166 - Disturbance recording parameters (measurements and monitored values)

Parameter (description/label)	Value	Description
Sample rate/SR		Sample rate per cycle (two options to select: 48/cycle or 24/cycle)
Maximum time setting/MaxLen		Maximum time setting (in second) This value depends on the number and type of the selected channels and the configured recording length.
Status/Status		Status of recording
	-	Not active
	Run	Waiting for a triggering
	Trig	Recording
Add recorder channel/AddCh		Add one channel. The maximum number of channels used simultaneously is 16. **NOTE:** For P5T30 or P5L30, delete one channel first if you want to add an extra channel. The maximum number of channels for DR is 16, so it is not possible to add more channels, even if it is a valid channel.
	IA, IB, IC	Phase current
	IN	Measured neutral current by CSH or CTs according to the model of PowerLogic P5
	VAB, VBC, VCA	Phase to phase voltage (only available in three voltage measurement modes: 2VPP+VN, 2VPP+VN+VPPy, VPP/VPPy)
	VA, VB, VC	Phase to neutral voltage (only available in four voltage measurement modes: 3VP, 3VP/VPy, 3VP/VPPy, 3VP+VN)
	VN	Neutral voltage
	f	Frequency (reference side)
	IN.sens	Sensitive neutral current
	VABy	Phase to phase voltage taken from other side of the CB for synchro-check scheme
	VAy	Phase to neutral voltage taken from other side of the CB for synchro-check scheme
	fy	Frequency (comparison side)
	DI	Digital inputs 1-20 and virtual inputs 1-4 status
	Other DI	The remaining digital inputs available and the function keys status
	DO	All digital outputs and virtual outputs 1-6 status

Table 166 - Disturbance recording parameters (measurements and monitored values) (Continued)

Parameter (description/label)	Value	Description
	Starts	Start signals of all enabled protection functions
	Trips	Trip signals of all enabled protection functions
Remove all channels/ClrCh	-; Clear	Remove all channels

Table 167 - Disturbance recording parameters (settings)

Parameter (description/label)	Value	Description
Recording length/Time	0.1...30 s	Recording length (in second)
Pre trigger time/PreTrig	0...100%	Amount of recording before triggering
Disturbance recording event	On (checkmark); Off	The event log is created or not when Disturbance recording is triggered.
Recording memory events	On (checkmark); Off	The event log is created or not when Disturbance recording is reset (clear the recording, reset the time and so on).
Manual triggering/ManTrig	-; Trig	Command to launch manually a new disturbance recording
Clear oldest buffer/Clear	-; Clear	Clear the oldest disturbance recording
Clear all buffers/ClrAll	-; Clear	Clear all the disturbance recordings

The selection of signals depends on the model of PowerLogic P5 protection relay and also on the voltage measurement mode.

Characteristics

Table 168 - Disturbance recording characteristics

Characteristics	Values	Note
Sample rate	48 samples/cycle 24 sample/cycle	
Recording time (one record)	0.1...30 s	
Pre-trigger rate	0...100%	
Number of selected analog channels	0...16	
File format	IEC 60255-24:1999 IEC 60255-24:2013	ASCII format

The recording time and the number of records depend on the time setting and the number of selected channels.

Voltage interruptions

Description

The PowerLogic P5 protection relay includes a simple function to detect voltage interruptions. The function calculates the number of voltage interruptions and the total time of the voltage-off time within a given calendar period. The period is based on the relay's real-time clock. The available periods are:

- 8 hours, 00:00...08:00, 08:00...16:00, 16:00...24:00
- one day, 00:00...24:00
- one week, Monday 00:00...Sunday 24:00
- one month, the first day 00:00...the last day 24:00
- one year, 1st January 00:00...31st December 24:00

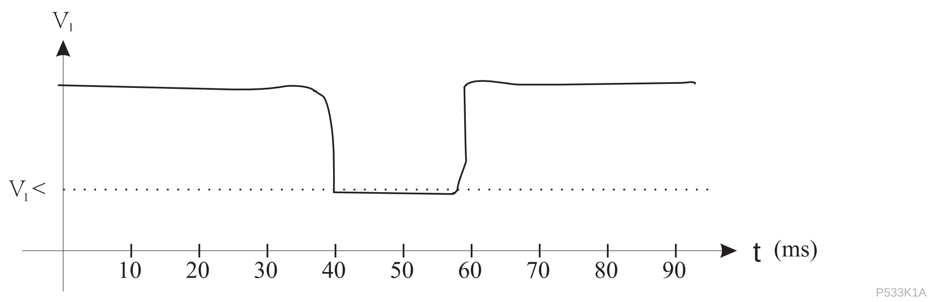
After each period, the number of interruptions and the total interruption time are stored as previous values. The interruption counter and the total time are cleared for a new period. Previous values are overwritten.

Voltage interruption is based on the value of the positive sequence voltage V1 and a set limit value. Whenever the measured V1 goes below the limit, the values of the interruption counter and the total time counter starts are incremented.

The shortest recognised interruption time is 40 ms. If the voltage-off time is shorter, it may be recognised depending on the relative depth of the voltage dip.

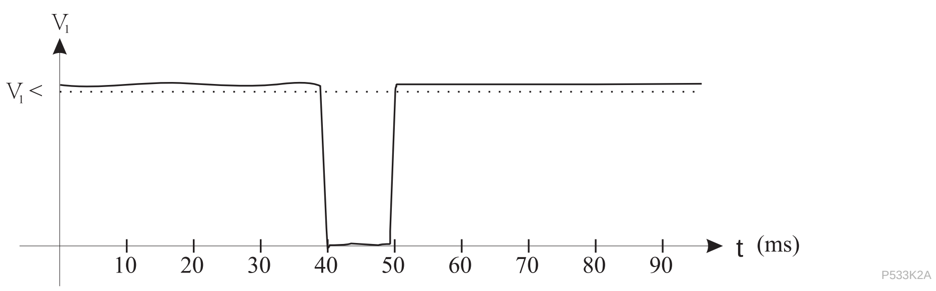
If the voltage has been significantly above the limit V1< and then there is a small and short under-swing, it is not recognised.

Figure 345 - A short voltage interruption which is probably not recognised



On the other hand, if the limit V1< is high and the voltage has been near this limit, and then there is a short but very deep dip, it is recognised.

Figure 346 - A short voltage interrupt that will be recognised



Settings and measurements

The following Setting parameters of the voltage interruption function, page 566 describes the setting parameter used for the voltage interruption and Measured and recorded values of the voltage interruption function, page 566 shows the related measured values available.

Table 169 - Setting parameters of the voltage interruption function

Parameter	Value
Voltage low limit/V<	
Setting range	10%...120% Vn[153]
Resolution	1% Vn[153]
Reset ratio	> 103%
Accuracy	3%
Int. Calc. period/Period	
Options	8h; Day; Week; Month; Year
Characteristic time	
Start time	< 60 ms
Disengaging time	< 60 ms

Table 170 - Measured and recorded values of the voltage interruption function

	Parameter	Value	Description
Measured value	Voltage	LOW; OK	Current voltage status
	V1		Measured positive sequence voltage
Recorded values	Interruption counter/Count		Number of voltage interruptions during the current observation period
	Prev. # of interrupts/Prev		Number of voltage interruptions during the previous observation period
	Total interrupt time/ Total		Total (summed) time of voltage interruption during the current observation period **NOTE:** Total interrupt time "5 20" means 5 days and 20 hours.
	Previous total int. time/Prev		Total (summed) time of voltage interruption during the previous observation period

153. Vnom

Fault data logging

Fault log provides fault signals including the measured fault data captured during a fault sequence. The fault logs are logged in chronological order with reference to the specific fault.

A new fault log is triggered by a starting signal of a protection function.

As an example, a typical fault log is shown in Example of I>1 LOG and its visibility in local panel and communication protocols, page 567.

There is detailed information available of the eight latest faults: date, time stamp, setting group active, fault type, fault phase, fault value, I/Vpole angle, elapsed delay, pre-fault current and fault direction.

The information can be different according to the protection functions.

Table 171 - Example of I>1 LOG and its visibility in local panel and communication protocols

Parameters (description/label)	Value	Description
Date/Date	2022-02-28	Time stamp of the fault log, date
hh:mm:ss:ms	13:28:41.321	Time stamp, time of day
Group/SetGrp	1	Active setting group during fault
Fault type/Fault type	A-N	Fault type
Fault phase/Fault phase	A	Fault phase
I>1 fault value/Fault value	5.00 pu	Maximum fault current
I/Vpol angle	120°	I/Vpol angle
Elapsed delay/End delay	100%	Elapsed time of the operating time setting. 100% = trip
Pre-fault current/Pre-fault current	0.00 pu	1 s average phase currents before the fault
Fault direction	Forward	Fault direction

Table 172 - Example of VT supervision and its visibility in local panel and communication protocols

Parameter (description/label)	Value	Description
Date/Date	2018-02-12	Time stamp of the fault log, date
hh:mm:ss:ms	09:45:15.245	Time stamp, time of day
V2 value/V2	x V	Negative sequence voltage
I2 value/I2	x A	Negative sequence current

The fault logs can be read via:

- Local panel

  In the **Log** view of each protection function in the **Protection** sub-menu
- eSetup Easergy Pro or Web HMI

  In each protection function view in the **Protection** menu
- Communication

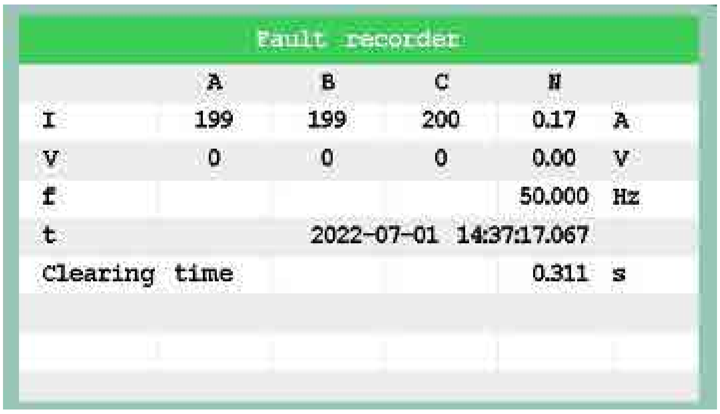
  In this case, only the latest fault logs can be read.

Fault recorder

PowerLogic P5 provides a dedicated fault recorder panel to display the last fault information. Compared to the fault data logging, fault recorder can provide additionally the magnitude of all the phases.

Fault record is triggered instantaneously by general trip signal. This function records the fault information right after the global trip signal is issued.

Figure 347 - An example of fault recorder in P5x30 local panel



From the fault recorder panel, you will find the following information:

- IA, IB, IC magnitudes in primary [A]
- VA, VB, VC magnitudes in primary [V]
- IN.calc (derived value regardless sensing mode) in primary [A]
- VN.calc (derived value regardless voltage connection mode) in primary [V]
- Frequency magnitude f in [Hz]
- Trip time stamp (= Time when global trip (on event))
- Clearing time (the interval from trip to CB open) = Time when CB open (on event) – Time when global trip (on event)

Access fault recorder screen

After a fault occurred, the fault record can be read from local panel. There are two methods to access:

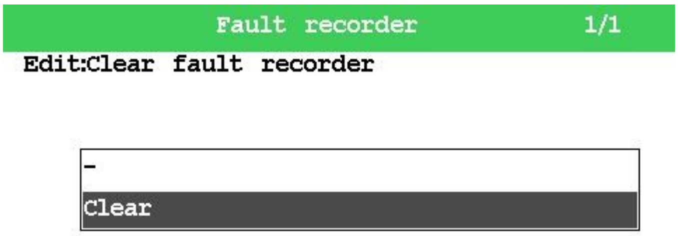
- When alarm messages popup or current view is the home screen, press *i* key to access the **Fault recorder** screen to check the last fault information in detail.
- After setting *Fault recorder* as default screen (in the eSetup Easergy Pro software, in **GENERAL/Local panel conf**.), when default screen is displayed, press ◁ or ▷ key to access the **Fault recorder** screen.

Figure 348 - Setting Fault recorder as default screen

Reset fault recorder value

Fault recorder value can be reset by following one of the two methods:

- On local panel, go to **LOGS & ALARMS /Fault recorder** screen, select *Clear* option.



- In eSetup Easergy Pro, go to **Device/Clear** page, enable the **Clear fault recorder** checkbox, then click **OK**.

After the reset operation, all the values will be reset to default values.

InterRelay communication log

The InterRelay communication log records the following events:

- Comm link failure on/off
- Comm failure on/off
- Comm error on/off
- Address not paired on/off
- Loopback test mode on/off
- Loopback test OK on/off
- Loopback test NOK on/off

The InterRelay communication logs can be enabled/disabled by eSetup Easergy Pro in **LOGS**/**Event enabling – other**, in the **InterRelay communication** section.

Running hour counter

Description

The running hour counter is typically used to monitor the service time of the motor or appropriate feeder. This function calculates the total active time of the selected digital input, virtual I/O or function key. The resolution is 10 seconds.

Settings / characteristics

Table 173 - Running hour counter settings/characteristics

Settings / Characteristics (description/label)	Value
Engine running hours/Run hours	
Setting range	0...876000 h
Engine running/Runs (in seconds)	
Setting range	0...3599 s
Resolution	10 s
Start counter/Starts	
Setting range	0...65535
Running hour status/Status	
Options	Stop; Run
Run hour DI link	
Options	Selection of one digital input (DI), one virtual input (VI), one virtual output (VO), or one function key (Fx).
Started at	Date and time of the last activation
Stopped at	Date and time of the last inactivation

Maximum and minimum values of the last 31 days and 12 months

Maximum and minimum values of the phase currents and active/reactive/apparent power measurements from the last 31 days and the last 12 months are stored in the relay's non-volatile memory. Corresponding time stamps are stored for the last 31 days. This can be viewed in the **LOGS** menu/**Month max** sub-menu of the eSetup Easergy Pro.

The registered values are listed in the following table:

Table 174 - Registered values

Measurement	Max	Min	Description	31 days	12 months
IA, IB, IC	■		Phase current (fundamental frequency value)		
IN.meas, IN.sens	■		Neutral current		
S	■		Apparent power	■	■
P	■	■	Active power	■	■
Q	■	■	Reactive power	■	■

The timebase can be a value from one cycle to one minute. Also a demand value can be used as the timebase and its value can be set between 10 and 60 minutes.

Table 175 - Parameters of the day and month registers

Parameter	Value	Description
Timebase		Parameter to select the type of the registered values
	20 ms	Collect min and max of one cycle values[154]
	200 ms	Collect min and max of 200 ms average values
	1 s	Collect min and max of 1 s average values
	1 min	Collect min and max of 1 minute average values
	demand	Collect min and max of demand values
ResetDays		Reset the 31 day registers
ResetMonth		Reset the 12 month registers

154. This is the fundamental frequency RMS value of one cycle updated every 20 ms.

System clock and synchronisation

The PowerLogic P5 protection relay's internal clock is used to time-stamp events and disturbance recordings.

The system clock should be externally synchronised to get comparable event time stamps for all the protection relays in the system.

The synchronising is based on the difference of the internal time and the synchronising message or pulse. This deviation is filtered and the internal time is corrected softly towards a zero deviation.

Time zone offsets

Time zone offset (or bias) can be provided to adjust the protection relay's local time. The offset can be set as a Positive (+) or Negative (-) value within a range of -15.00 to +15.00 hours and a resolution of 0.01 h. Basically, resolution by a quarter of an hour is enough.

Daylight saving time (DST)

The protection relay provides automatic daylight saving adjustments when configured. A daylight saving time (summer time) adjustment can be configured separately and in addition to a time zone offset in the **GENERAL** menu/**System clock** sub-menu of the eSetup Easergy Pro.

Daylight time standards vary widely throughout the world. Traditional daylight/ summer time is configured as one (1) hour positive bias. The new US/Canada DST standard, adopted in the spring of 2007 is one (1) hour positive bias, starting at 2:00am on the second Sunday in March, and ending at 2:00am on the first Sunday in November. In the European Union, daylight change times are defined relative to the UTC time of day instead of local time of day (as in U.S.), so European customers need to carefully check the local country rules for DST.

The daylight saving rules are by default UTC +2:00 (24-hour clock):

- Daylight saving time start: Last Sunday of March at 03.00
- Daylight saving time end: Last Sunday of October at 04.00

To help ensure proper hands-free year-around operation, automatic daylight time adjustments must be configured using the “Enable DST” setting in the **GENERAL** menu/**System clock** sub-menu of the eSetup Easergy Pro and not with the time zone offset option.

Synchronisation modes and priority

PowerLogic P5 provides multiple synchronisation modes. The modes and priority are listed as follows.

Priority	Mode
1	IEEE1588
2	IRIG-B
3	SNTP
4	SNTP backup
5	DI pulse signal
6	Modbus
7	IEC101/103
8	DNP3

Synchronisation with DI

The clock can be recognised by reading minute pulses from digital or virtual inputs. The sync source is selected with the SyncDI setting. When a rising edge is detected from the selected input, the system clock is adjusted to the nearest minute. The length of the digital input pulse should be at least 50 ms. The delay of the selected digital input should be set to zero.

Synchronisation correction

If the sync source has a known offset delay, it can be compensated with this setting. This is useful for compensating hardware delays or transfer delays of communication protocols. A positive value compensates a lagging external sync and communication delays. A negative value compensates any leading offset of the external synch source.

Sync source

When the protection relay receives new sync message, the sync source display is updated. If no new sync messages were received within the last 200 or 400 seconds, the protection relay switches over to internal sync mode.

The timeout check value is either 200 seconds or 400 seconds, depending on the following cases:

- if no SNTP server IP address is available or only one SNTP server IP address is available, the timeout check value is 200 seconds.
- if there are two available SNTP server IP addresses, the timeout check value is 400 seconds.
- if the time source is IEEE1588, the timeout check value is 400 seconds, not affected by the available number of SNTP IP addresses.

Sync source: IRIG-B

IRIG-B synchronisation is supported by the IRIG-B module connected to the optional extension module of the protection relay.

Deviation

The time deviation means how much the system clock time differs from the sync source time. The time deviation is calculated after receiving a new sync message. The filtered deviation means how much the system clock was really adjusted. Filtering takes care of small deviation in sync messages.

Auto-lag/lead

The protection relay synchronises to the sync source, meaning that it starts automatically leading or lagging to stay in sync with the master. The learning process takes a few days.

Table 176 - Clock synchronisation parameters

Parameter (description/label)	Value	Description
synchronising source/ SySrc		Clock synchronisation source
	Internal	If there is no synchronising source within 200 s or 400 s, Internal will be the clock synchronisation source, refer to Synchronisation modes and priority, page 573 for more information.
	DI	Digital input
	SNTP	Protocol sync
	ModBus	Protocol sync
	ModBus TCP	Protocol sync

Table 176 - Clock synchronisation parameters (Continued)

Parameter (description/label)	Value	Description
	IEC101	Protocol sync
	IEC103	Protocol sync
	DNP3	Protocol sync
Minute sync pulse DI/ SyncDI[155]		The digital input used for clock synchronisation. Possible value depends on the type of I/O card installed.
	-	DI not used for synchronising.
	Select one digital or virtual input	
Synch correction/ SyOS	-10000.000... +10000.000 s	synchronisation correction for any constant deviation in the synchronising source
Auto adjust interval/ AAIntv[156]	0.0...1000.0 s	Adapted auto-adjust interval for 1 ms correction
Average drift/AvDrft	lead; lag	Adapted average clock drift sign
Sync message counter/MsgCnt	0...65535	The number of received synchronisation messages or pulses
Latest time deviation/ Dev	± 32767 ms	Latest time deviation between the system clock and the received synchronisation
Filtered sync deviation/FilDev	± 125 ms	Filtered synchronisation deviation

Table 177 - System clock parameters

Parameter (description/label)	Value	Description
Date/Date		Current date
Time of day/Time		Current time
Date style/Style	yyyy-mm-dd	Date format
	dd-mm-yyyy	
	mm-dd-yyyy	
Time zone/Time zone	-15.00...+15.00[157]	UTC time zone for SNTP synchronisation.[158]
Status of DST/DST	enabled; disabled	Daylight saving time for SNTP
Enable event	enabled; disabled	

155. Set the DI delay to its minimum and the polarity so that the leading edge is the synchronising edge.
156. If external synchronisation is used, this parameter is set automatically.
157. A range of -11 h - +12 h would cover the whole Earth but because the International Date Line does not follow the 180° meridian, a wider range is needed.
158. Decimal numbers are used, e.g. the time zone of 5:45 is expressed as 5.75.

Monitoring functions

Trip circuit supervision (ANSI 74)

Description

Trip circuit supervision monitors the wiring from the protective device to the circuit breaker trip coil. This function monitors the availability of the circuit when it is requested to trip and reports an issue if needed.

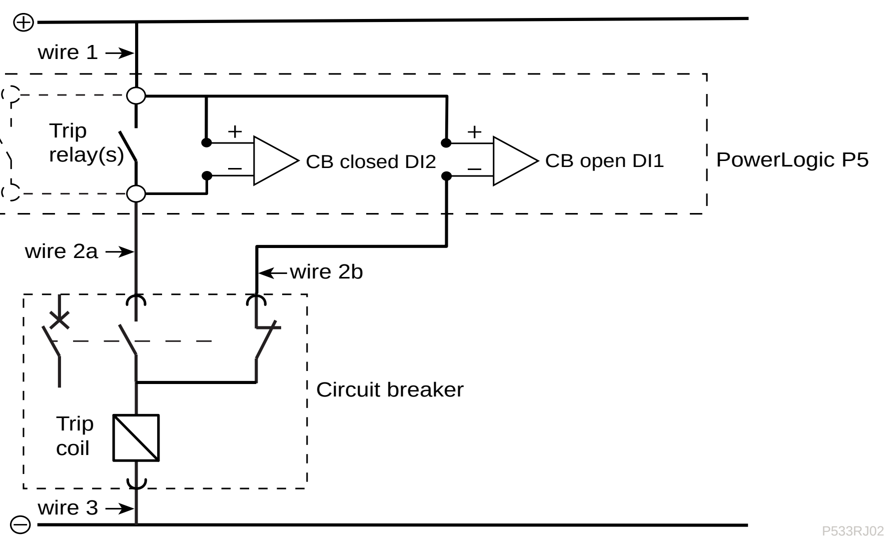
By default, this user-configurable supervision function uses the PowerLogic P5 programmable logic to monitor the circuit continuity, loss of auxiliary supply voltage or mismatching of the CB position indication contacts. Depending on user settings, the function inhibits closing of the circuit breaker.

In this user manual only the default trip circuit supervision using 2 digital inputs is described. Other schemes using just one input and external resistors can be equally set up, managed by DI configuration and logic scheme adaptation.

Trip circuit supervision scheme

The trip circuit supervision scheme using two digital inputs 52a and 52b can be implemented as illustrated in the following wiring diagram. No external resistors are needed for this scheme to function.

Figure 349 - Trip circuit supervision scheme



In the normal condition, when the trip circuit is OK, the status of inputs is opposite (0,1) or (1,0). When the trip circuit is not OK (coil, wires, auxiliary contact state or auxiliary voltage failure), both logic inputs are in the same state and an alarm is issued after a delay. This delay is needed to help prevent false signaling during breaker opening events. The timing is set based on breaker operating time and trip pulse length.

The following table summarises the TCS alarm output depending on the CB and its auxiliary contact positions as well as possible wiring failure conditions.

CB position	Conditions	CB open DI1	CB closed DI2	TCS alarm
Closed	Trip circuit OK	Closed	Open	False
	Wire 1 failure[159]	Open	Open	True

159. "failure" indicates that one or more of the components are permanently open circuit or short circuit.

CB position	Conditions	CB open DI1	CB closed DI2	TCS alarm
	Wire 2a failure[160]	Open	Open	True
	Wire 3 or trip coil failure[160]	Open	Open	True
Open	Trip circuit OK	Open	Closed	False
	Wire 1 failure[160]	Open	Open	True
	Wire 2b failure[160]	Open	Open	True
	Wire 3 or trip coil failure[160]	Open	Open	True

Figure 350 - Block diagram of trip circuit supervision (ANSI 74)

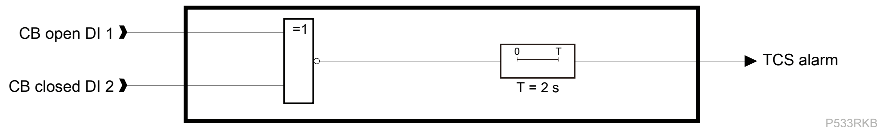
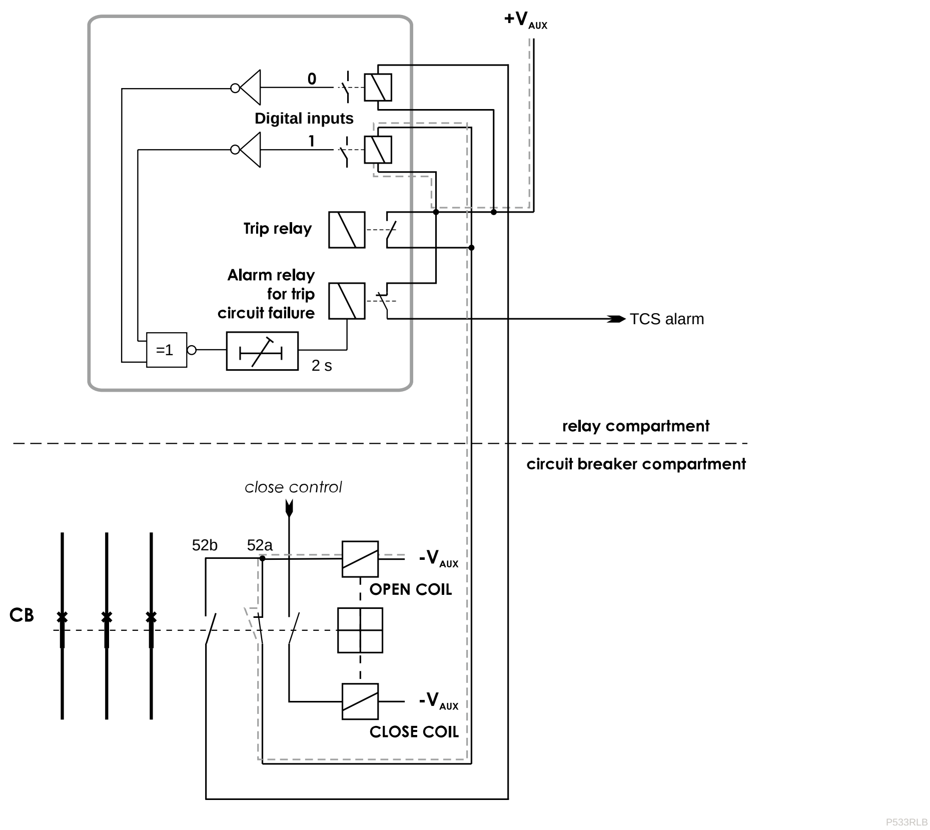
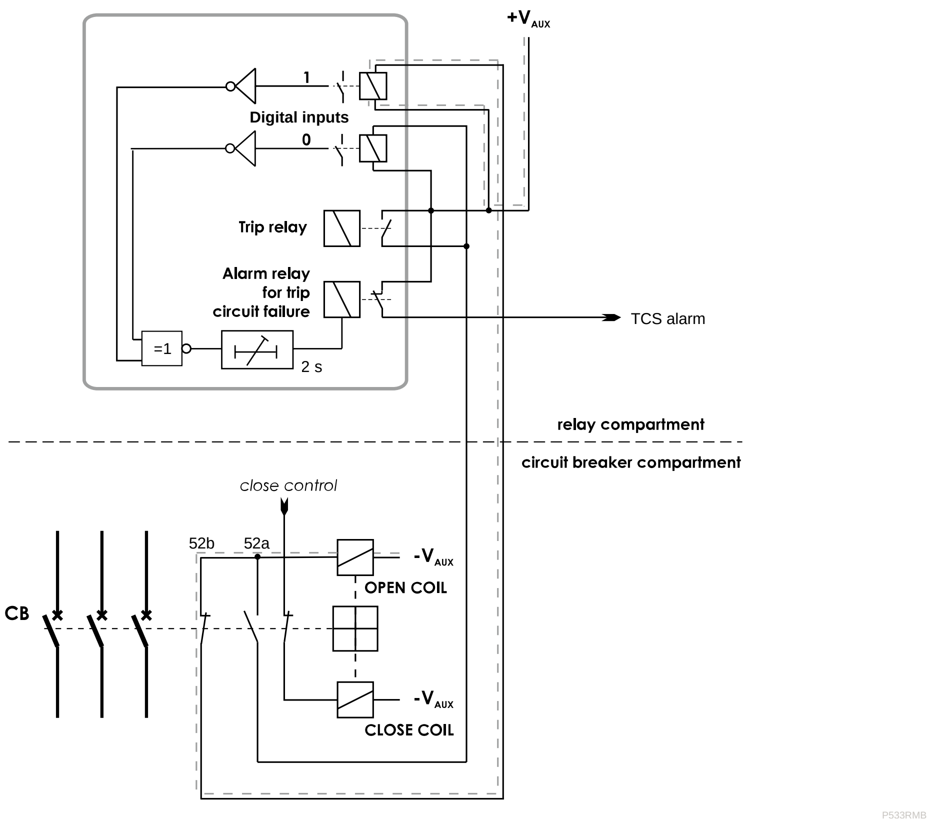


Figure 351 - TCS with two digital inputs when the CB is in closed position



160. "failure" indicates that one or more of the components are permanently open circuit or short circuit.

Figure 352 - TCS two digital inputs when the CB is in open position



The figure below shows the default logic configuration of TCS in PowerLogic P5. In this example the TCS is latched when an error condition is encountered and reset using a virtual input.

Figure 353 - An example of logic configuration for TCS

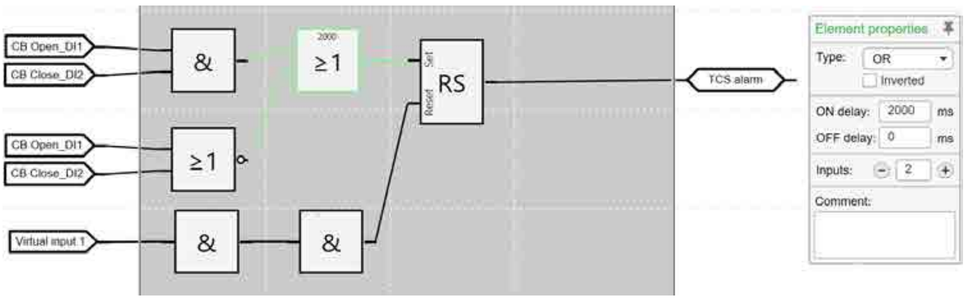
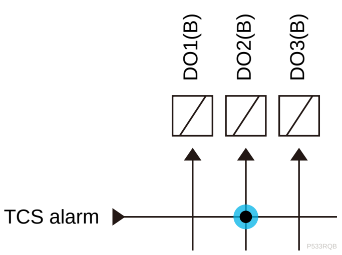


Figure 354 - An example of output matrix configuration for TCS



Transformer monitoring (ANSI 26/63)

Introduction

The transformer monitoring function (ANSI 26/63) is used to monitor signals from external Buchholz or Thermostat devices. Big transformers are usually fitted with one or more Buchholz relays.

A Buchholz relay detects gases that arise due to normal ageing processes of the transformer insulation. After a sufficient amount of gas has accumulated, the alarm contact is activated. This measurement principle has the effect that the alarm is also activated if the filling level of the insulating oil sinks below the mounting place of the Buchholz relay due to a leakage. Since in such a case the filling level sinks quite rapidly, it is common to have a separate detection hardware for this, which then issues an insulation alarm.

The number of such relays mounted at the transformer is dependent on the size and construction details (mainly whether it is 3-phase or three single-phase transformers, and whether it is with or without tap changer(s)).

Depending on the situation, the Buchholz relay either alarms operations or trips the CBs to prevent the transformer from damages. These alarm and trip signals can be routed to the protection IEDs for logging purposes, for using its communication link to transmit the signals to the SCADA system, or in case of the Buchholz trip to activate the tripping also through the protection IED trip circuit.

Main features of transformer monitoring function:

- Log relevant events when the input signals change state
  It can log any state change of the 8 signals (5 for alarm, 2 for trip, 1 for blocking) in the event buffer.
- Feed the trip input signals into the global trip signal.
  It can show alarm on the local panel when any of the 2 trip signals (gas trip/ oil flow trip) gets asserted.

Depending on the digital input signals, transformer monitoring indicates one of the following statuses:

Table 178 - Statuses of the transformer monitoring

Status	Description
-	Normal status, function is enabled and in normal operation (= in none of the following statuses); or function is not enabled.
Alarm	Function is enabled and in normal operation (not blocked) and any of the alarm input signals is active (= any of the 5 DIs for insulation alarm/ oil temperature alarm/ gas alarm/ oil at minimum level/ oil at maximum level is active).
Trip	Function is enabled and in normal operation (not blocked) and any of the trip input signals is active (= any of the 2 DIs for gas trip/ oil flow trip is active).
Blocked	Function is enabled and input assigned at “DI for blocking” is active.

The monitoring signals are readily available in P5 matrices as DI or VI with customizable names. Customization of DI/VI names is readily available to prevent doubts and mistakes about their meanings. Therefore there is no need to add the signals from transformer monitoring into any matrix.

Figure 355 - Transformer monitoring function in eSetup Easergy Pro

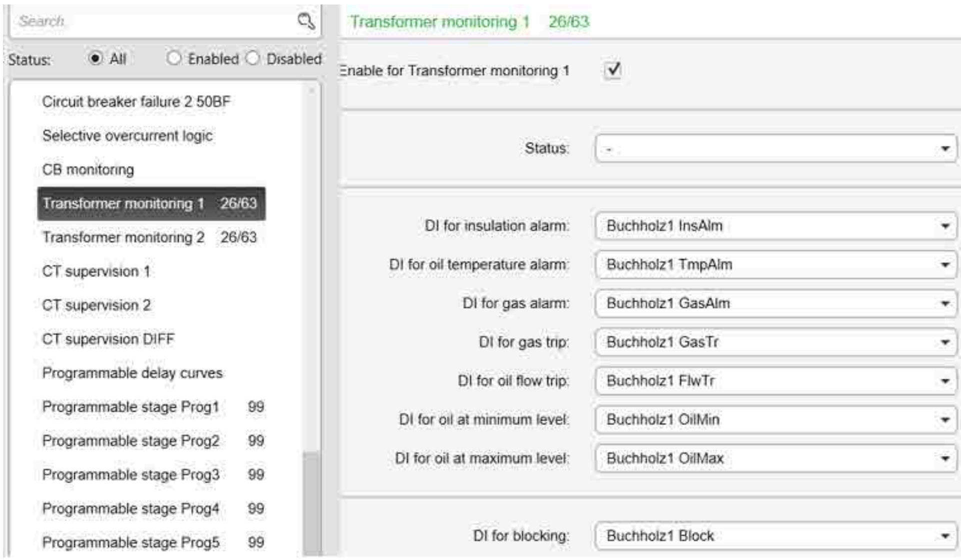
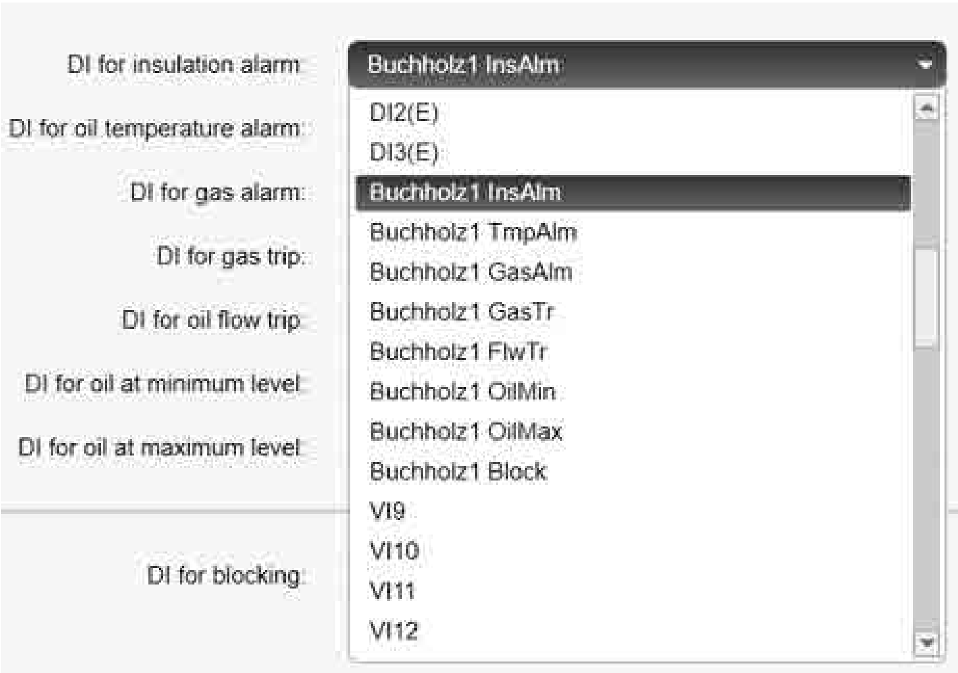


Figure 356 - DI/VI List



NOTE: The names of VI1 to VI8 have been customised in the figure above.

About setting group

The configuration of this monitoring function is independent from P5 setting groups. Only general settings are required.

Available links to P5 inputs

Although the signals are wired electrical input signals from physical Buchholz relays, they can be made available not only for assignment to the P5 physical opto-coupler inputs, but also to virtual (GOOSE) inputs.

DI signal

Table below lists the digital input signal for one instance of transformer monitoring.

Table 179 - 8 signals from transformer monitoring

Signal name	Description
Insulation alarm	Insulation liquid critical (refill insulation medium)
Oil temperature alarm	Insulation liquid temperature alarm
Gas alarm	Gas in insulation liquid alarm
Oil at minimum level	Insulation liquid level minimum
Oil at maximum level	Insulation liquid level maximum
Gas trip	Gas in insulation liquid trip
Oil flow trip	Insulation liquid flow trip because of gas
Block	Input assigned at “DI for blocking” is active

Blocking input signal

The purpose of blocking input signals is to inform the function about a defect in the monitoring system (defect sensor, loss of supply voltage, etc.). If this input is active, transformer monitoring function continues to read the connected digital input signals.

If transformer monitoring function is enabled and the block input signal gets asserted, then the global trip signal gets reset once it is triggered from this function only.

Global trip signal

If transformer monitoring function is enabled and in normal operation (not blocked) and any of the trip input signal (= any of the 2 DIs for gas trip/oil flow trip) gets asserted, then it will feed the trip signal into the global trip signal.

Three cases will reset the global trip signal if it is triggered from transformer monitoring function only.

- If transformer monitoring function is enabled and in normal operation (not blocked) and all the trip input signals get reset.
- If transformer monitoring function is enabled and the block input signal gets asserted.
- If transformer monitoring function gets disabled.

Characteristics

Table 180 - Characteristics of the transformer monitoring (ANSI 26/63)

Settings and characteristics	Values
Enable for Transformer monitoring	
Options[161]	Disabled; Enabled
Status	

161. Configured via Output Matrix

Table 180 - Characteristics of the transformer monitoring (ANSI 26/63) (Continued)

Settings and characteristics	Values
Options[162]	-; Alarm; Trip; Blocked
DI for insulation alarm	
Range	DIx; VIx
DI for oil temperature alarm	
Range	DIx; VIx
DI for gas alarm	
Range	DIx; VIx
DI for gas trip	
Range	DIx; VIx
DI for oil flow trip	
Range	DIx; VIx
DI for oil at minimum level	
Range	DIx; VIx
DI for oil at maximum level	
Range	DIx; VIx
DI for blocking	
Range	DIx; VIx

162. Configured via Output Matrix

Circuit breaker monitoring

Description

Periodic maintenance of circuit breakers is necessary to help ensure that the trip circuit and mechanism operate correctly and that the interrupting capability has not been compromised due to previous fault interruptions. The PowerLogic P5 protection relay records various statistics related to each circuit breaker operation, allowing an accurate assessment of the circuit breaker condition. Statistics are recorded to allow evaluation of both the electrical wear of the breaker contacts and the mechanical wear of the breaker mechanism.

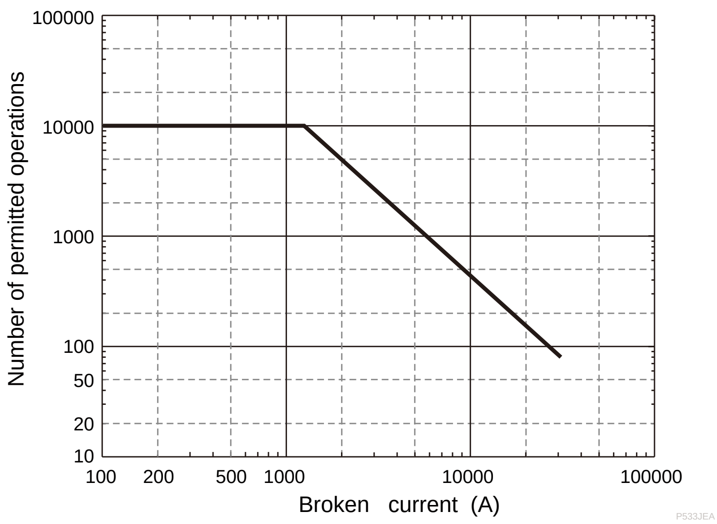
Transformer differential protection P5T30 provides one such CB monitoring element which can be linked to one CB and to the measured phase currents of that end accordingly.

Electrical wear

Breaker curve

The permitted CB operation number is defined by a CB permissible operation curve (CB wear curve). This curve is usually available in the documentation of the CB manufacturer. The curve specifies the permissible number of operations for every level of broken current.

Figure 357 - An example of circuit breaker permissible operation curve



As shown in the figure below, in the PowerLogic P5 protection relay, this curve is parameterised in the CB monitoring function with a maximum of eight points in the form of [CurveIx, CurveNx]. If less than eight points are needed, the unused points are set to [I_{BIG}, 1], where I_{BIG} is more than the maximum breaking capacity.

Table 181 - Values of the above circuit breaker wear characteristic graph

Point	Interrupted current (kA)	Number of permitted operations
1	0 (mechanical age)	10,000
2	1.25 (rated current)	10,000
3	31.0 (maximum breaking current)	80
4 - 8	100	1

The values are taken from the figure above. The table (circuit breaker curve) is edited with eSetup Easergy Pro or Web HMI in the **CB Monitoring** view of the protection menu.

Two alarms on "Operations left" limit

The CB monitoring function is designed with two alarms, each with two parameters:

- Alarm current level

  This parameter can be set to the CB's nominal current or any typical application current for the first alarm, and to a typical fault current for the second alarm.

- Operations left limit

  This parameter determines when an alarm is activated. When the "operations left" at the given current level drops below this limit, the alarm is started.

The permitted operations at these two alarm levels can be calculated automatically according to the breaker curve and logarithmic interpolation (see next section). Any actual interrupted current is logarithmically weighted for the two given alarm current levels and the number of operations left at the alarm points is decreased accordingly. PowerLogic P5 protection relay shows the allowed "operations left" in the **PROTECTION** menu/**CB Monitoring** sub-menu, based on the breaker curve, logarithmic interpolation and actual interrupted current.

Logarithmic interpolation

The permitted number of operations for the currents between the defined points is logarithmically interpolated using this equation:

$$C = \frac{a}{I^n}$$

P533JFA

where

C = permitted operations

I = broken current

a, n = constant according to the following two equations, where ln represents the natural logarithm function, C_k/C_{k+1} is the permitted number of operations defined by CurveN, Curve(N+1) in the breaker curve table, and I_k/I_{k+1} is the corresponding broken current defined by CurveIk, CurveI(k+1) in the breaker curve table.

$$a = C_k I_k^n$$

P533JJA

$$n = \frac{ln \frac{C_k}{C_{k+1}}}{ln \frac{I_{k+1}}{I_k}}$$

P533JGA

Each time a trip signal is detected, the corresponding permitted operations shall be calculated based on the broken current I_{brk}:

$$C_{brk} = \frac{a}{I_{brk}^n}$$

P533JHA

The corresponding decreased number of operations of the alarm level is calculated as:

$$\Delta = \frac{C_{alarm}}{C_{brk}}$$

P533JIA

Example of logarithmic interpolation

According to the equations above and the breaker operation curve points definition taken from An example of circuit breaker permissible operation curve, page 583:

- 10000 operations at 1.25 kA

- 80 operations at 31 kA

if the alarm 2 current setting is 6 kA, then the permitted number of operations can be calculated as follows:

$$n = \frac{\ln \frac{10000}{80}}{\ln \frac{31000}{1250}} = 1.5038$$

P533JKA

$$a = 10000 \times 1250^{1.5038} = 454 \times 10^{6}$$

P533JLA

$$C_{alarm2} = \frac{a}{I_{brk}^{\ n}} = \frac{454 \times 10^{6}}{6000^{1.5038}} = 945$$

P533JMA

Thus, the maximum number of current-breaking operations at 6 kA is 945. A useful alarm level for “Operations left” could be in this case for example 50, which is about five percent of the maximum.

If the interrupted three phase currents are IA = 12.5 kA, IB = 12.5 kA and IC = 1.5 kA, the corresponding decreased number of operations of phases A, B for alarm 2 are calculated as:

$$C_{brk1,2} = \frac{a}{I_{brk}^{\ n}} = \frac{454 \times 10^{6}}{12500^{1.5038}} = 313$$

P533JNA

$$\Delta_{1,2} = \frac{C_{alarm}}{C_{brk}} = \frac{945}{313} = 3$$

P533JOA

In phase C, the current is less than the alarm limit current 6 kA. For such currents, the decrement is one (just mechanical wear).

Five ranges of cumulative current

Each time the CB opens, the broken current is added to the corresponding total cumulative broken current, phase by phase. The cumulative broken current is given in $(kA)^2$.

In addition to the total cumulative broken current, there are five cumulative broken current ranges to assess the breaking device pole condition. Each range’s high limit value is configurable and the low limit value equals to the high limit of its previous range. Each range has three different counters, one for each phase, to record how many times the broken current falls into the range. The cumulative broken current record is configured in the **PROTECTION** menu/**CB Monitoring** sub-menu.

The cumulative broken current is also computed by phase. When the PowerLogic P5 protection relay is in test mode or the CB has been withdrawn, the cumulative broken current is not updated.

An alarm signal will be generated when the cumulative broken current of any phase exceeds the "broken I alarm setting".

Mechanical wear

CB Open counter, Protection Trip counter and Rack out counter

The “CB Open” counter is to record the number of CB close to open operation. It is incremented even if the PowerLogic P5 protection relay is in test mode.

The “Protection Trip” counter is to record CB open times issued from Global trip. This counter can also be set to a custom value but it does not increment during test mode.

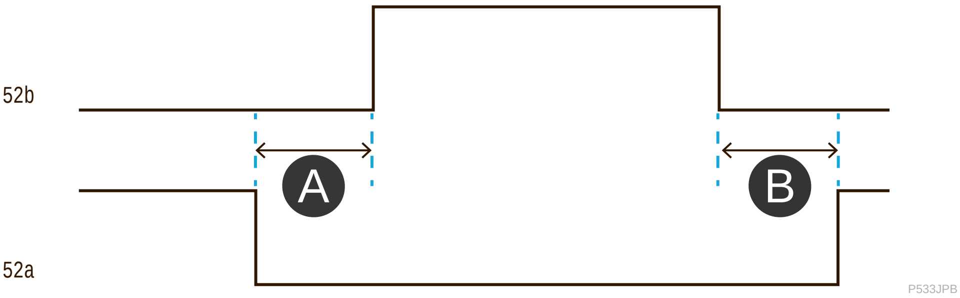
If, for whatever reason the circuit breaker does not open successfully after the pulse setting time out (configured in object), the trip counters are not incremented.

The “Rack out” counter is to record the number of racking in/out operations of the CB truck. It is incremented in both, normal and test mode.

Open time, close time and charging time

If two different digital signals are used to indicate the 52a (open) and 52b (close) status of the CB position, the open time is measured from the moment when the “52b” status becomes false to the moment when the “52a” status becomes true; the close time is measured from the moment when the “52a” status becomes false to the moment when the “52b” status becomes true, as shown in Figure below.

Figure 358 - Open and close time determination



A	Open time	B	Close time

However, if the CB position is only configured as 52a or 52b, the open time and close time will be recorded as 0 each time when its related status changes.

The charging time is computed from the moment when the CB position changes to close to the moment when the spring status changes to ready. The spring status is configured through "DI for object ready" setting in Objects.

Open/close times and charging times are recorded for 8 latest operations in the PowerLogic P5, each with a timestamp. If the time recorded exceeds the range, the time will be tagged as a "dummy" value (65535) which allows the customer to easily detect something is wrong with the CB.

Table 182 - Range of CB monitoring recording data

Recording data	Range
Opening or closing time	0...300 ms
Charging time	0...1 min
Number of mechanical operations	0...65535
Rack-in rack-out operations	0...65535

These CB open times, close times and charging times are also recorded when the PowerLogic P5 is in test mode.

Parameters of the CB monitoring function

Table 183 - Parameters of the CB monitoring function

Parameter	Value	Unit	Description	Note
CB monitoring status				
Al1A Al1B Al1C Al2A			Operation number left for - Alarm 1, phase A - Alarm 1, phase B - Alarm 1, phase C - Alarm 2, phase A	

Table 183 - Parameters of the CB monitoring function (Continued)

Parameter	Value	Unit	Description	Note
Al2B Al2C			- Alarm 2, phase B - Alarm 2, phase C	
Latest broken current				
hh:mm:ss:ms / Date			Time stamp of the latest trip operation	
Phase current IA Phase current IB Phase current IC		A A A	Broken current of phase A Broken current of phase B Broken current of phase C	
Cumul. broken current IA/CmltvIA		$(kA)^2$		
Cumul. broken current IB/CmltvIB		$(kA)^2$		
Cumul. broken current IC/CmltvIC		$(kA)^2$		
Alarm				
Alarm 1				
Current level	0.00...100.00	kA	Alarm1 current level	Editable
Operation limit	100,000...1		Alarm1 limit for operations left	Editable
Alarm 2				
Current level	0.00...100.00	kA	Alarm2 current level	Editable
Operation limit	100,000...1		Alarm2 limit for operations left	Editable
Circuit breaker curve setting				
Current points (CurveIx, x = 1, 2, … 8)	0.00...100.00	kA	8 current points of the CB wear characteristic	Editable
Limit for operation left (CurveNx, x = 1, 2, … 8)	0...100,000		8 permitted operation numbers according to CurveIx	Editable
Cumulative broken current setting				
High limit	0.0...100.0	kA	High limit setting for each range	Editable
Broken I alarm setting	0...65,535		Cumulative broken current alarm threshold	Editable
Event setting				
'Op. limit alarm 1 On' event	On ; Off		Enable/disable the 'Alarm1 on' event	Editable
'Op. limit alarm 1 Off' event	On ; Off		Enable/disable the 'Alarm1 off' event	Editable
'Op. limit alarm 2 On' event	On ; Off		Enable/disable the 'Alarm2 on' event	Editable
'Op. limit alarm 2 Off' event	On ; Off		Enable/disable the 'Alarm2 off' event	Editable
‘Broken I Alarm on’ event	On ; Off		Enable/disable the ‘Broken I Alarm on’ event	Editable
‘Broken I Alarm off’ event	On ; Off		Enable/disable the ‘Broken I Alarm off’ event	Editable

Parameter	Accuracy
Characteristic of recorded data	
Opening or closing time	±5 ms
Charging time	±1 s
Number of mechanical operations	1
Cumulative squared broken current	±10%
Rack-in rack-out operations	1

Digital Circuit Breaker monitoring

Overview

As add-on devices of some circuit breakers of Schneider Electric, for example EvoPact HVX or other circuit breakers, for preventive or predictive maintenance of switchboard and switchgears, PowerLogic P5 protection relay has capabilities to monitor and control the MV equipment.

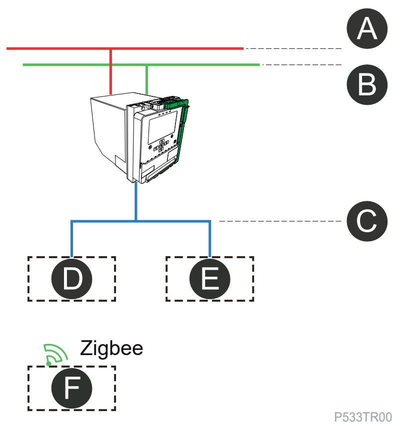
The monitoring functions help user to simplify maintenance scheduling therefore to increase service continuity. By providing general health index for the circuit breaker and health index of key components (it means the coils and so on).

The condition monitoring function uses different sensors and modules:

- PowerLogic TH110 and PowerLogic CL110 for thermal and environmental monitoring, connected directly to PowerLogic P5 through radio frequency Zigbee Green Power protocol.
- Other sensors embedded in the Schneider Electric circuit breakers, connected to the EcoStruxure Operation Server Breaker Monitoring module (EOS-BM100) to execute the following monitoring:
  - Mechanism monitoring
  - Vacuum Interrupter monitoring
  - Truck position monitoring
  - Charging motor monitoring
  - Coils monitoring
- EcoStruxure Operation Server Motor Control and Monitoring module (EOS-MCMx00 with x=1, 2) for:
  - Control of two direct current motors (EOS-MCM100) or up to 4 motors (EOS-MCM200)
  - Measure the current consumption of motor
  - Motor protection against over current
  - Motor monitoring to detect age-related degradation.
  - Interlocking logic rules for control commands such as breaker open and close, and rack in and rack out.
  - Management of automatic sequences for control of the motors and the circuit breaker.

PowerLogic P5 collects data from EOS-BM100/EOS-MCMx00 through Modbus serial (slot N or Slot M+N) to manage alarms, display the data on screen, also enable user to perform CB and switch control through communication.

Figure 359 - Monitoring and control offer architecture



A	Control network	B	Monitoring network
C	Cubicle (Modbus serial)	D	EOS-BM100
E	EOS-MCMx00	F	Zigbee sensors

The condition monitoring of MV equipment is possible with the following order references of PowerLogic P5 protection relays.

Table 184 - P5x20 and P5x30 order codes:

Model number	Slot	Communication board
AABx-xxx**EW**-xxxx	N, P	E - RS485 serial line module W - Extension module radio
AABx-xx**GGW**-xxxx	M and N, P	G - Ethernet TP with HSR/PRP and RS485 W - Extension module radio
AABx-xx**HHW**-xxxx	M and N, P	H - Ethernet FO with HSR/PRP and RS485 W - Extension module radio

The key elements of monitoring functions are as listed below:

Table 185 - Key elements Digital Circuit Breaker monitoring of PowerLogic P5 protection relay

	Features and functions	Associated modules/ sensors
Environmental monitoring	Ambient temperature and relative humidity monitoring	PowerLogic CL110
Thermal monitoring	CB power connections arms thermal monitoring	PowerLogic TH110
	Busbar connections thermal monitoring	PowerLogic TH110
	Cables connections thermal monitoring	PowerLogic TH110
	Temperature rise alarm according to temperature and current measuring	PowerLogic P5
Auxiliary circuit monitoring	Shunt release condition monitoring	EOS-BM100
	Spring charging motor condition monitoring	EOS-BM100
	Closing / Opening shunt releases current curve	EOS-BM100
Operating mechanism condition monitoring	Circuit breaker Closing / Opening time	EOS-BM100
	Circuit breaker rebounding alarm on opening	EOS-BM100
	Circuit breaker closing / opening speed	EOS-BM100
	Vacuum Interrupter contacts gap monitoring	EOS-BM100
Interrupter condition monitoring	Vacuum Interrupter contacts condition monitoring	EOS-BM100
	Poles closing / opening synchronisation[163]	EOS-BM100
	Vacuum Interrupter contacts pressure monitoring	EOS-BM100
CB motorised truck, earthing/grounding switch monitoring and control	Control by Local display	PowerLogic P5
	Monitoring by local display	PowerLogic P5
	Motorised CB truck control and protection	EOS-MCMx00

163. For availability, please consult Schneider Electric.

Table 185 - Key elements Digital Circuit Breaker monitoring of PowerLogic P5 protection relay (Continued)

	Features and functions	Associated modules/ sensors
	CB Truck motor condition monitoring/ Isolator motor condition monitoring	EOS-MCMx00
Earth/ground switch monitoring	Motorised earthing/grounding switch control and protection	EOS-MCMx00
	Motorised earthing/grounding switch motors condition monitoring	EOS-MCMx00
Racking compatibility monitoring	Truck stroke monitoring (Racking compatibility monitoring)	EOS-BM100
3-Position switch monitoring	Disconnector / Earth/ground switch monitoring (if motor selected)	EOS-MCMx00

Configuration of Digital Circuit Breaker

Configuration tool and process

The configuration of the Digital Circuit Breaker monitoring and Zigbee sensor is made by eSetup Easergy Pro.

The operations to configure are different according to the types of modules or sensors:

- Connection and configuration of EOS-BM100/EOS-MCMx00.
- Pairing operation of Zigbee sensors, please refer to Pairing of sensors, page 590.

Pairing of sensors

Preparation

Connect the device with laptop and launch eSetup Easergy Pro, login with InstallerLevel account.

Check and confirm the following items in eSetup Easergy Pro:

1. In **DEVICE/TEST** menu bar, **Device information** section, the **Order code** (model number) of the connected PowerLogic P5 device is displayed. If the 16th character of this code is “W”, it means the Zigbee module is installed.
2. If the connected PowerLogic P5 device is equipped with Zigbee module, in **GENERAL** menu tab, a section with the name **Zigbee network** will be displayed. Please check and confirm the listed items in this section:
   - The value of **Zigbee network status** is *OK*.
   - The list of **Zigbee devices** is empty if no Zigbee sensor is configured.

Pairing of sensor with PowerLogic P5 is consist of three steps:

- Import or input manually the whitelist
- Pair the sensors
- Map the sensors

Import or input manually the whitelist of sensors

PowerLogic P5 supports connection with up to 18 TH110 and 3 CL110 sensors. Normally, when the first time pairing of sensors, if there are numbers of sensors to be paired, it’s proposed to import a whitelist. A template of whitelist can be exported by eSetup Easergy Pro from **GENERAL**/**Zigbee network** section. There are four buttons on top right, click on **Export whitelist** button to export the template whitelist to the selected path. The exported template file is “whitelist. json”. As shown below:

Figure 360 - Template of whitelist

whitelist.json - Notepad

File Edit Format View Help

```
{"ZGP": {
    "version": "1.0",
    "NTW": {
        "NAME": "P5_ZB",
        "DESCRIPTION": "P5 Zigbee Network",
        "ZCH": "AUTO",
        "TXPOWER": "7",
        "SECURITY": "YES"
    },
    "ZDEVICES": [
        {"NAME": "-", "DESCRIPTION": "-", "TYPE": "CL110", "ID": "-", "TOUT": "600", "LOCATIONINDEX": "-"},
        {"NAME": "-", "DESCRIPTION": "-", "TYPE": "CL110", "ID": "-", "TOUT": "600", "LOCATIONINDEX": "-"}
    ]
}}
```

The template whitelist.json file is not ready for import, the number of rows of key values in the field “ZDEVICES” shall be extended to be in line with the number of Zigbee sensors to be paired, and the key values shall be updated accordingly:

- NAME: the name of the sensor, with a limit of length of not more than 16 characters.
- DESCRIPTION: the description of sensor, with a limit of length of not more than 16 characters.
- TYPE: TH110 or CL110[164].
- ID: the ID must be copied from the sensor to be paired, which is normally printed on the side of the sensor.
- TOUT: time out setting of the sensor, value between 120 and 65535, unit: second(s). PowerLogic P5 will stop pairing after the given duration.
- (Optional for this step) LOCATIONINDEX: the default value of the keys are “-”, which can be changed to number from 1 to 21[165]. If the values are changed from “-” to numbers, eSetup Easergy Pro will map the sensors automatically according to the numbers after imported the whitelist. If the location index values are not changed from “-”, manually map of sensors will be needed. For the mapping of sensors, refer to Map the sensors, page 594.

Figure 361 - Example of whitelist

whitelist.json - Notepad

File Edit Format View Help

```
{"ZGP": {
    "version": "1.0",
    "NTW": {
        "NAME": "P5_ZB",
        "DESCRIPTION": "P5 Zigbee Network",
        "ZCH": "AUTO",
        "TXPOWER": "7",
        "SECURITY": "YES"
    },
    "ZDEVICES": [
        {"NAME": "CUB01CL01", "DESCRIPTION": "Environment",   "TYPE": "CL110", "ID": "ff9099c8", "TOUT": "600", "LOCATIONINDEX": "1"},
        {"NAME": "CUB01CL02", "DESCRIPTION": "Cold Point",    "TYPE": "CL110", "ID": "ff9099cb", "TOUT": "600", "LOCATIONINDEX": "2"},
        {"NAME": "CUB01CL03", "DESCRIPTION": "Substation",    "TYPE": "CL110", "ID": "ff909921", "TOUT": "600", "LOCATIONINDEX": "3"},
        {"NAME": "CUB01TH01", "DESCRIPTION": "CB upper armA", "TYPE": "TH110", "ID": "ffe2a8ee", "TOUT": "600", "LOCATIONINDEX": "4"},
        {"NAME": "CUB01TH02", "DESCRIPTION": "CB upper armB", "TYPE": "TH110", "ID": "ffe2a941", "TOUT": "600", "LOCATIONINDEX": "5"},
        {"NAME": "CUB01TH03", "DESCRIPTION": "CB upper armC", "TYPE": "TH110", "ID": "ffe2aa1d", "TOUT": "600", "LOCATIONINDEX": "6"},
        {"NAME": "CUB01TH04", "DESCRIPTION": "CB lower armA", "TYPE": "TH110", "ID": "ffe2a81f", "TOUT": "600", "LOCATIONINDEX": "7"},
        {"NAME": "CUB01TH05", "DESCRIPTION": "CB lower armB", "TYPE": "TH110", "ID": "ffe2a94b", "TOUT": "600", "LOCATIONINDEX": "8"},
        {"NAME": "CUB01TH06", "DESCRIPTION": "CB lower armC", "TYPE": "TH110", "ID": "ffe2a834", "TOUT": "600", "LOCATIONINDEX": "9"},
        {"NAME": "CUB01TH07", "DESCRIPTION": "Busbar1 connA", "TYPE": "TH110", "ID": "ffe2aa2b", "TOUT": "600", "LOCATIONINDEX": "10"},
        {"NAME": "CUB01TH08", "DESCRIPTION": "Busbar1 connB", "TYPE": "TH110", "ID": "ffe2a932", "TOUT": "600", "LOCATIONINDEX": "11"},
        {"NAME": "CUB01TH09", "DESCRIPTION": "Busbar1 connC", "TYPE": "TH110", "ID": "ffe2a8fc", "TOUT": "600", "LOCATIONINDEX": "12"},
        {"NAME": "CUB01TH10", "DESCRIPTION": "Busbar2 connA", "TYPE": "TH110", "ID": "ffe2aa46", "TOUT": "600", "LOCATIONINDEX": "13"},
        {"NAME": "CUB01TH11", "DESCRIPTION": "Busbar2 connB", "TYPE": "TH110", "ID": "ffe2aa4b", "TOUT": "600", "LOCATIONINDEX": "14"},
        {"NAME": "CUB01TH12", "DESCRIPTION": "Busbar2 connC", "TYPE": "TH110", "ID": "ffe2aa3f", "TOUT": "600", "LOCATIONINDEX": "15"},
        {"NAME": "CUB01TH13", "DESCRIPTION": "cable1 connA",  "TYPE": "TH110", "ID": "ffe2a986", "TOUT": "600", "LOCATIONINDEX": "16"},
        {"NAME": "CUB01TH14", "DESCRIPTION": "cable1 connB",  "TYPE": "TH110", "ID": "ffe2a9aa", "TOUT": "600", "LOCATIONINDEX": "17"},
        {"NAME": "CUB01TH15", "DESCRIPTION": "cable1 connC",  "TYPE": "TH110", "ID": "ffe2a801", "TOUT": "600", "LOCATIONINDEX": "18"},
        {"NAME": "CUB01TH16", "DESCRIPTION": "cable2 connA",  "TYPE": "TH110", "ID": "ffe2aa3b", "TOUT": "600", "LOCATIONINDEX": "19"},
        {"NAME": "CUB01TH17", "DESCRIPTION": "cable2 connB",  "TYPE": "TH110", "ID": "ffe2a96a", "TOUT": "600", "LOCATIONINDEX": "20"},
        {"NAME": "CUB01TH18", "DESCRIPTION": "cable2 connC",  "TYPE": "TH110", "ID": "ffe2a92d", "TOUT": "600", "LOCATIONINDEX": "21"},
    ]
}}
```

164. The type of the first 3 sensors in the whitelist must be CL110.
165. The value of location index of the CL110 sensors must be 1 to 3.

After prepared the whitelist, in eSetup Easergy Pro, **GENERAL/Zigbee network** section, click on **Import whitelist** to import the whitelist file.

After imported, a pop-up window is displayed to require a reboot of device. After reboot, check the **GENERAL/Zigbee network** section, in **Zigbee network status**, the value of **Network information** should be *NETWORK OK|1*.

If there are error during the importing, eSetup Easergy Pro will show the error code in log section. The following table lists the error codes:

Table 186 - Error code list of whitelist importing

Index	Label	Note
1	File Check Ok	Whitelist file check success.
2	Bad File	Whitelist file check failed (does not exist or failed to open).
3	Bad JSON Format	Whitelist file JSON format check failed.
4	Bad NTW	Whitelist file NTW content check failed.
5	Bad DEVICES	Whitelist file DEVICES content check failed.
6	Bad Name	Whitelist file DEVICES name check failed.
7	Bad Description	Whitelist file DEVICES description check failed.
8	Bad Type	Whitelist file DEVICES type check failed.
9	Bad ID	Whitelist file DEVICES ID check failed.
10	Bad TOUT	Whitelist file DEVICES TOUT check failed.
11	Too Many PowerLogic CL110	Whitelist file DEVICES CL110 too many.
12	Too Many PowerLogic TH110	Whitelist file DEVICES TH110 too many.
13	Unknow Failure	Whitelist file unknow failure.

Network information is composed by two parts, the first part describes the network state, the second part is the state code. For example: “NETWORK OK|1” is composed by NETWORK OK and 1. The details are listed below:

Table 187 - Zigbee states

	State code and meaning of state code			
Network information	0 No network	1 Some devices need pair/unpair	2 All devices OK	3 Network processor information internally saved
NO NETWORK	√			
NETWORK JOINING		√	√	√
NETWORK OK		√	√	√

Manual input is another available way to fill in the whitelist, however, it is proposed when you update a single sensor or replace a sensor. In **GENERAL/Zigbee network/Zigbee devices** section, double click a cell of the list to change the value of the sensor.

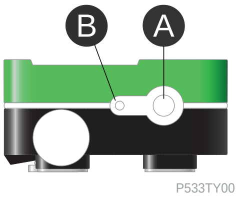
Pair the sensors

When the whitelist is imported or updated in PowerLogic P5, activate the sensors to start pairing operation.

PowerLogic TH110 is powered by the current flowing through the point where the sensor is fixed. The startup current for it is 13 A. In case of the current flowing through achieves the startup current, TH110 will power on and activate automatically.

PowerLogic CL110 is battery-powered. By default, the sensor is in "Factory mode" (sleeping mode) to be paired with any open access point as soon as the button is pressed. To launch the pairing of CL110, press the push button at the side of the sensor as shown in Push on button and green LED of PowerLogic CL110, page 593 until the green LED flashes.

Figure 362 - Push on button and green LED of PowerLogic CL110



A	Push button for pairing	B	Green LED

For the detail information of the sensors, please refer to:

- the installation guide of PowerLogic TH110 (document reference: MFR7945801) through this link: https://www.se.com/us/en/download/document/MFR7945801/
- the user guide of PowerLogic CL110 (document reference: QGH40088) through this link: https://www.se.com/uk/en/download/document/QGH40088/

There are two methods to start the pairing of the sensors at eSetup Easergy Pro side:

- Pairing one by one: Initiate pairing from eSetup Easergy Pro/**GENERAL**/**Zigbee network**, in the list of **Zigbee devices**. For each listed sensor, there are two buttons in the cell of **Actions**. Click on **Pair** button to initiate the pairing of the sensor.
- Massive pairing: in **Zigbee devices**, click on **Mass. pair** button to initiate massive pairing.

  NOTE: The pairing one by one and massive pairing are exclusive for eSetup Easergy Pro, when the **Mass. pair** button is pressed down, pressing **Pair** buttons will not be executed, vice versa. The **Mass. unpair**, **Unpair**, and **Remove** are also exclusive.

When pairing, the value of **Network information** will be *NETWORK JOINING|1*. After paired successfully, the value will be changed to *NETWORK OK|1*, in the list **Zigbee devices**, in column **Paired**, the value of the sensor will be changed from *Unpaired* to *Paired*.

To interrupt the pairing, click on **dis. Zigbee pair** button, the pairing will be stopped, the already paired sensors will be kept.

The followed table lists the buttons for the pair/unpair operations:

Table 188 - The buttons for the pair/unpair operations

Button	Function of button
Mass. pair	Massive pairing command, to launch the massively pairing after import of the whitelist or edit manually the IDs.
Mass. unpair	Massive unpairing command, to massively unpair the sensors. One of the use case is to massively unpair the paired sensors before replacing the sensors massively.
dis. Zigbee pair	Deactive pairing command, stop pairing process during pairing or massive pairing, the pairing will be stopped but already paired sensors will be kept.
Unpair	Unpair a paired sensor.
Pair	Pair a sensor.
Remove	Remove a sensor and remove its configuration from PowerLogic P5.

Map the sensors

The aim of this step is to assign mapping of paired sensors to specified location, for example the cable, the busbar, the upper and lower circuit breaker arms, and so on. In eSetup Easergy Pro/**GENERAL**/**Zigbee network**, there is a list under **Sensor mapping**, double click on the cells of **Sensor index** and select the correct index code according to the list of **Zigbee devices**.

Communication settings and configuration of EOS-BM100/EOS-MCMx00

Setting of protocol

Connect the laptop to PowerLogic P5 with USB cable, set protocol follow these steps:

1. Launch eSetup Easergy Pro.
2. Log-in as *EngineerLevel* or *InstallerLevel*.
3. In eSetup Easergy Pro/**COMMUNICATION**/**Protocol configuration**/**Serial port**, set **Remote port protocol** to *Digital CB*.
4. In **Serial port settings**, set the **Speed of transmission**, **Parity**, and **Response timeout**. The default serial port parameters are:
    - Speed of transmission = *38400* bps
    - Parity: *Even*
    - Stop bits = *1*
    - Response timeout = *1000* ms
5. Click on **Write** button on top left of eSetup Easergy Pro interface, the device will be rebooted when the writing is done. After reboot, the menu tab **DIGITAL CB** will be displayed.

Module configuration

In **DIGITAL CB** menu tab, click on **Module configuration**, the EOS-BM100 and EOS-MCMx00 module communication can be enabled/disabled by checking/unchecking in the column **Enabled** of the table of **Module configuration**, the list of sections at left will be shown or hidden as the modules are enabled/disabled.

Address setting

In eSetup Easergy Pro/**Digital CB**/**Module configuration**, the items to be configured are:

- Enabled: enable/disable the communication between PowerLogic P5 and the modules.
- Slave ID: double click the cell to set slave ID, ensure the ID value is the same with the ID setting on the module.

To ensure the communication with PowerLogic P5, set Modbus slave ID of the module correctly:

- 11~19 for EOS-BM100, default ID is 11,
- 21~29 for EOS-MCMx00, default ID is 21.

For the detail of physical connection to PowerLogic P5, please refer to Connection of PowerLogic P5 with EOS-BM100/EOS-MCMx00, page 112.

Monitoring functions

Environmental monitoring

This function is enabled/disabled in eSetup Easergy Pro/**PROTECTION**/**Environmental monitoring**/**Environmental monitoring**.

PowerLogic P5 monitors the environmental condition of the substation by measuring the relative humidity and temperature with battery powered CL110 Zigbee sensors. One CL110 for substation environment, two CL110 in the cubicle (mainly in cable compartment for condensation).

Based on the calculation of the gap between measured values and the normal values, the environmental monitoring monitors the aging of the cubicle and provides estimated date of next maintenance.

According to IEC 62271-304, 4 levels of condensation and 2 levels of pollution are defined concerning climatic conditions and measuring the time spent in each level to determine an acceleration factor which reduces the maintenance time. The levels of severity are described in the following table:

Table 189 - Levels of condensation

Level	Description
CO	Condensation occurs not more than twice a year. Equipment used in locations with humidity and temperature control in order to avoid condensation.
CL	Non-frequent condensation, not more than twice a month. Equipment used in locations without humidity and temperature control (protection for daily variations of outside climate, but condensation cannot be excluded).
CH	Frequent condensation, more than twice a month. Equipment used in locations without temperature control.
CH+	Very frequent condensation, more than twice a week.

Table 190 - Levels of pollution

Level	Description
PL	Light pollution Ambient air not significantly polluted by dust, smoke, corrosive or flammable gases, vapours or salt.
PH	Heavy pollution Location with no special precautions to minimize presence of deposits. (excluding conductive dust and industrial smoke producing thick conductive deposits)

Considering both condensation level and pollution level, the severity degrees are defined as follows:

Table 191 - Severity degrees

		Pollution	
		PL	PH
Condensation	CO	Degree 0	Degree 1
	CL	Degree 1	Degree 2
	CH	Degree 2	Degree 3
	CH+	Degree 3	Degree 3

Degree 0 is the degree of normal maintenance period, the other degrees will shorten the maintenance period.

This monitoring will warn out in case of:

- High severity degree according to pollution and environmental conditions
- Close calculated maintenance date
- High ambient temperature or humidity

The values of aging pace and next maintenance date are recalculated every day based on the measured temperature, humidity and condensation, and set alarms in case. If the condensation alarm was started the day before and not stopped in the next day, a “full day” will be recorded and will be used in calculation of the aging pace and next maintenance date.

The features of the environmental monitoring functions are listed in the following table:

Table 192 - Features of the environmental monitoring function

Feature	Description
Condensation presence	It measures the ambient temperature, the ambient relative humidity of cable compartment or busbar of the switchgear, calculates the temperature of dew point each hour, so that to calculate the presence of condensation.
Condensation level	The monitoring function measures condensation level every day, in considering the record of last 3 days with significant condensation levels or use the exact label on the front panel since the past 365 days, it defines the condensation level from CO to CH+.
Pollution level	It is a self-declaration of pollution level PL or PH depending on the ambient air situation (significantly polluted or not).
Degree of severity	The degree of severity is calculated daily based on condensation level and pollution level. The maintenance period is re-evaluated each month, including: • Consumed Maintenance time (in day) • Ageing Pace (calculated daily) • Date of next maintenance (rounded to month, calculated daily)

Thermal monitoring

This function is enabled/disabled in eSetup Easergy Pro/**PROTECTION**/**Thermal monitoring**/**Enable thermal monitoring**.

PowerLogic P5 monitors the quality of the connection and insulation by measuring the temperature of connections of:

- circuit breaker (arms)
- busbar
- cable

The temperature of the connections will rise if the connections are not in good condition.

The thermal monitoring uses TH110 and CL110 sensors, which output temperature value every two minutes by default with Zigbee Green Power protocol. PowerLogic P5 treats with the temperature values from sensors to provide different levels of alarms as listed below:

- Absolute Temperature
- Phase Temperature Discrepancy
- Fix relative Temperature rise
- Self-Adapted Temperature rise

Three alarm levels are defined as below:

- Events: notification of changes that are not yet alarming. This level of alarm will generate only event log, no LED light will be triggered.

- Orange alarm: Non urgent verification or part replacement requested. This level of alarm will trigger alarm signal and light on user programmable LED to yellow.
- Red alarm: Immediate action required. This level of alarm will trigger alarm signal and light on user programmable LED to red and block some application functions by configured matrix.

The following data of thermal monitoring are stored in PowerLogic P5:

Table 193 - PowerLogic P5 stored thermal monitoring data

Name of data	Type of data	Polling rate	Resolution
Each connection T°	Measured value	2 minutes	1°C
Each connection T° threshold 1	Setting	N/A	1°C
Each connection T° threshold 2	Setting	N/A	1°C
S/S Ambient T°	Measured value	2 minutes	1°C

Circuit breaker monitoring

Charging motor monitoring

Charging motor monitoring function is managed by EOS-BM100, it monitors the energy consumption of the load spring motor and counts the number of operations. The alarms will be raised up in case of excessive of energy/current or the duration of charging, or the number of operations has reached the threshold. There will be PowerLogic P5 events corresponding to the alarms.

Coils monitoring

The coils monitoring function is managed by EOS-BM100, it monitors the status of the MX or MN opening coils and XF closing coil and the activation time of the coils thanks to their internal self-check function[166].

At each operation, the activation time of the coils will be measured and compared with thresholds depending on coil references. The alarms will be generated in case of:

- non-activation of coil
- long reaction time
- great number of operations

The EOS-BM100 records also the number of operations.

There will be PowerLogic P5 events corresponding to the alarms and coil current curves displayed.

Mechanism monitoring

The mechanism monitoring function monitors the operating mechanism reliability, it measures the following aspects of circuit breaker:

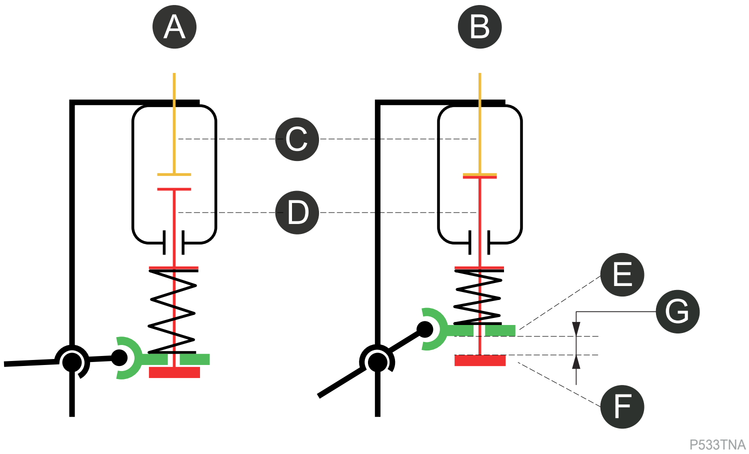
- Operating speed: the EOS-BM100 measures speeds of the mechanism on different points, it will generates alarm in case of low speed. There will be PowerLogic P5 events corresponding to the alarms.
- The number of operations: the EOS-BM100 counts the number of operations and raises an alarm when the counted number have reached the rated value. There will be PowerLogic P5 events corresponding to the alarms.

166. For electronic coils only.

Vacuum interrupter mechanical monitoring

This monitoring function is managed by EOS-BM100 module, it measures the erosion gap (Egap) of each phase. An alarm will be raised inside EOS-BM100 when the measured value gets out of range. There will be PowerLogic P5 events corresponding to the alarms.

Figure 363 - Erosion Gap definition



A	Opened position	B	Closed position
C	Fixed contact	D	Movable contact
E	Sensor location	F	Magnet location
G	Measured Egap		

NOTE: The Egap measure allows to monitor contacting pressure and ensures the contact springs are enough compressed to guaranty a good opening.

Truck position monitoring

Truck position monitoring function is managed by EOS-BM100, by measuring continually the distance between the door of cubicle and the circuit breaker/ disconnector, it checks if the electrical power connections of circuit breaker/ disconnector are correctly inserted/aligned with the cubicle connectors. Alarms will be raised up in case of abnormal distance. There will be PowerLogic P5 event corresponding to the alarms.

ES motor and truck motor monitoring

Managed by EOS-MCMx00, it monitors the energy consumption of the ES motor and the truck motor and counts the number of operations. The EOS-MCMx00 measures the current of motors during the whole activation time. The alarms will be raised up in case of excessive of energy/current or the duration of charging, or the number of operations has reached the threshold.

There will be PowerLogic P5 events corresponding to the alarm and motor current curves displayed..

Circuit breaker alarm status and health index

EOS-MCMx00 monitors the CB alarm status. The status is OK (health index higher than 70%), ORANGE (health index between 30% and 70%) and RED (Health index lower than 30%) based on the worst status of coils/mechanism/ Egap /charging motor status. This status indicates the occurrence of an alarm concerning the CB.

When CB alarm status changes, there will be PowerLogic P5 alarms and events.

Circuit breaker health index is a synthesis of sub-elements of the previous monitoring functions. It is calculated based on the following aspects:

- Circuit breaker mechanism health index
- Erosion gap (Egap) health index
- Charging motor health index
- Racking device motor (truck motors) health index
- Coil health index

Alarms management

According to their severity or priority, the alarms are classed with two levels in EOS-BM100/EOS-MCMx00 and in thermal and environmental monitoring:

- Event: for event which are not alarm, since they are not abnormal conditions, but still need to be mentioned as an evolution of the condition.
- Alarm: for the abnormal conditions needed to pay attention of or even intervention.

In PowerLogic P5, events are present in event logs, alarms are present in alarm list. Real time alarm information will pop up on local HMI.

PowerLogic P5 collects alarms signals from EOS-BM100/EOS-MCMx00, converts to local alarms accordingly, or generates local alarms based on information collected from thermal monitoring and environmental monitoring.

Alarm types

Two levels of severity for alarms are defined:

- Red alarm: immediate action required (health index < 30%)
- Orange alarm: Non- urgent verification, maintenance to be planed (health index between 30% and 70%)

Control functions of Digital Circuit Breaker

PowerLogic P5 is able to operate the circuit breaker, the ES motor and truck/ disconnector motor from local HMI with push button, or remotely with control functions.

> **NOTE:** The control functions are available only if the EOS-MCMx00 has been selected.

PowerLogic P5 is able to execute the following control operations through Modbus serial communication with EOS-MCMx00:

- Operate coil of 1 opening coil and 1 closing coil, of release coil or undervoltage coil, electronic coil or non-electronic coil.
- Send order to operate truck/disconnector motor and ES motor.

PowerLogic P5 also gives information of the reason why an operation is forbidden.

Configuration of Digital Circuit Breaker Control functions

With control objects of PowerLogic P5, it is possible to set activate/inactivate of control and define the following device controls:

- Circuit breaker: Open/Close
- Truck: racking-in and racking-out
- DS (Disconnector): Open/Close
- ES (Earthing switch): Open/Close

The selection of Remote or Local control mode is managed by PowerLogic P5.

The control function is achieved by controllable objects of PowerLogic P5, control objects can be found in eSetup Easergy Pro/**CONTROL**/**Objects**, the sections **Control object x**, x equals to 1 to 6, in where:

- the selection **Object open DI** is the setting for the open control.
- the selection **Object close DI** is the setting for the close control.
- the selection **Object DO for MCMx00 control** is setting for the control of CB or MSW.

  NOTE: The **Object open DI** and **Object close DI** must be selected in pair. The selection in **Object open DI** and **Object close DI** must be relevant to the selection in **Object DO for MCMx00 control**. If not, the control will be failed.

The configurations for CB control are as follows:

1. Select *CB open* for **Object open DI**,
2. Select *CB close* for **Object close DI**,
3. Select *CB* for **Object DO for MCMx00 control**.

The configurations for MSWx (x equals to 1 to 4) control are as follows:

1. Select *MSWx open* for **Object open DI**,
2. Select *MSWx close* for **Object close DI**,
3. Select *MSWx* for **Object DO for MSWx00 control**.

Local control

In PowerLogic P5 local control mode, control commands are received from PowerLogic P5 function button or digital input.

Remote control

In PowerLogic P5 remote control mode, control commands are received from Modbus or IEC61850 client.

Order sources

PowerLogic P5 receives control orders from the following sources:

- Hardwired interface push buttons, selectors in front of the cubicle
- A remote device as Edge, SCADA

The following table lists the operations PowerLogic P5 can manage:

Table 194 - Operations PowerLogic P5 can manage

Operation	From hardwired interface	From remote device
Open/close CB	Yes	Yes
Rack in/out TRUCK	Yes	Yes
Open/Close disconnector	Yes	Yes
Open/Close ES	Yes	Yes

Delay mode

PowerLogic P5 can set operation delay time. There are two kinds of delay time selectable in front of cubicle:

- 0 s: operation start instantly