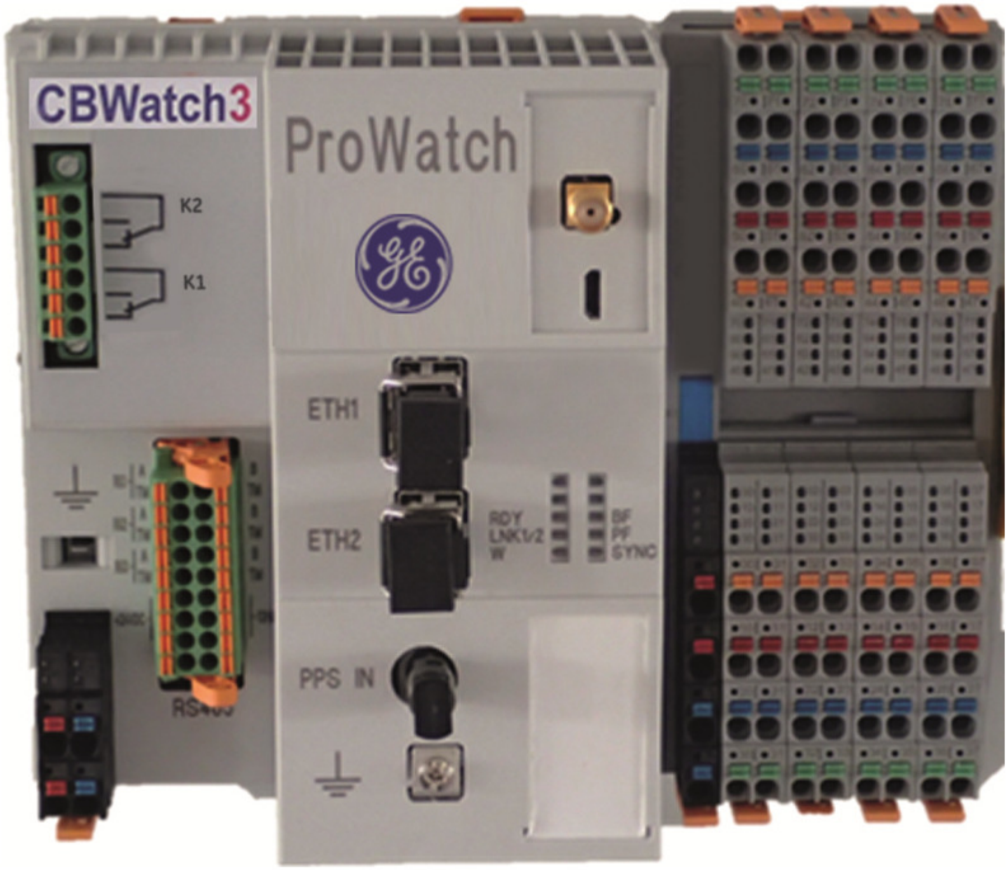
CBWatch3

Circuit Breaker Monitoring



CBWatch 3 User Manual

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PURPOSE OF THIS DOCUMENT

This document is the user manual. It provides readers with information on the CBWatch3 system, GE's solution for monitoring high-voltage circuit-breakers. This manual is intended to help users understand, install, use and maintain the CBWatch3.

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SAFETY INSTRUCTIONS AND WARNING

NOTE: electrostatic discharges (ESD) can cause irreparable damage to the CBWatch3 system.
Observe the necessary safety precautions when handling components which are vulnerable to electrostatic discharge (EN 61340-5-1 and EN-61340-5-2 as well as IEC 61340-5-1 and IEC 61340-5-2).

RISK OF ELECTRIC SHOCK, EXPLOSION OR ELECTRICAL ARC

- Switch off power before assembly, disassembly, cabling or maintenance.
- Check that the product's power supply voltage is compatible with that of the power supply.
- The installation, use and maintenance of CBWatch3 and related products described in this manual must be limited exclusively to personnel who are qualified and trained in the operation of monitoring systems.
- GE shall not be liable in the case of improper use of the product.

Incorrect application of these instructions may entail death or serious injury.

Handling electronic equipment

The CBWatch3 contains electrical and electronic components which may still be charged after disconnection. The user may suffer electric shocks if all the necessary precautions and instructions are not followed before handling or opening the casing.
Before use, check that all the connectors and cables are properly connected to CBWatch3.

Unpacking

In spite of the general robustness of the CBWatch3, it requires handling precautions before assembly. When you receive the CBWatch3, check that no damage has occurred during transport. In case of any claim, contact the carrier and advise GE.

Storage

If you do not install the CBWatch3 as soon as it is received, store it in a place sheltered from dust and damp, in its original packaging. If the packaging box contains a desiccant packet, keep it in place.
However, the humidity absorption agent will lose its effectiveness if the unprotected packaging box is open to the surrounding atmosphere or bad weather.
Storage temperature: from -40°C to +70°C

Set-up

The CBWatch3 can be installed in a control cabinet paired with a high-voltage circuit breaker.
Its position must be chosen for easy inspection, which implies easy access to the connections of the CBWatch3 in case it is required.

1 GENERAL OVERVIEW

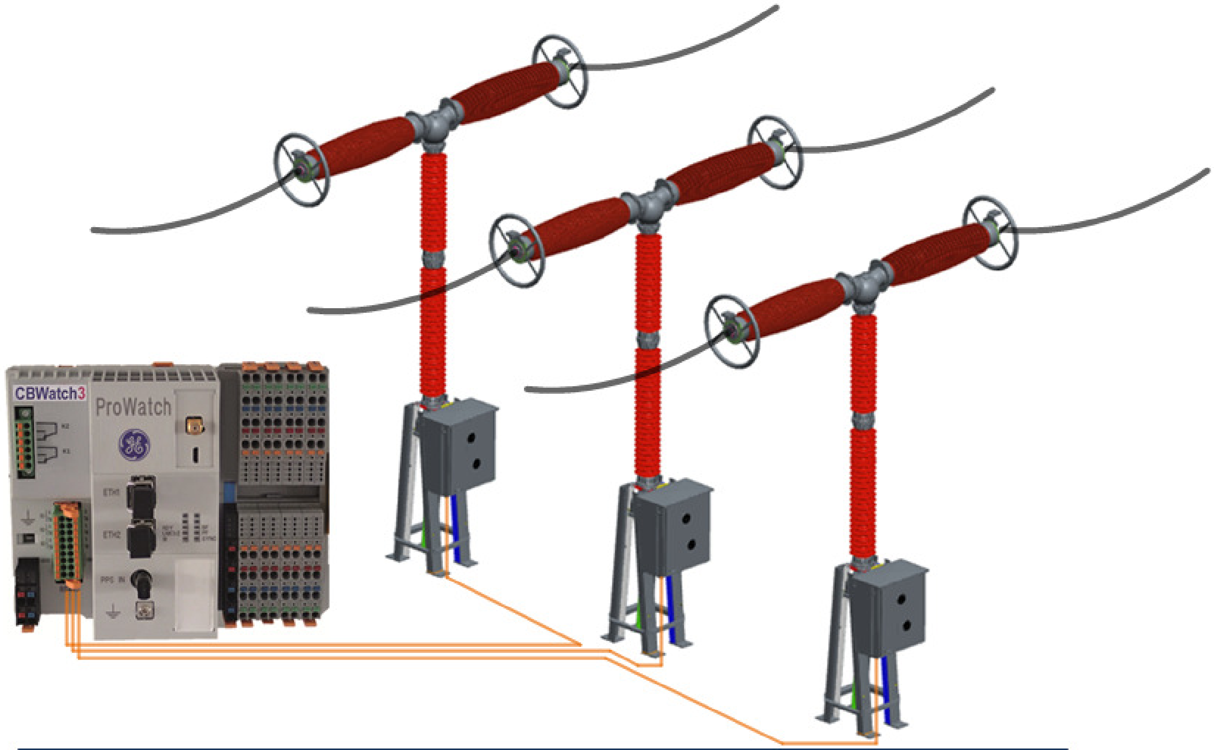
1-1 Introduction

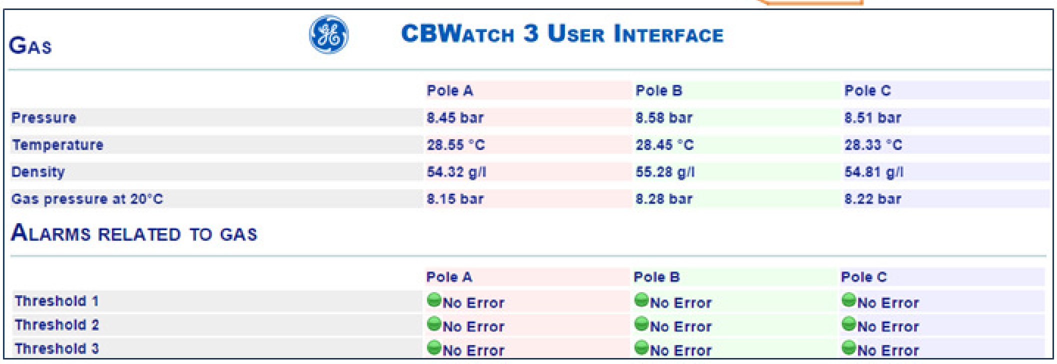
This manual is intended to provide the reader with general information on the various functions use in monitoring high-voltage circuit breakers and how the CBWatch3 works.

All the CBWatch3 monitoring options are detailed in this user manual. Depending on which CBWatch3 configuration has been purchased and installed, all the options described in this document may not be available.

1-2 Product Description

All of the sensors are connected to CBWatch3 supervision module. The interface for communication with the CBWatch3 is implemented through an Ethernet connection and a standard web browser.





GAS — **CBWATCH 3 USER INTERFACE**

	Pole A	Pole B	Pole C
Pressure	8.45 bar	8.58 bar	8.51 bar
Temperature	28.55 °C	28.45 °C	28.33 °C
Density	54.32 g/l	55.28 g/l	54.81 g/l
Gas pressure at 20°C	8.15 bar	8.28 bar	8.22 bar

ALARMS RELATED TO GAS

	Pole A	Pole B	Pole C
Threshold 1	No Error	No Error	No Error
Threshold 2	No Error	No Error	No Error
Threshold 3	No Error	No Error	No Error

Figure 1 – Circuit-breaker and monitoring overview

The CBWatch3 module is usually installed inside the circuit-breaker's low-voltage electrical control cabinet or in a separate enclosure installed next to it, mounted on 35 x 7.5 mm DIN rails. The various sensors are then installed on the circuit-breaker.

The minimum configuration dimensions are given below:

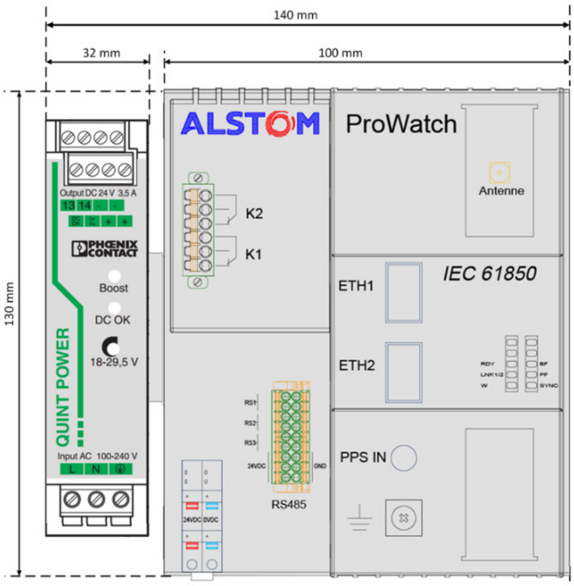


Figure 2 – CBWatch3 minimum configuration dimension

The maximum configuration dimensions are given below:

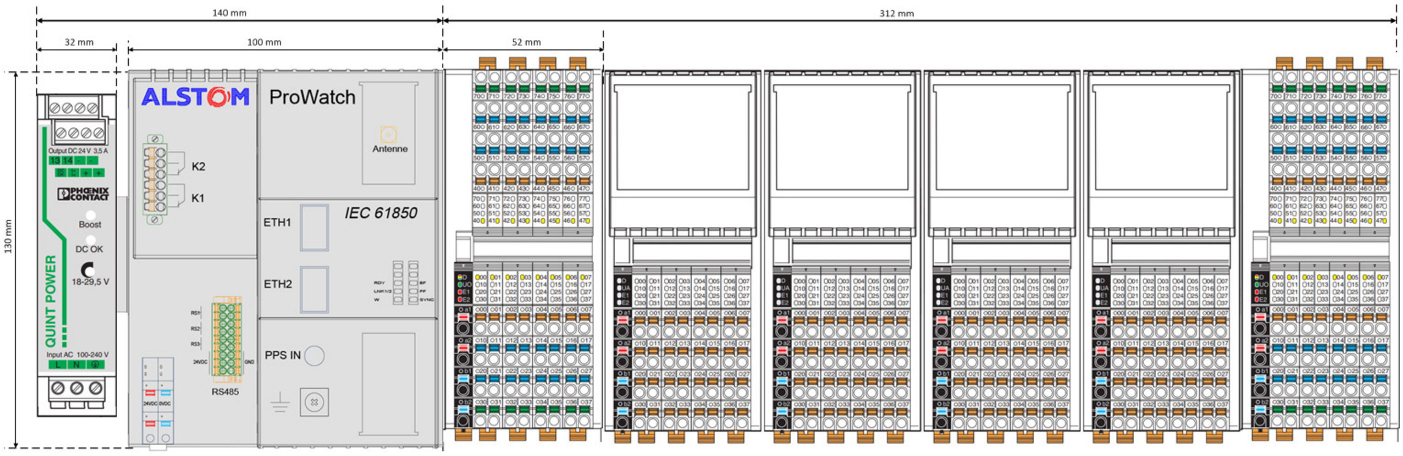


Figure 3 – CBWatch3 maximum configuration dimension

We recommend connecting the shielding for the sensor cables to earth at least at one of the two ends.

1-3 Application

The CBWatch3 constantly assesses the state of the circuit breaker. It signals remotely, and in real-time, any anomalies to the asset maintenance and/or supervision service. CBWatch3 can thus give advance warning of an impending issue and thus minimise the risk of "failure to operate".

Remote diagnostics can also help to optimise and reduce maintenance costs, principally through:
- Optimisation of corrective actions following a failure,
- Implementation of condition based maintenance.

1-3.1 Optimisation of corrective actions, following a failure:

In case a failure is detected on a high-voltage circuit breaker, the system automatically generates an alarm to the sub-station's supervision system. This alarm may be relayed towards the duty person by an out-of-hours duty management system. The maintenance service is thus immediately informed of the fault. It can use the analysis provided to it by the remote diagnostic system to define the best action to undertake. It can decide an immediate action or plan a postponed action in full knowledge of the facts. It can prepare the spare parts and tools that will be necessary and send the technician to the site who will be best able to resolve the fault.

1-3.2 Implementation of condition based maintenance

The continuous monitoring of the circuit breaker's main operating parameters enables any anomaly to be immediately detected. Above all, through calculation of trends concerning these parameters, this monitoring can predict and therefore give advance warning of these anomalies. Condition based maintenance consists of not performing the maintenance operation as long as the remote diagnostic system has not detected any deterioration in performance. The maintenance service therefore has a tool enabling them to only intervene when the circuit-breakers really needs it.

1-4 Technical specifications

Installation:

Installation of the supervision system in the electrical cabinet
Modules are mounted on a DIN rail

Environment:

Ambient temperature: -40°C to +70°C
Electromagnetic compatibility as per the following standards:

- IEC 60068
- IEC 1000-4-4
- IEC 61850 8.1
- IEC 61869
- IEC 55022

Power supplies

90 – 240 Vac/Vdc
Tolerance: -30 % to +15 %
Consumption: 30 VA maximum

Reliability:

High level of reliability and availability due to continuous self-monitoring of electronic modules and sensors.

Standard:

CBWatch3 is compliant with the recommendations of IEEE C37.10.1

2 DESCRIPTION OF EQUIPMENT

Note: All the modules described hereafter in this section may not be present in your CBWatch3 configuration

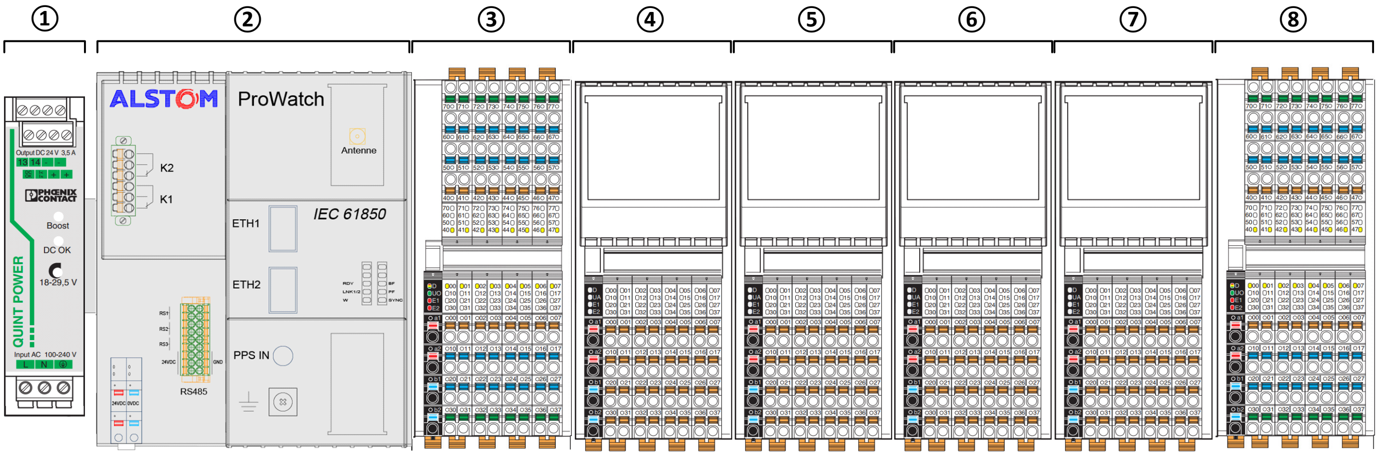


Figure 4 – CBWatch3 composition

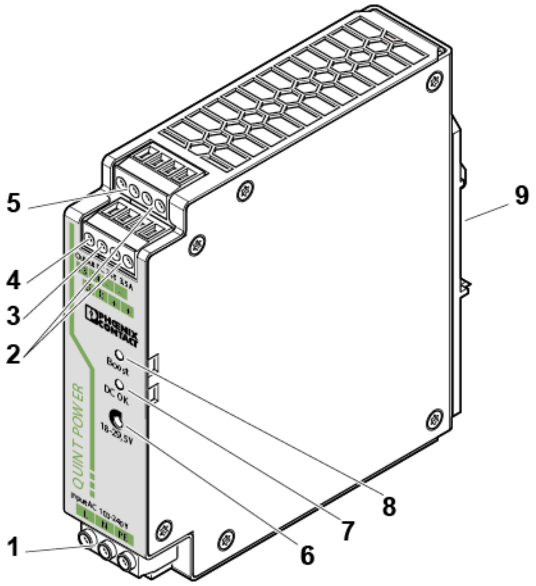
1 Power supply
2 ProWatch Module
3 DI16 Module
4 AI8-1 Module
5 AI8-2 Module
6 AI8-3 Module
7 RTD8 Module
8 DO16 Module

2-1 Power supply

2-1.1 Description of module

The power supply provides the 24 V DC necessary to the ProWatch and the various sensors. The 24VDC is supplied by a standard AC-DC/DC converter which can accept an input voltage between: 90 and 240 V AC and DC and provide an output voltage that can be adjusted between 18 V and 29.5 V using a potentiometer located at the front.

The 24 V DC output is protected against short-circuits and overloading, with a fault indicator alarm and automatic restoration after eliminating the fault.
The automatic overall protection against short circuits (SFB: Selective Fuse Breaking) at each level enables the 24 V DC to be distributed in the system without requiring any fuses.



1	AC input
2	DC output
3	POWER BOOST, coupling output, active
4	DC-OK, coupling output, active
5	DC output OK without potential
6	18VDC potentiometer… 29.5 VDC
7	LED "DC OK"
8	LED "BOOST"
9	Adapter for universal mounting rail UTA 107/30

Figure 5 – CBWatch3 Power supply

Characteristics

- Rapid triggering of standard protection circuit-breakers thanks to the new dynamic power reserve
- Reliable starting of difficult loads thanks to the POWER BOOST static power reserve
- Preventive monitoring of operation
- High operational reliability thanks to a high MTBF > 500,000 h
- long duration protection against brown-outs >20 ms
- high dielectric rigidity up to 300 V AC

2-2 Potential distributors

2-2.1 Description

In order to facilitate the supply of 24Vdc power to the various CBWatch3 sensors, we use potential distributors. These module allows to distribute a single 24Vdc power supply voltage potential input to many devices. We use two different colors to distinguish the plus and minus of the 24Vdc signal. Blue for -24Vdc and grey for +24Vdc.

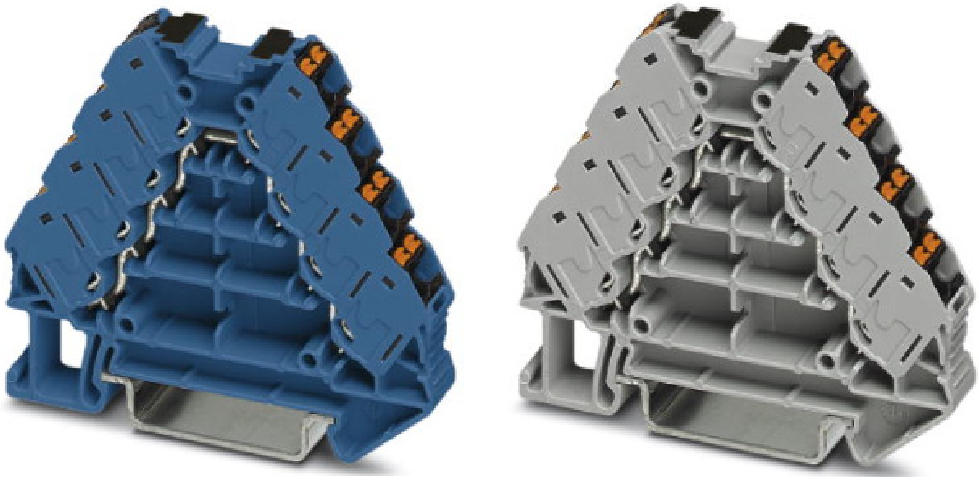


Figure 6 – Potential distributors

2-2.2 Technical data

Potential distributors:

- Nom. voltage: 250 V
- Nominal current: 17.5 A,
- Cross section: 0.14 mm² - 2.5 mm²,
- Connection type: Push-in connection
- Number of positions: 2
- Number of level : 4
- Number of connections: 16
- Rated surge voltage : 4 kV
- Width: 8.3 mm, Length: 64 mm

2-3 ProWatch Module

2-3.1 Description of module

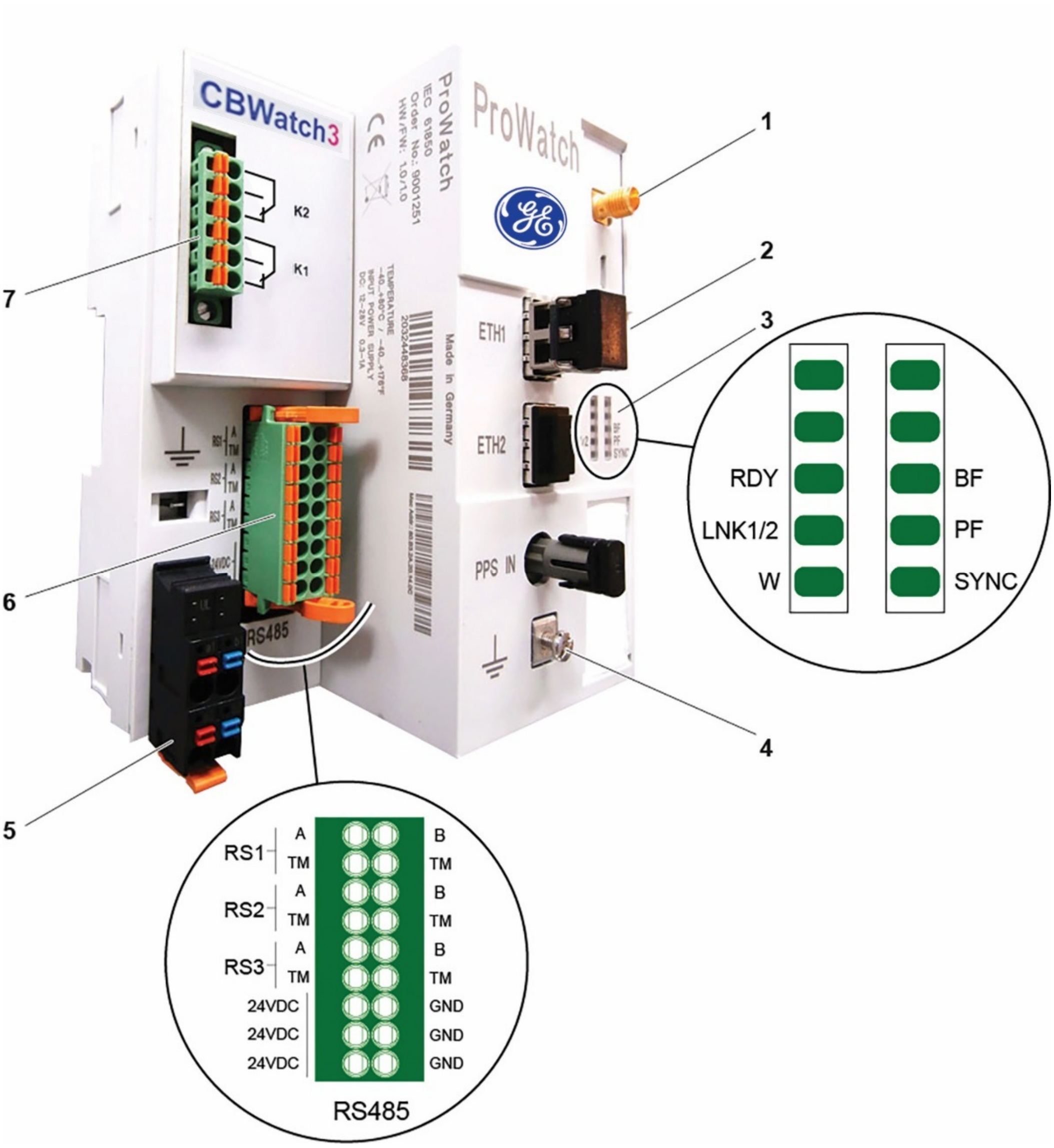
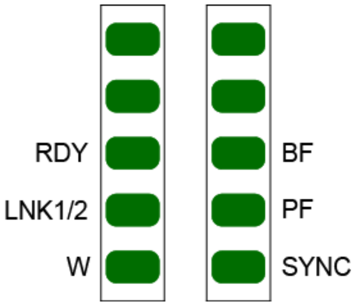


Figure 7 – ProWatch module

1 Bluetooth antenna (optional)
2 Ethernet connector
3 LED
4 Earth connection
5 Power supply terminals
6 Modbus RS485 connector
7 2 programmable output contacts

2-3.2 Description of LEDs



LEDs	States	Operating
RDY	Continuous green	Self-test control (Pro Watch) equals OK + GAS sensors present, in accordance with the configuration (number of sensors, possibly none).
	Flash Green	Starting
	Continuous orange	Self-test OK but at least one GAS sensor not present (bad RS485 link, HS sensor,…)
	Continuous red	Self-test NOK
LNK1/2	Continuous green	Link Ethernet #1 OK Link Ethernet #2 OK
	Flashes green/off	Link Ethernet #1 OK Link Ethernet #2 NOK Or conversely
	off	No Ethernet link established
BF	See Phoenix Contact description	Bus fault Error in module bus. = led "D" in the FIBO MDK. To be connected directly to the IP FIBO output in its future version.
PF	See Phoenix Contact description	Peripheral fault Module peripheral error. = led "E" in the FIBO MDK. To be connected directly to the IP FIBO output in its future version.
SYNC	Continuous green	Synchro 61850 established (1588 or 1pps)
	Flash Green	Synchro in the process of acquisition
	Off	No synchro, application without 61850
	Orange	No synchro, application with 61850
W	Continuous green	Bluetooth active
	Fleetingly off	Exchange of frames
	Continuously off	Bluetooth inactive

Figure 8 – ProWatch LED description

2-3.3 Description of Modbus RS485 connector

The 3 serial ports are insulated up to 1.8kVrms (1min). The level of insulation is limited by the internal transformer, which provides the power to the insulated transmitters/receivers

Terminal resistors of 120Ω may be activated (in the case of a long network) by short-circuiting two pins.

The isolated 24 V DC power supply lines of the connector are used to power the pressure and temperature sensors.

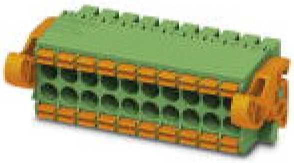


Figure 9 – ProWatch Connector

The assignment of the pin configuration of the connector is the following:

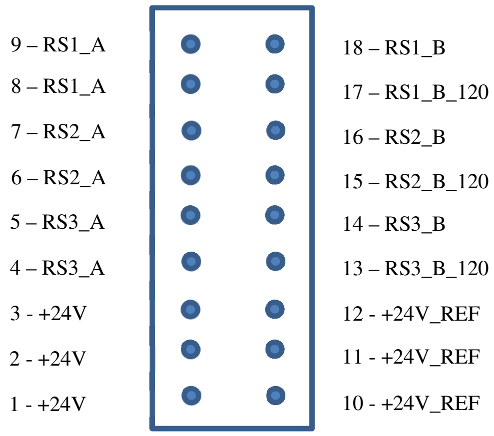


Figure 10 – ProWatch pin assignment

2-3.4 Self-test functionality

During the energizing of the ProWatch module, a complete self-test of the hardware equipment and software functions is carried out. Then during normal operation, regular self-tests permanently monitor the electronic module and the sensors.

In particular, the self-test will detect any bad connection between the various modules mounted on the bus and show which module has the problem.

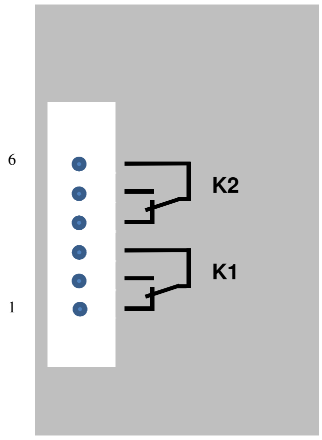
2-3.5 K1 & K2 programmable output contacts

As standard, the ProWatch module includes 2x programmable relay alarm outputs (K1 & K2).

- The K2 output is used to provide the state of the CBWatch3 following a regular system self-check. It can inform the maintenance service and/or supervision system of an internal malfunction.

- The K1 output is user programmable. Any alarm or combination of alarms can be assigned to this contact. For example, as the table below shows, in the context of gas supervision, it is possible to assign one of the thresholds to this contact.

The figure below represents the contacts as well as their rating:



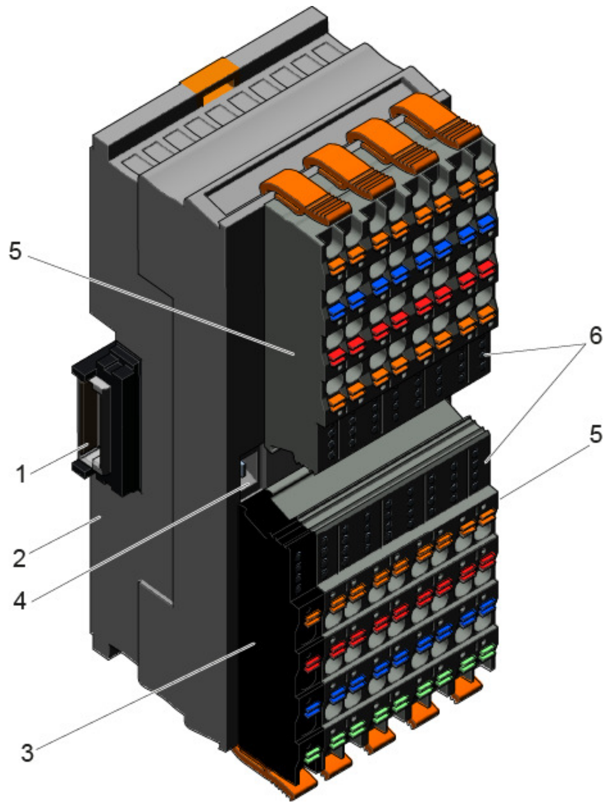
Load / Item	Resistive load
Contact type	Single
Contact material	Ag-Alloy + gold plating (Cd free)
Rated load	8 A at 250 VAC 5 A at 30 VDC
Rated carry current	8 A
Max. switching voltage	250 VAC, 30 VDC
Max. switching current	8 A

Figure 11 – Contact rating

2-4 DI16 Module

2-4.1 Description

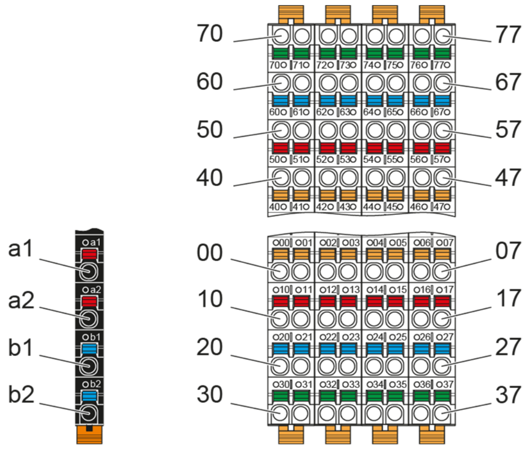
This module provides 16x digital inputs and connects to the ProWatch module through the bus. It is used for the acquisition of all-or-nothing digital signals. The module is manufactured to sustain the environmental conditions.



1 Base for bus
2 Electronic module
3 Power supply voltage connectors
4 Identification of functions
5 Male peripheral connectors
6 State diagnostic indicators

Figure 12 – DI16 Module

2-4.2 Allocation of terminals



Terminal	Colour	Allocation
a1, a2	RED	24 V DC (UI)
b1, b2	Blue	GND
00 … 07	Orange	IN1 … IN8
40 … 47	Orange	IN9 … IN16
10 … 17, 50 … 57	RED	24 V DC (US)
20 … 27, 60 … 67	Blue	GND
30 … 37, 70 … 77	Green	FE

Figure 13 – DI16 Module terminals

UI	Power supply for on/off entry modules (internal bypass)
GND	Reference potential of the power supply voltage (internal bypass)
US	Sensors power supply
IN	on/off inputs
FE	Functioning earth

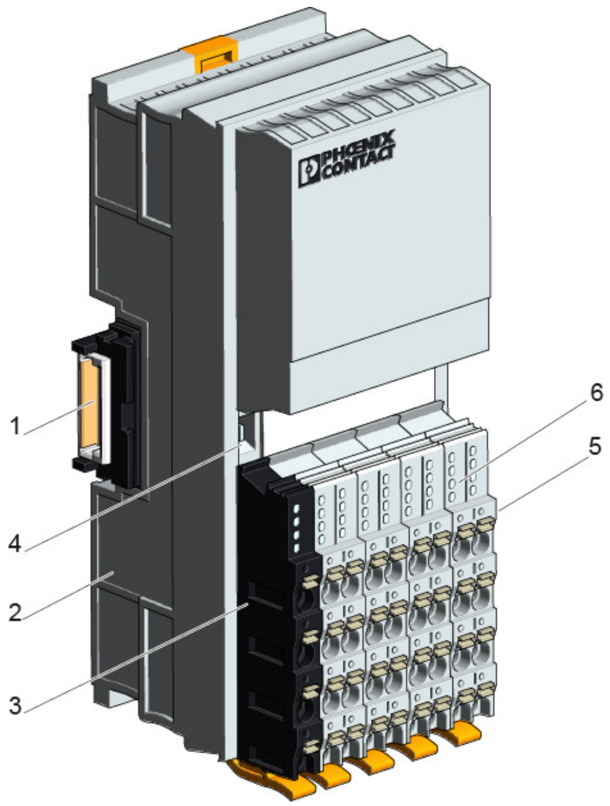
2-4.3 Connections to terminals

Terminal	Connection	Type	See more details in
IN01	52A Auxiliary Contact - Pole B	True/False	"Operation Timing"
IN02	52B Auxiliary Contact - Pole B	True/False	"Operation Timing"
IN03	Rewind Motor Contact - Pole B	True/False	"Stored Energy Motor Run Time"
IN04	Open Command - Pole C	True/False	"Coil Command Detection"
IN05	Close Command - Pole C	True/False	"Coil Command Detection"
IN06	52A Auxiliary Contact - Pole C	True/False	"Operation Timing"
IN07	52B Auxiliary Contact - Pole C	True/False	"Operation Timing"
IN08	Rewind Motor Contact - Pole C	True/False	"Stored Energy Motor Run Time"
IN09	Circuit Continuity Check	True/False	"Control Circuit Continuity"
IN10	Open Command - Pole A	True/False	"Coil Command Detection"
IN11	Close Command - Pole A	True/False	"Coil Command Detection"
IN12	52A Auxiliary Contact - Pole A	True/False	"Operation Timing"
IN13	52B Auxiliary Contact - Pole A	True/False	"Operation Timing"
IN14	Rewind Motor Contact - Pole A	True/False	"Stored Energy Motor Run Time"
IN15	Open Command - Pole B	True/False	"Coil Command Detection"
IN16	Close Command - Pole B	True/False	"Coil Command Detection"

2-5 AI8 Module

2-5.1 Description

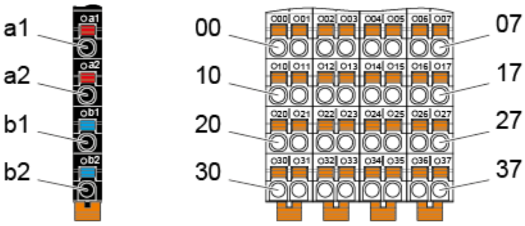
This module provides 8x analogue inputs and connects to the ProWatch module through the bus. It enables acquisition of analogue voltage and amperage signals. The module is manufactured to sustain the environmental conditions.



1 Base for bus
2 Electronic module
3 Power supply voltage connectors
4 Identification of functions
5 Male peripheral connectors
6 State diagnostic indicators

Figure 14 – AI8 Module

2-5.2 Allocation of terminals



Terminal	Colour	Allocation
a1, a2	RED	24 V DC (UA)
b1, b2	Blue	GND
00 ... 07	Orange	U1+ ... U8+
10 ... 17	Orange	U1- ... U8-
20 ... 27	Orange	I1+ ... I8+
30 ... 37	Orange	I1- ... I8-

Figure 15 – AI8 Module terminals

UA Power supply for analogue modules (internal bypass)
GND Reference potential at UA (internal bypass)
Ux+/- Voltage input +/- Channel x
Ix+/- Input +/- Channel x
x Channel (x = 1 ... 8)

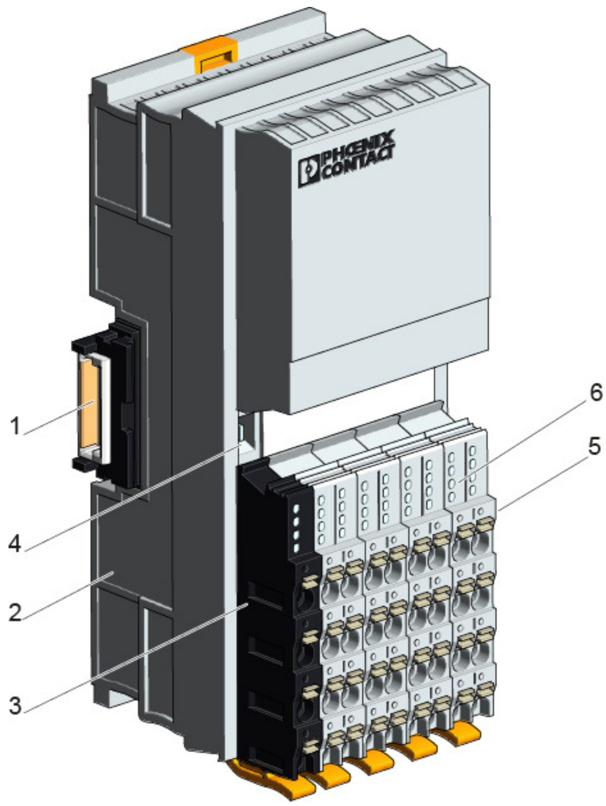
2-5.3 Connections to terminals

Module	Terminal	Connection	Type	See for more details
1	IN00	DC Voltage - Supply 1	0-10V	"DC Supply Measurement"
1	IN01	DC Voltage - Supply 2	0-10V	"DC Supply Measurement"
1	IN02	Primary AC Current - Pole A	+/-10V	"Primary AC Current Measurement"
1	IN03	Primary AC Current - Pole B	+/-10V	"Primary AC Current Measurement"
1	IN04	Primary AC Current - Pole C	+/-10V	"Primary AC Current Measurement"
1	IN05	Travel - Pole A	4-20mA	Alternative for "Operations Timing"
1	IN06	Travel - Pole B	4-20mA	Alternative for "Operations Timing"
1	IN07	Travel - Pole C	4-20mA	Alternative for "Operations Timing"
2	IN00	Rewind Motor Current - Pole A	4-20mA	"Stored Energy Motor Current Monitoring"
2	IN01	Opening Coil 1 Current - Pole A	4-20mA	"Coil Current Monitoring"
2	IN02	Opening Coil 2 Current - Pole A	4-20mA	"Coil Current Monitoring"
2	IN03	Closing Coil Current - Pole A	4-20mA	"Coil Current Monitoring"
2	IN04	Spare Analogue Input 1		Spare
2	IN05	Spare Analogue Input 2		Spare
2	IN06	Spare Analogue Input 3		Spare
2	IN07	Spare Analogue Input 4		Spare
3	IN00	Rewind Motor Current - Pole B	4-20mA	"Stored Energy Motor Current Monitoring"
3	IN01	Opening Coil 1 Current - Pole B	4-20mA	"Coil Current Monitoring"
3	IN02	Opening Coil 2 Current - Pole B	4-20mA	"Coil Current Monitoring"
3	IN03	Closing Coil Current - Pole B	4-20mA	"Coil Current Monitoring"
3	IN04	Rewind Motor Current - Pole C	4-20mA	"Stored Energy Motor Current Monitoring"
3	IN05	Opening Coil 1 Current - Pole C	4-20mA	"Coil Current Monitoring"
3	IN06	Opening Coil 2 Current - Pole C	4-20mA	"Coil Current Monitoring"
3	IN07	Closing Coil Current - Pole C	4-20mA	"Coil Current Monitoring"

2-6 RTD8 Module

2-6.1 Description

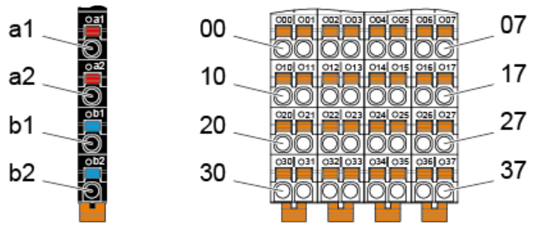
This module provides 8x temperature inputs and connects to the ProWatch module through the bus. It enables acquisition of signals from resistor temperature sensors. All common sensors made of platinum and nickel as per DIN EN 60751 and SAMA are handled, as well as the sensors CU10, CU50, CU53 and various types of KTY8x sensors. The module is manufactured to sustain the environmental conditions.



1 Base for bus
2 Electronic module
3 Power supply voltage connectors
4 Identification of functions
5 Male peripheral connectors
6 State diagnostic indicators

Figure 16 – RTD8 Module

2-6.2 Allocation of terminals



Terminal	Colour	Allocation
a1, a2	RED	24 V DC (UA)
b1, b2	Blue	GND (UA)
00 ... 07	Orange	U1+ ... U8+
10 ... 17	Orange	I1+ ... I8+
20 ... 27	Orange	I1- ... I8-
30 ... 37	Orange	U1- ... U8-

Figure 17 – RTD8 Module terminals

UA	Power supply for analogue modules (internal bypass)
GND (UA)	Reference potential at UA (internal bypass)
Ux+/-	Voltage input +/- Channel x
Ix+/-	Input +/- Channel x
x	Channel (x = 1 ... 8)

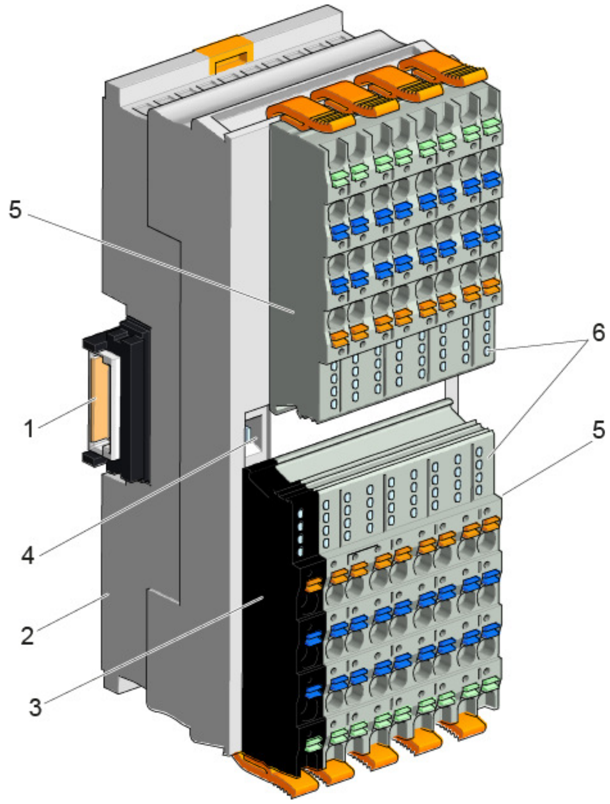
2-6.3 Connections to terminals

Terminal	Connection	Type	See more details in
IN00	Ambient Temperature	PT100	"Operation Timing"
IN01	Cabinet Temperature 1	PT100	"Cabinet Temperature"
IN02	Cabinet Temperature 2	PT100	"Cabinet Temperature"
IN03	Cabinet Temperature 3	PT100	"Cabinet Temperature"
IN04	Cabinet Temperature 4	PT100	"Cabinet Temperature"
IN05	Cabinet Temperature 5	PT100	"Cabinet Temperature"
IN06	Spare Temperature Input 1	PT100	Spare
IN07	Spare Temperature Input 2	PT100	Spare

2-7 DO16 Module

2-7.1 Description

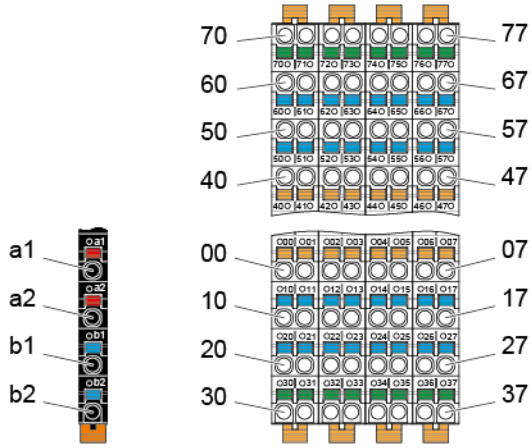
This module provides 16x digital outputs and connects to the ProWatch module through the bus. It is used for the transmission of digital "all-or-nothing" signals. It provides 16 outputs to which you can assign one of the 16 configurable alarms via the HMI. The outputs are protected against short circuits and overloading. The module is manufactured to sustain the environmental conditions.



1 Base for bus
2 Electronic module
3 Power supply voltage connectors
4 Identification of functions
5 Male peripheral connectors
6 State diagnostic indicators

Figure 18 – DO16 Module

2-7.2 Allocation of terminals



Terminal	Colour	Allocation
a1, a2	RED	24 V DC (Uo)
b1, b2	Blue	GND
00 … 07	Orange	OUT1 … OUT8
40 … 47	Orange	OUT9 … OUT16
10 … 17, 50 … 57	Blue	GND
20 … 27, 60 … 67	Blue	GND
30 … 37, 70 … 77	Green	FE

Figure 19 – DO16 Module terminals

Uo Power supply for on/off entry modules (internal bypass)
GND Reference potential of the power supply voltage (internal bypass)
OUT on/off outputs
FE Functioning earth

2-7.3 Interface relay

A CBWatch3 equipped with the DO16 module is complemented with external relays which can translate the alarm signals received from the DO16 module. 16 relays are available and take the form of 2x8 relay banks. Relays are connected to a PLC and each PLC can receive 8 relays. The PLC must be supplied with 24Vdc, usually from the CBWatch3 power supply.
When the alarm threshold is reached, the Do16 module will trigger the relay and move the associated auxiliary contact position.

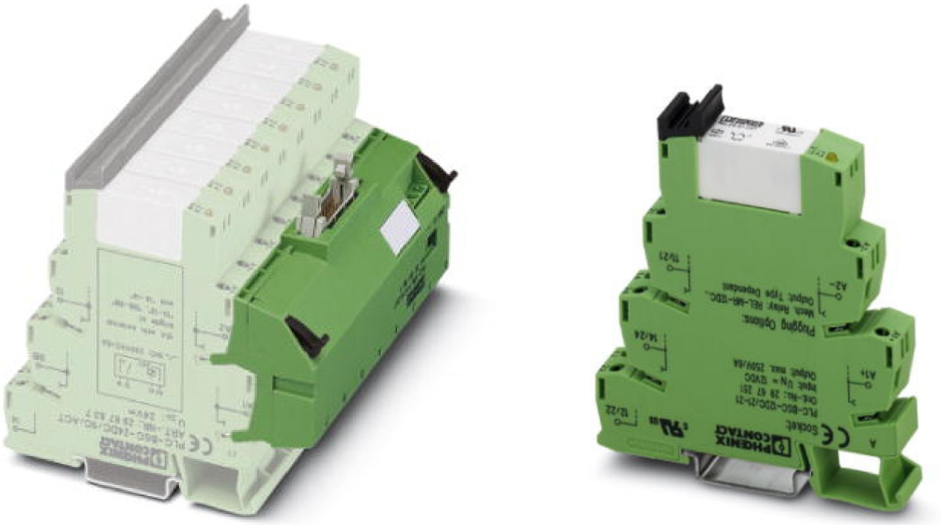
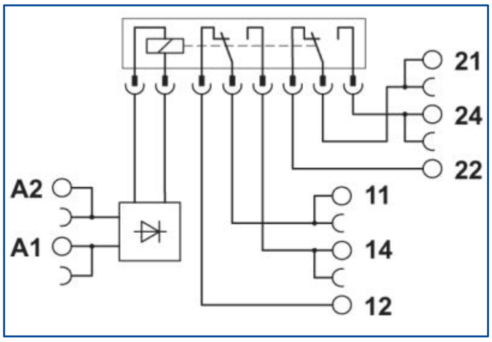


Figure 20 – DO16 Relays

Circuit diagram:



Technical data:

Interrupting rating (ohmic load) max.	140 W (at 24 V DC)
	85 W (at 48 V DC)
	60 W (at 60 V DC)
	44 W (at 110 V DC)
	60 W (at 220 V DC)
	1500 VA (for 250 V AC)

2-8 Common indicators on Input/output modules

2-8.1 Description of LEDs

The same LEDs are present on all the input/output modules and are located on the connectors.

Designation	Color	Meaning	State	Description
D	Red/yellow/green	Diagnostics for local bus communication		
		Run	Green on	The device is ready for operation, communication within the station is OK. All data is valid. There are no faults.
		Active	Flashing green	The device is ready for operation, communication within the station is OK. The data is **not** valid. Valid data from the controller/higher-level network is not available. There is no fault in the module.
		Device application not active	Flashing green/yellow	The device is ready for operation, communication within the station is OK. Output data **cannot** be output and/or input data **cannot** be read. There is a fault on the I/O side of the module.
		Ready	Yellow on	The device is ready for operation but has still not detected a valid cycle after power-on.
		Connected	Flashing yellow	The device is not (yet) part of the active configuration.
		Reset	Red on	The device is ready for operation but has lost the connection to the bus head.
		Not connected	Flashing red	The device is ready for operation but there is no connection to the previously existing device.
		Power down	Off	Device is in (power) reset.
U_x	Green	U_x	On	I/O supply is present.
			Off	I/O supply is not present.
E1/E2	Red	I/O error or channel error	On	I/O error or channel error present. Channel errors are directly relatable to a channel. I/O errors are not directly relatable to a channel.
			Off	No I/O error or channel error.

Figure 21 – Module LED description

3 DESCRIPTION OF SENSORS

Note: All the sensors described hereafter may not be present in your specific CBWatch3 configuration

3-1 SF_6 gas pressure and temperature sensor

3-1.1 Description

These sensors are used for monitoring gas pressure and temperature and are of the digital type. They use an integrated microprocessor and communicate with the ProWatch module through digital signals (not analogue 4-20mA) using an extended proprietary Modbus protocol over an RS485 link.
Each sensor is calibrated individually in the factory over its entire usage range. The two values of absolute pressure and temperature are transmitted separately to the ProWatch main module.

Figure 22 – Pressure and temperature sensor

3-1.2 Technical characteristics of the sensor

High measurement performance:

High measurement precision for pressure over a temperature range from -40°C to +85°C
Measures over a full scale up to 17 bars

High data transmission speed:

Pressure precision to 25 mbar
Pressure and temperature information transmitted separately
Communication protocol Modbus RS485 115 kBd

HMI CBWatch 3: Measurement \ Sensors

Via the Human Machin Interface, it is possible to read the serial numbers of each sensor installed, as well as the last 5 pressures and temperatures measured

GAS PRESSURE AND TEMPERATURE SENSORS

	Pole A	Pole B	Pole C
Serial number	337998	338131	338083
Sensor reset counter	0	0	0
Sensor no answer counter	0	0	0
Temperatures measurements	28.55 °C	28.45 °C	28.33 °C
	28.55 °C	28.45 °C	28.33 °C
	28.55 °C	28.45 °C	28.33 °C
	28.55 °C	28.45 °C	28.33 °C
	28.55 °C	28.45 °C	28.33 °C
Pressures measurements	8.450 bar	8.580 bar	8.510 bar
	8.450 bar	8.580 bar	8.510 bar
	8.450 bar	8.580 bar	8.510 bar
	8.450 bar	8.580 bar	8.510 bar
	8.450 bar	8.580 bar	8.510 bar

Figure 23 – HMI - Pressure and temperature sensor

3-2 Open/close command detection sensor array

3-2.1 Description

An open/close command on the control circuit is detected using this sensor array. The sensors detect a current rising edge on the coil in the control circuit. This detection is used to launch the operation data acquisition. The array connects to the DI16 module if present in the configuration.

There are 6x coils in the array:

- up to 3 for the open/trip command lines of each phase (1 to 3 on the left)
- up to 3 for the close command lines of each phase (4 to 6 on the right)

If redundant trip or close lines are present, the same coil is used to detect the command.

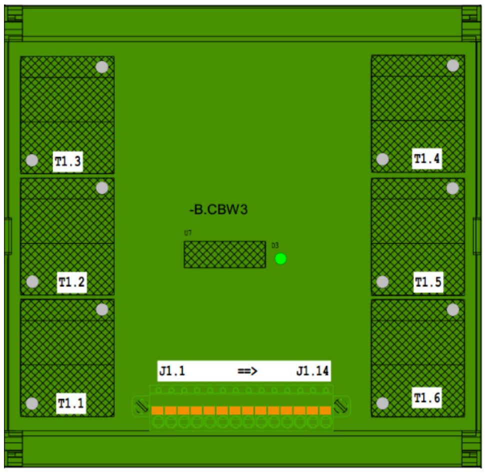


Figure 24 – Command detection sensor

Terminal block output assignment J1.1 to J1.14:

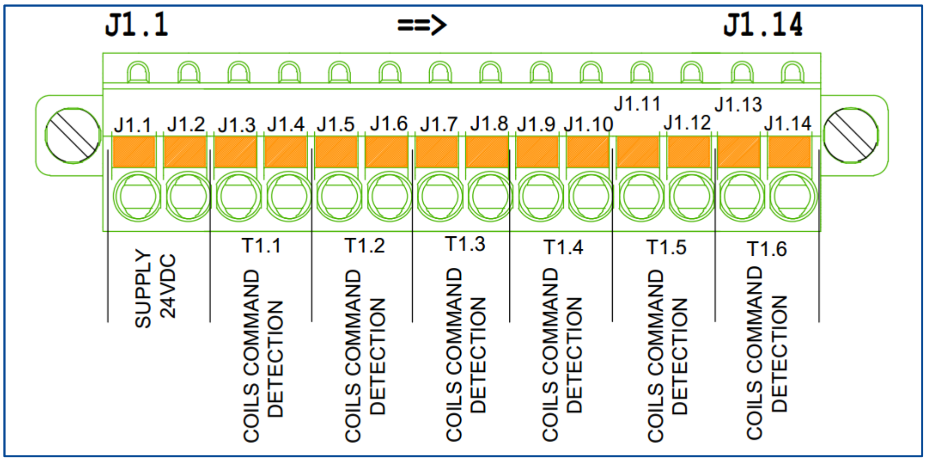


Figure 25 – Command detection sensor terminals assignment

3-3 DC current measurement sensor

3-3.1 Description

A Hall-effect traversing connector coil current sensor is used for measuring DC current. For our application, we are using these sensors with various ranges to:

- measure the DC current flowing through all the open/close coils
- measure the DC current used by the DC spring rewinding motor(s)

The sensor connects to an AI8 module if present in the CBWatch3 configuration.

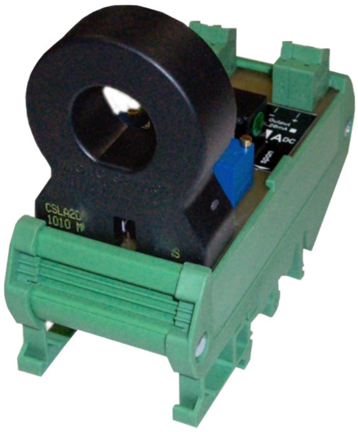


Figure 26 – DC current sensor

3-3.1 Technical characteristics of the sensor

Input	-2A /+2A dc -15A /+15A dc
Output	4mA to 20mA
Supply voltage	18V to 36V dc
Environmental Temperature Limits (Operating)	-25°C to +65°C
bandwidth	500Hz

Figure 27 – DC current sensor technical data

3-4 Control Circuit Continuity

3-4.1 Description

The TCW sensor connects itself in the DC control circuit and injects a small current in the control line (below the level needed to actuate the coil) in order to continually check the continuity of the circuit and to make sure that the coil is not open-circuit.
The sensor has 3 channels and returns a digital true/false signal as to the good state of the circuit.

If at least one coil monitoring relay opens for a period > 10 seconds, then an alarm is activated by changing its status. The TCW, if present in the configuration, connects to the DI16 module.

A separate TCW sensor is required for each DC supply source and it can handle a maximum of 3 circuits so up to 3x TCW sensors may be needed for an IPO breaker.

Figure 28 – TCW sensor

3-4.2 Connections

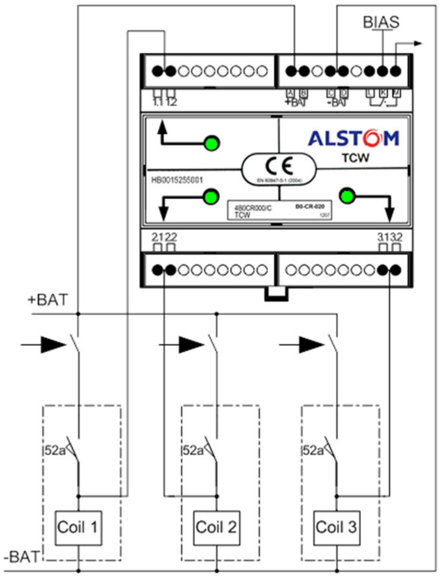


Figure 29 – TCW Connections

3-5 DC voltage measurement sensor

3-5.1 Description

A voltage converter is used to provide a 0-10V signal image of the DC power supply voltage which can be received by an AI8 analogue input module if present in the CBWatch3 configuration. The primary range of the DC power supply voltage measured is 0 to 280Vdc.

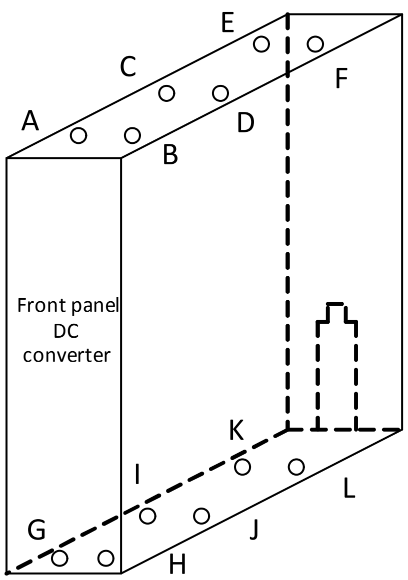
The voltage converter has 2 channels, so can convert two different DC voltages, typically the primary and secondary DC supplies used by trip coil 1 and trip coil 2

All these parameters are set in the analogue channel settings of the HMI.

Figure 30 – DC voltage converter

3-5.2 DC converter connections

Here is a schematic representation of the converter connections:



Markers on the scheme	Markers on the module	Markers on the module	Function	
A	X.1	5+	280V	Channel 1
B	X.2	6-	0V	
C	X.3	7+	10V	
D	X.4	8-	0V	
E			Not used	
F			Not used	
G	X.5	1+	280V	Channel 2
H	X.6	2-	0V	
I	X.7	3+	10V	
J	X.8	4-	0V	
K	24+	9+	24+	24V power supply
L	24-	10-	24-	

3-5.1 DC Voltage Measurement - Connection principle

The substation DC power is connected directly to the converter

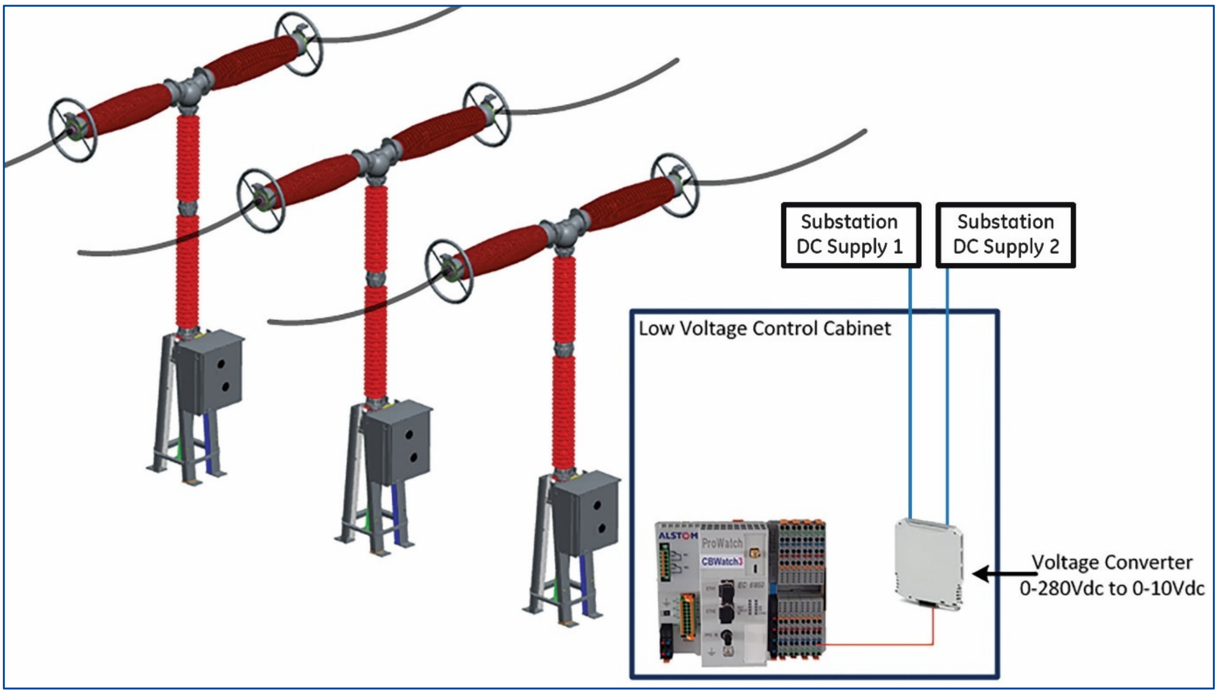


Figure 31 – DC Power connections

3-6 Primary current measurement

To measure the primary current being interrupted by the circuit breaker, we rely on the circuit breaker's own built-in primary current CT. There are two options used, depending on whether a split core CT is used or not.

3-6.1 Option 1 - Description

A split-core CT is used to connect to the wires of the CB built-in CT, one per phase. The CT used has a ratio of 50A / 16.66mA which can be fed to the AI8 analogue input module if present in the configuration.

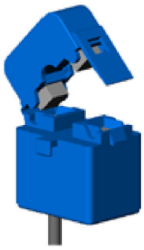


Figure 32 – Primary current split-core CT

3-6.2 Option 1 - Connections

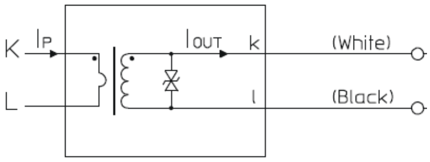


Figure 33 – Primary current split-core CT connections

3-6.3 Option 1 - Connection principle

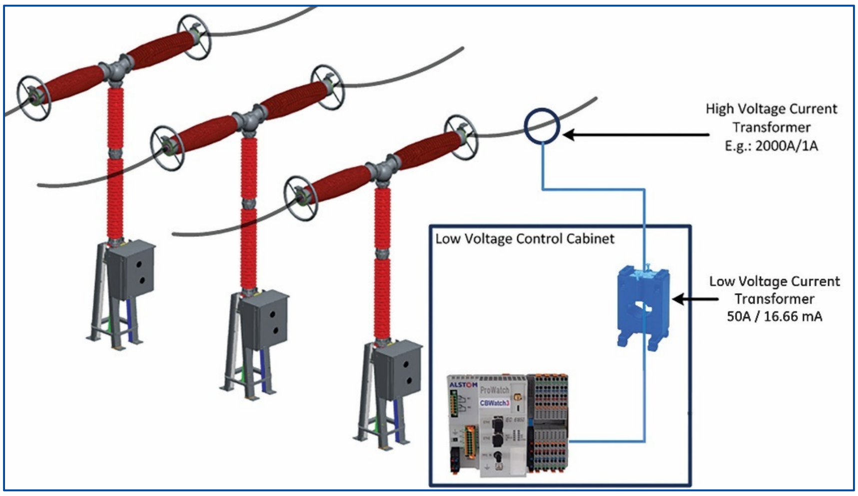


Figure 34 – Connections for Option 1

3-6.4 Option 2 - Description

First a fixed core CT is used to connect to the wires of the CB built-in CT, one per phase. The CT used has a ratio of 10A / 5mA

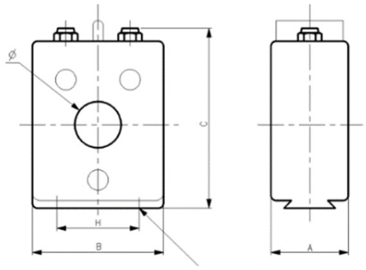


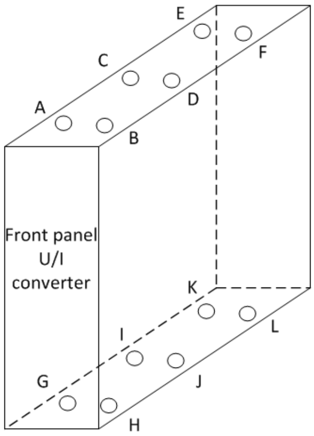
Figure 35 – Primary current closed CT

Then a current converter is used to convert the mA signal coming from the CT (+/- 100 mA) to a voltage signal (+/-10V) which can be received by an AI8 analogue input module if present in the CBWatch3 configuration.

Figure 36 – Primary current closed CT converter

The converter has 3 channels, so one converter can convert the primary current of all three phases.

3-6.5 Option 2 - Converter connections



Markers on the scheme	Markers on the module	Function
A	C1	+100mA
B	C2	-100mA
C	C5	+100mA
D	C6	-100mA
E	C9	+100mA
F	C10	-100mA
G	C3	+10V
H	C4	-10V
I	C7	+10V
J	C8	-10V
K	C11	+10V
L	C12	-10V

3-6.6 Option 2 - Connection principle

The primary interrupted current is acquired through 2 levels of CT which are then connected to the converter.

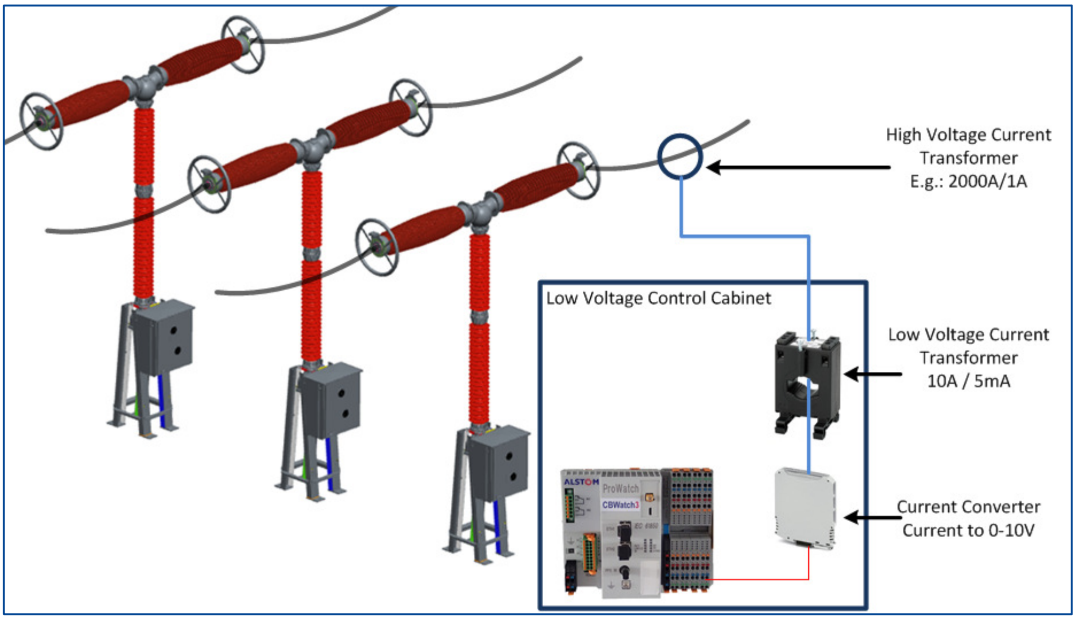


Figure 37 –Connections for Option 2

3-7 AC current measurement sensor

3-7.1 Description

To monitor the current used by an AC spring winding motor or by an AC pump motor, a current transducer is used to convert sinusoidal AC current into a 4-20 mA current proportional to the input.
The AC wire is threaded through the red built-in CT on the picture below.
The transducer connects to an AI8 module if present in the CBWatch3 configuration

Figure 38 – AC current sensor

3-7.2 Technical characteristics of the sensor

Input	0A ac to 15A ac
Output	4mA to 20mA
Supply voltage	20V to 265V dc or ac
Environmental Temperature Limits (Operating)	-10°C to +60°C
bandwidth	40Hz to 500Hz

Figure 39 – AC current sensor technical data

3-8 AC voltage measurement sensor

3-8.1 Description

We can monitor the AC voltage supplied to, for example, the AC pump motor to ensure that it is present and that the motor will work when needed. A true RMS AC voltage transducer is used to convert sinusoidal AC voltage into a proportional 0-5V dc input.
The transducer connects to one of the spare analogue inputs of the AI8 modules if present in the CBWatch3 configuration

Figure 40 – AC voltage sensor

3-8.2 Technical characteristics of the sensor

Input	0 to 250 V ac
Output	0 to 5 V dc
Supply voltage	24 Vdc ±10%

Figure 41 – AC voltage sensor technical data

3-9 Pneumatic pressure sensor

3-9.1 Description

When a pneumatic circuit is used to generate the stored energy to operate the breaker, we can monitor the pressure built up in the circuit to ensure that it is sufficient. To do this, we use a pressure sensor that we plumb into the circuit using a T-piece.

.

The sensor connects to one of the spare analogue inputs of the AI8 modules if present in the CBWatch3 configuration.

Figure 42 – Pressure sensor

3-9.2 Technical characteristics of the sensor

Input	0 to 300 PSI
Output	0 to 5 V dc
Supply voltage	24 Vdc ±10%

Figure 43 – Pressure sensor technical data

3-10 Travel sensor

3-10.1 Description

This optional sensor is used for monitoring primary contact travel. It uses non-contact inductive technology. The sensor provides a linear output proportional with the angle of rotation, from 0° to 60°. The output is a current between 4 to 20mA and it connects to the AI8 module if present in the configuration.

Note: this sensor is typically never used on a retrofit CBWatch3 installation due to its invasive nature.

Figure 44 – Travel sensor

3-10.2 Technical characteristics of the sensor

Environmental Temperature Limits (Operating)	-40°C to +125°C
Supply voltage	16V to 28Vdc
Output	4 to 20 mA
Travel	90°
Frequency response	> 10 kHz (-3dB)

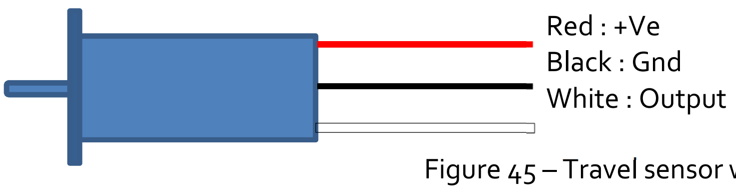


Figure 45 – Travel sensor wiring

3-11 Temperature sensor

3-11.1 Description

PT100 temperature sensors in 3-wire configuration are used to measure temperatures.

These are uses to measure the temperature in the various cabinets in order to ensure that the heaters are working and keeping the temperatures within an acceptable range. They can also be used to measure ambient temperature.

The PT100 sensors connect to the RTD8 temperature module if present in the CBWatch3 configuration. It is possible to connect up to 7 temperature sensors to the RTD8 module plus ambient temperature.

Figure 46 – Temperature sensor (PT100)

3-11.2 Technical characteristics of the sensor

Output	Variable resistor
Operating Temperature Limits	-40°C to +200°C
Resistor value	100 ohms at 0°C

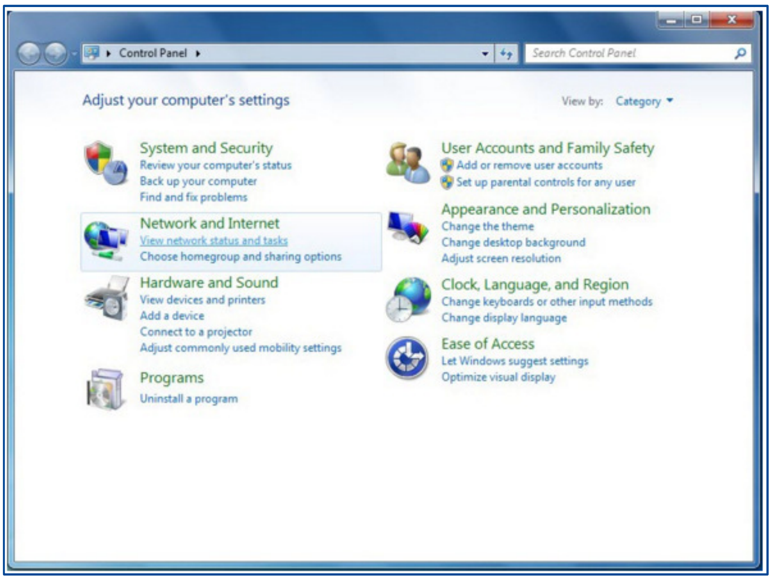
Figure 47 – Temperature sensor technical data

4 HUMAN-MACHINE INTERFACE (HMI)

The CBWatch 3 has an integrated Human-Machine Interface (HMI). Accessible from a web browser, it can access and display all parameters and measurements in CBWatch 3.

4-1 TCP/IP Network card configuration

Open Network Connections by clicking the Start button, and then clicking Control Panel. In the search box, type adapter, and then, under Network and Sharing Center, click View network connections. And then click "change adapter settings"



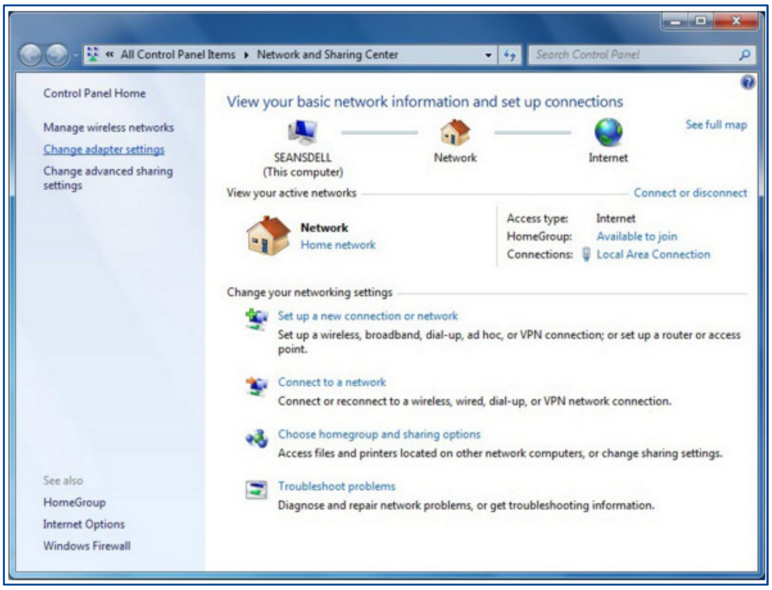


Figure 48 – Network card configuration step 1

Right-click the connection that you want to change, and then click Properties. If you're prompted for an administrator password or confirmation, type the password or provide confirmation.

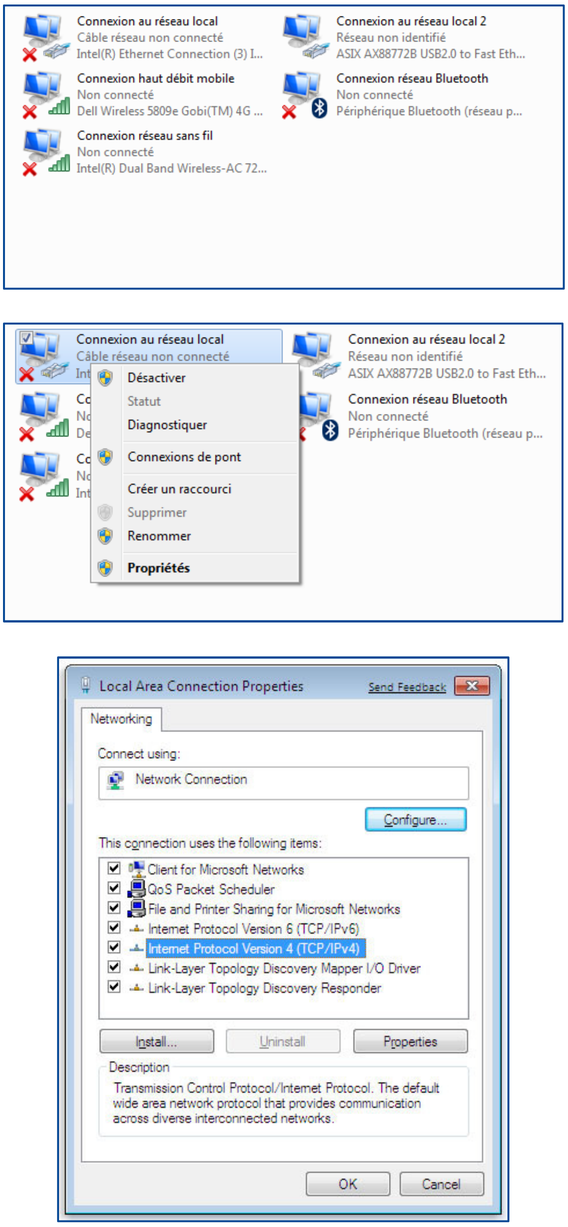
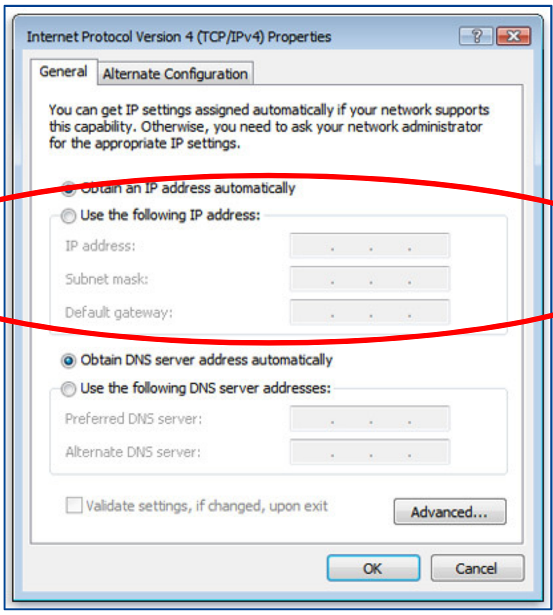


Figure 49 – Network card configuration step 2

To specify IPv4 IP address settings, do one of the following:

To get IP settings automatically using DHCP, click Obtain an IP address automatically, and then click OK.

To specify an IP address, click Use the following IP address, and then, in the IP address, Subnet mask, and Default gateway boxes, type the IP address settings.



Then you should set the IP address and subnet mask.
For example:
If the CBWatch3 IP address is 192.168.5.22, the network card must be as below:

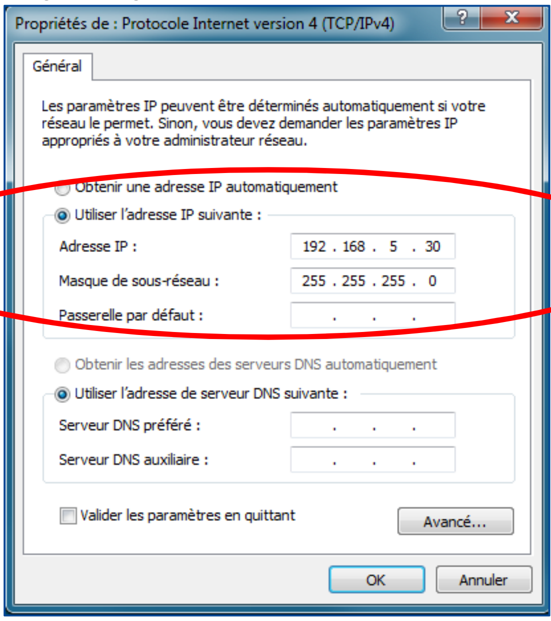


Figure 50 – Network card configuration step 3

The last number 30 could be between 1 and 254 with the exception of 22.

4-2 Connection to the CBWatch3

To be connected to the CBWatch3 you should use either an optical/RJ45 or optical/USB converter.

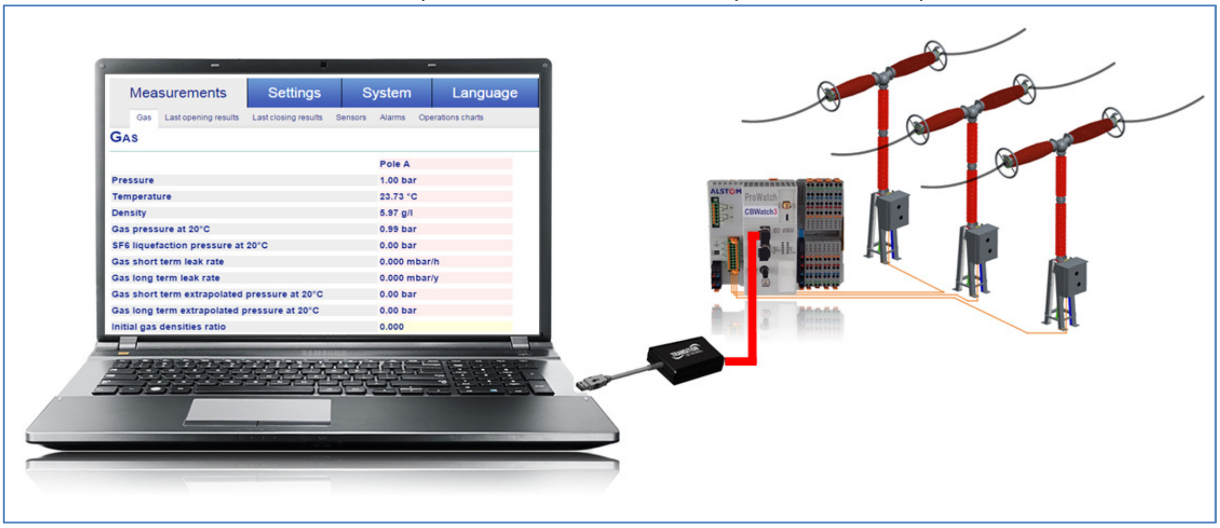


Figure 51 – Connection to the CBWatch3

To log in to the CBWatch 3 HMI you need to launch any Internet browser (for example: "Google Chrome" or "Mozilla Firefox") and enter the IP address in the address line.

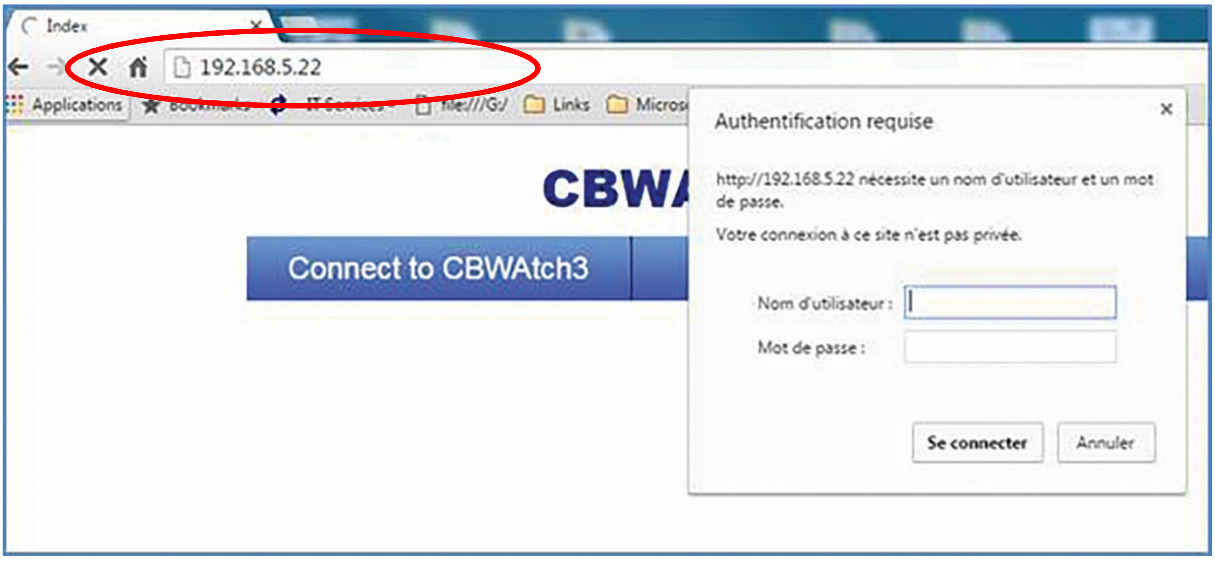


Figure 52 – CBWatch3 log in

4-3 CBWatch3 access level

Access to HMI data is limited according to the access level that the user has.

The main increasing levels of access are listed below. Each next level has the rights of the preceding level plus those listed:

1 User

All measurements and parameters, read-only

Possible to change the language of the HMI

2 Supervisor

Certain parameters are adjustable

Downloading parameters file

3 Specialist

All of the parameters relative to the application are adjustable

4 Expert

Several additional parameters are accessible:

Time and date, network, IEC 61850 file loading

In each sub-part, the adjustment of a parameter will take effect after it has been validated by pressing the "Set" button:

Note that for User level access, no password is required as access to data is read only. Please enter "User "as login, no password is required.

4-4 CBWatch3 network connection

Here is an example of a network connection layout. It is possible to have one or several CBWAtch3 connected on the same substation

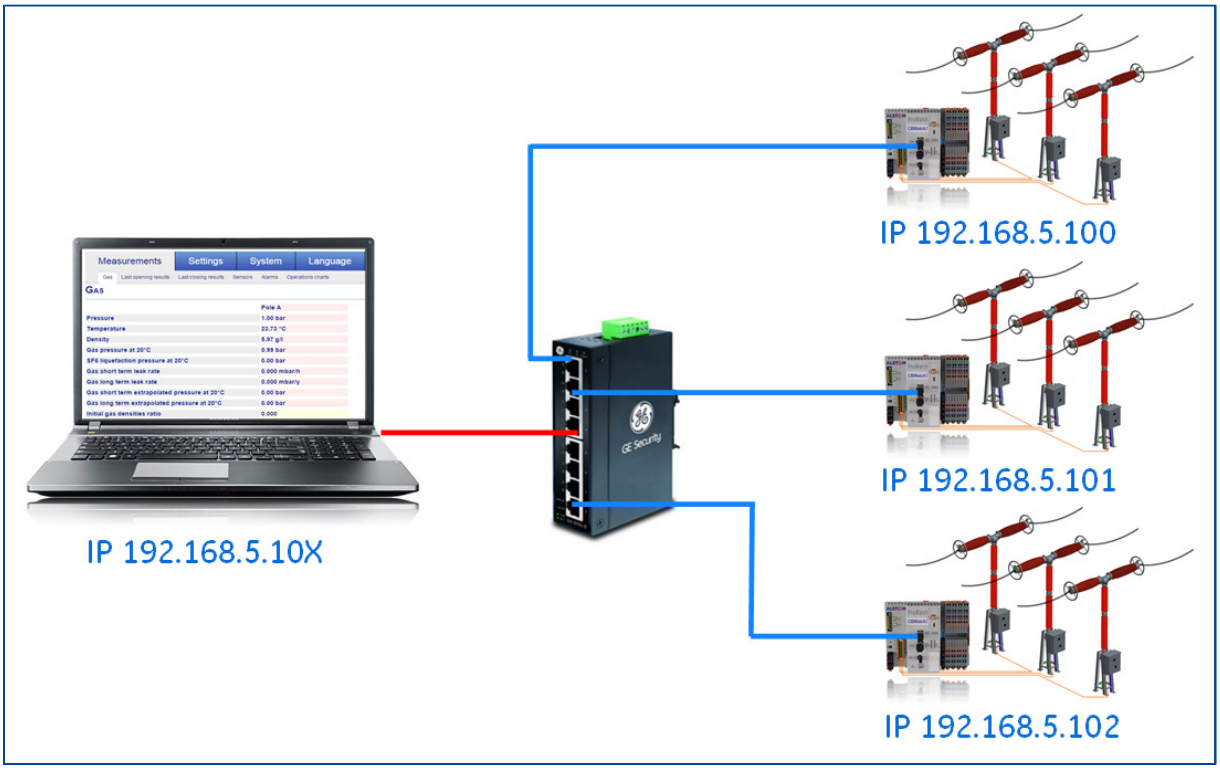


Figure 53 – CBWatch3 network connection

4-5 System Information

Once you have access to the HMI of the CBWatch3, you can visualise the serial number and firmware versions being used:

HMI CBWatch 3: System \ product Info

System Brand	Ge Grid Solutions
System name	CBWatch3
System serial number	30000005 65014628
FPGA	1.2
Software	cbw3_v2.7
IED code	0

Figure 54 – HMI – Product information

5 DESCRIPTION OF THE MONITORING FUNCTIONS

Note: All the functions described hereafter in this section may not be available in your specific purchased CBWatch3 configuration,

However, the following monitoring functions are described in the next section:

5.1 SF_6 Gas Monitoring

5.2 Control Circuit Monitoring

5.3 Operation Monitoring – Retrofit Situation

5.4 Operation Monitoring – New Build Situation

5.5 Arcing Contact Wear Monitoring

5.6 Stored Energy Motor Monitoring

5.7 Spare Analogue Channels Monitoring

5.8 Temperature Monitoring

5.9 Monitoring Alarms

5-1 SF_6 Gas Monitoring

5-1.1 General Description

If the circuit breaker being monitored uses SF_6 gas (or any other gas or gas mixture) to extinguish the arc, then the gas monitoring function can be setup for:

- Number of gas tanks:
  - 0 - no SF_6,
  - 1 - common tank for all 3 poles
  - 3 - one gas tank per pole
- Type of gas or gas mixture (SF_6, SF_6+CF_4, SF_6+N_2, ...)
- Gas pressure unit used: Select "Use PSI unit" if you want display pressure in PSI otherwise Bar unit will be used by default.

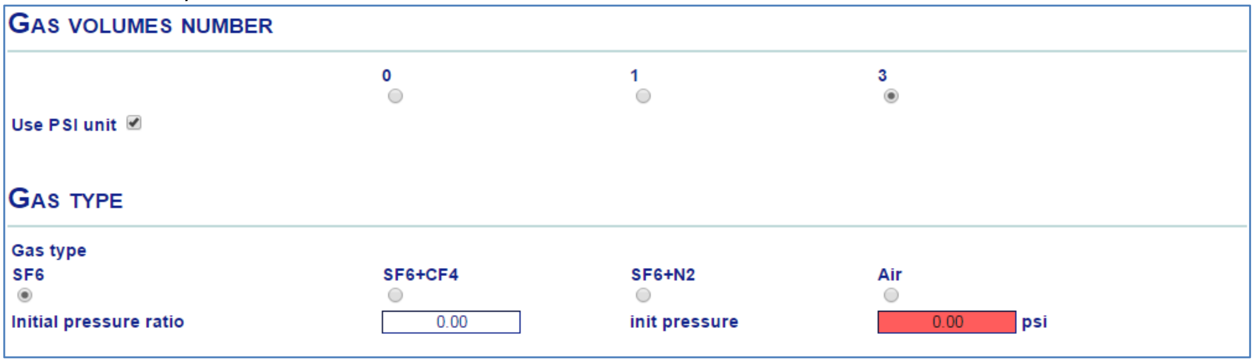


Figure 55 – Gas type configuration screen

The performance of a circuit breaker can be severely affected by the density of the gas contained in the circuit breaker. On commissioning, the circuit breaker is filled to its nominal filling density. During its life, it is necessary to monitor the density of the gas for the following reasons:

- to inform the operator of the necessity to carry out a re-fill operation when the density falls below a certain threshold,
- to take conservatory measures concerning the control of the circuit breaker (interlocking or automatic operation) if the density falls further below a minimum threshold, thus preventing the circuit breaker from fulfilling its function,
- to analyse the changes in density trend with a view to making forecasts.

5-1.2 Gas Measurements

Because gas pressure varies with temperature (see figure below), pressure values cannot be compared over time unless they are temperature compensated. Comparisons are therefore either made using pressure normalised at 20°C or using density expressed in kg/m3 (gr/l).

The principle used for density measurement is the measurement of the pressure and temperature, then the calculation of the density taking into account the thermodynamic laws of the gas or gas mixture used.

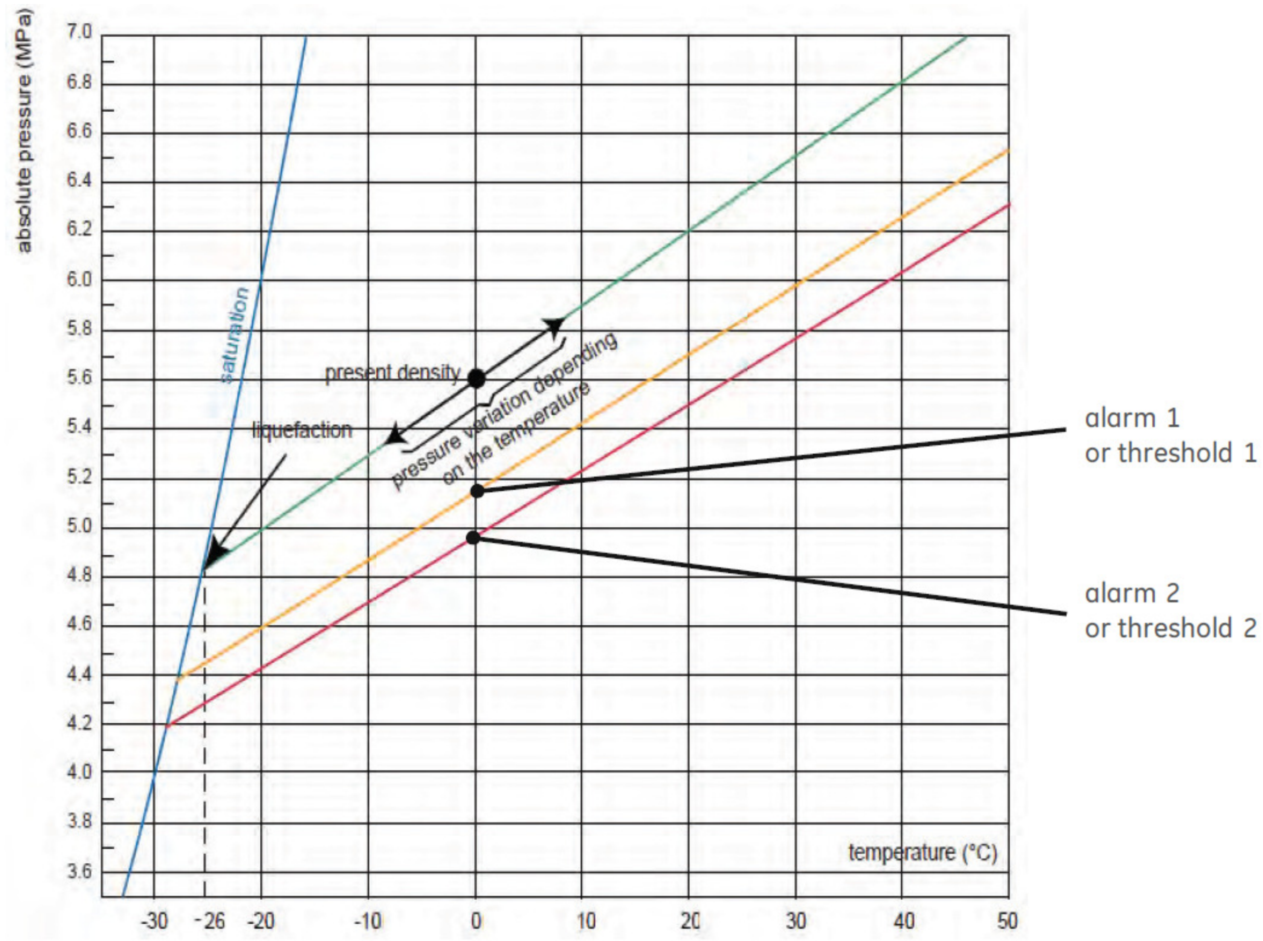


Figure 56– Thermodynamic law illustration

It is possible to display the following gas information in the HMI:

- Pressure: Raw absolute gas pressure measured from sensor
- Temperature: Raw temperature measured from sensor
- Density: Computed density from pressure and temperature values
- Gas pressure at 20°C: Equivalent absolute gas pressure calculated at nominal 20°C
- SF6 liquefaction pressure at 20°C: Absolute gas pressure at 20°C at which SF6 liquefies
- Gas short term leak rate: Per hour
- Gas long term leak rate: Per year
- Gas short term extrapolated pressure at 20°C: Linear regression computed with an history of 2 times the extrapolation delay
- Gas long term extrapolated pressure at 20°C: Linear regression computed with an history of 2 times the extrapolation delay
- Initial gas densities ratio: when an SF_6 gas mixture is used (e.g. SF_6+N_2 in very cold climates), this indicates the initial ratio of the added N_2 gas (e.g. 0.1 means 10%) entered during the setup

GAS

	Pole A	Pole B	Pole C
Pressure	8.45 bar	8.58 bar	8.51 bar
Temperature	28.55 °C	28.45 °C	28.33 °C
Density	54.32 g/l	55.28 g/l	54.81 g/l
Gas pressure at 20°C	8.15 bar	8.28 bar	8.22 bar
SF6 liquefaction pressure at 20°C	0.00 bar	0.00 bar	0.00 bar
Gas short term leak rate	0.000 mbar/h	0.000 mbar/h	0.000 mbar/h
Gas long term leak rate	0.000 mbar/y	0.000 mbar/y	0.000 mbar/y
Gas short term extrapolated pressure at 20°C	0.00 bar	0.00 bar	0.00 bar
Gas long term extrapolated pressure at 20°C	0.00 bar	0.00 bar	0.00 bar
Initial gas densities ratio	0.000		

Figure 57 – HMI – Gas monitoring bar

Note 1:
Because we need it to make density calculations and due to the nature of the sensor, the pressure value shown is the "absolute" value of the pressure inside the gas chamber.
If there is a gauge on the system, the gauge might show a "gauge pressure" (or relative to atmospheric pressure) which is the difference between the absolute pressure and the atmospheric pressure at this altitude and temperature. This is often referred to as XX PSIG (PSI Gauge)
One will then experience a difference between the two readings of approximately 1 bar or 100 kPa or 14.7 psi and should therefore take care when looking at the data or setting alarm limits.

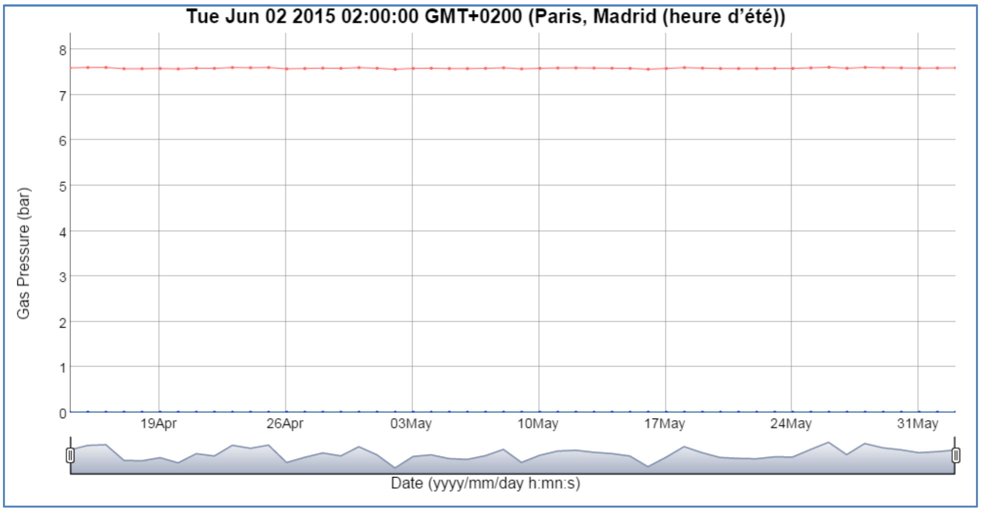
Note 2:
The pressure readings can be set to display in either bar or PSI, depending on preference:

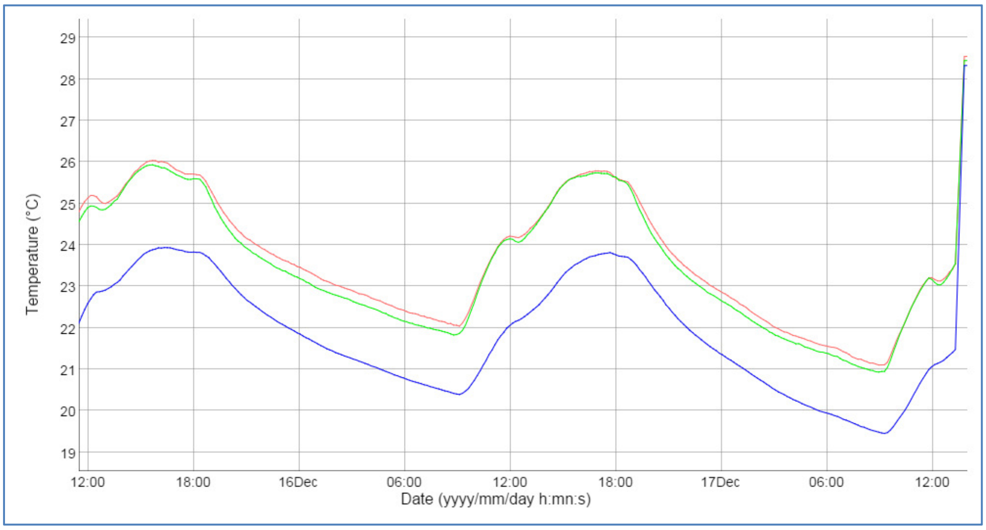
GAS *(G3.1.1)*

	Pole A	Pole B	Pole C
Pressure *(g3.1.1.5)*	86.47 psi *(d3.353)*	86.97 psi *(d3.354)*	87.89 psi *(d3.355)*
Temperature *(g3.1.1.6)*	8.45 °C *(d3.15)*	8.25 °C *(d3.16)*	8.31 °C *(d3.17)*
Density *(g3.1.1.7)*	40.55 g/l *(d3.18)*	40.85 g/l *(d3.19)*	41.31 g/l *(d3.20)*
Gas pressure at 20°C *(g3.1.1.8)*	90.72 psi *(d3.356)*	91.32 psi *(d3.357)*	92.28 psi *(d3.358)*
SF6 liquefaction pressure at 20°C *(g3.1.1.9)*	0.00 psi *(d3.359)*	0.00 psi *(d3.360)*	0.00 psi *(d3.361)*
Gas short term leak rate *(g3.1.1.10)*	0.000 psi/h *(d3.362)*	0.000 psi/h *(d3.363)*	0.000 psi/h *(d3.364)*
Gas long term leak rate *(g3.1.1.11)*	0.000 psi/y *(d3.365)*	0.000 psi/y *(d3.366)*	0.000 psi/y *(d3.367)*
Gas short term extrapolated pressure at 20°C *(g3.1.1.12)*	90.72 psi *(d3.368)*	91.33 psi *(d3.369)*	92.28 psi *(d3.370)*
Gas long term extrapolated pressure at 20°C *(g3.1.1.13)*	0.00 psi *(d3.371)*	0.00 psi *(d3.372)*	0.00 psi *(d3.373)*
Initial gas densities ratio *(g3.1.1.1)*	0.000		

Figure 58 – HMI – Gas monitoring psi

On the HMI you can also display short term or long term curves for pressure, temperature and density:





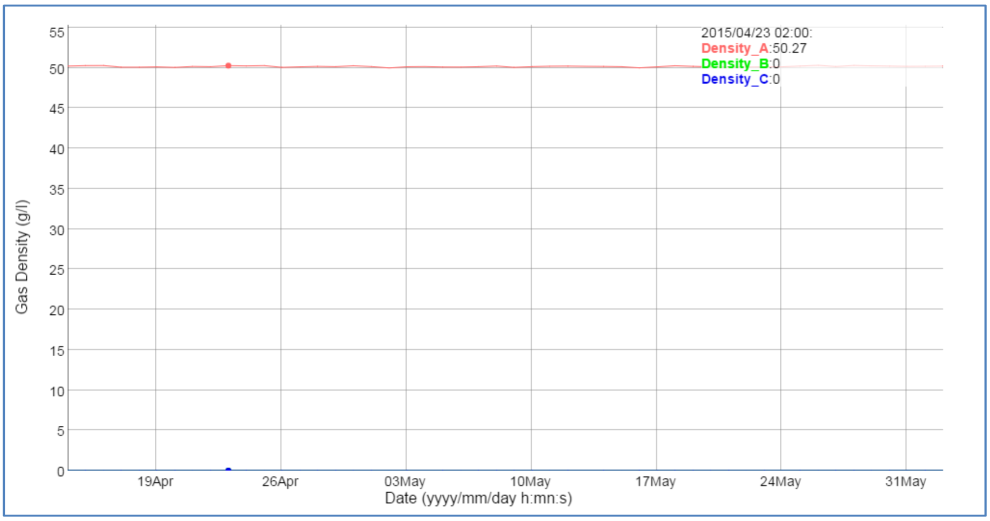


Figure 59 – HMI – Short and long term curves

5-1.3 Threshold alarms

The gas density can be expressed in kg/m3 (gr/l) or in terms of equivalent absolute pressure at nominal 20°C and is compared with a certain number of thresholds. Each of these thresholds can be set by the user in terms of value and hysteresis by setting a decreasing pressure threshold (minimum) and an increasing pressure threshold (maximum) for each level. The figure below illustrates the passage of the various thresholds with their hysteresis during the change in density:

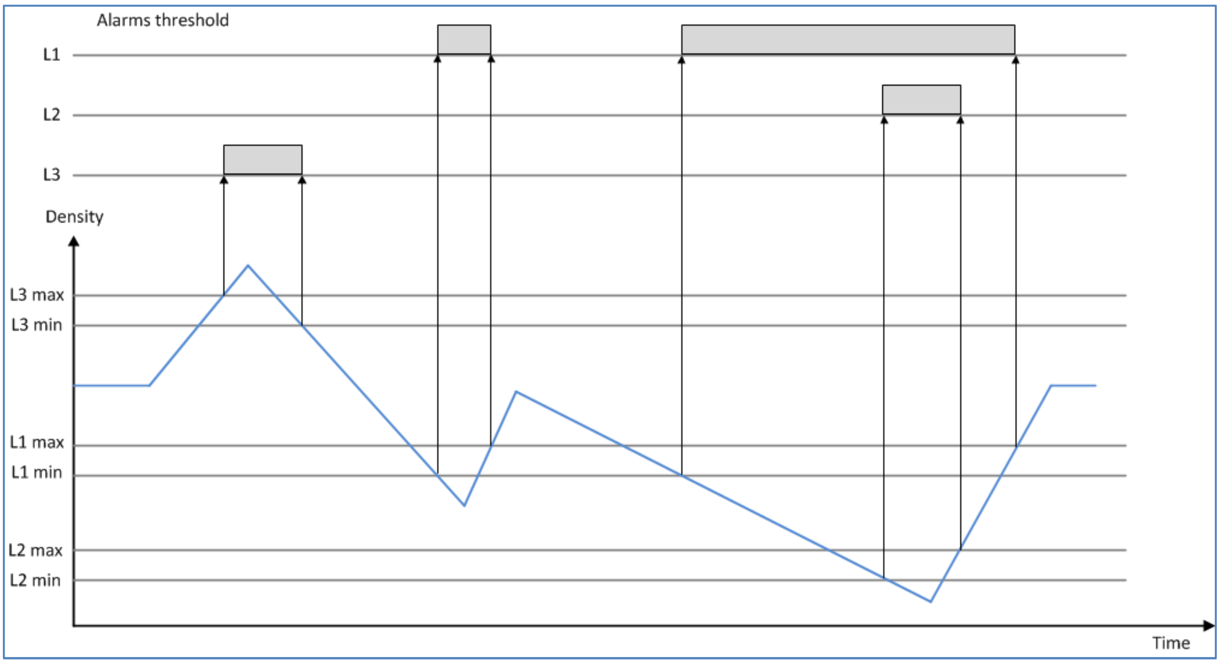


Figure 60 – Gas thresholds

- Threshold L1 "Additional filling": Below this threhold, the circuit breaker is still capable of fulfilling its function but a gas refill action is required to prevent it from reaching threshold L2.
- Threshold L2 "Interlocking or automatic operation": Below this threshold, the circuit breaker is no longer capable of fulfilling its function. In accordance with the operating diagrams, when this threshold is reached, one can either interlock or operate the circuit breaker automatically.
- Threshold L3 "Overfilling": When the amount of gas in the circuit breaker is too high, there is a risk of overpressure at elevated temperature.

Figure 61 – Threshold setup

We recommend to use +/-2% of the value you want to set the threshold at. However, if the sensor is exposed to direct sunlight, larger tolerances should be set to avoid false alarms due to swings in sensor temperatures

5-1.4 Long term trend alarm before L1

For this long term trend calculations, the equivalent gas pressure at 20°C is recorded. The recordings are taken every night at midnight. This allows for consistent conditions and the removal of external influence parameters such as solar radiation.
These recordings are used to carry out a linear extrapolation of the equivalent pressure at 20°C in the future. This allows forecasting of what this value will be in the future.

The long term future time horizon can be pre-set from 20 days to 200 days (see Configuration section).

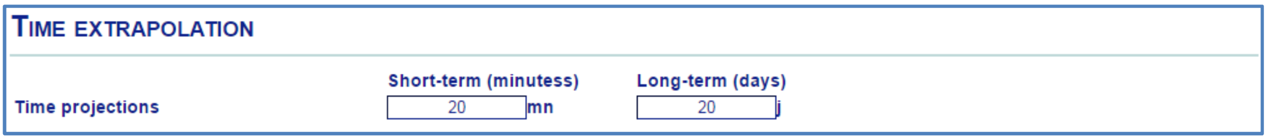


Figure 62 – Future long term time horizon setup

A comparison is then made between this predicted long term future value and threshold L1. An alarm (T1) is raised in case this threshold is reached or overshot.
This alarm indicated that at the calculated long term gas leak rate, threshold L1 will be reached within the long term time horizon that has been pre-set.

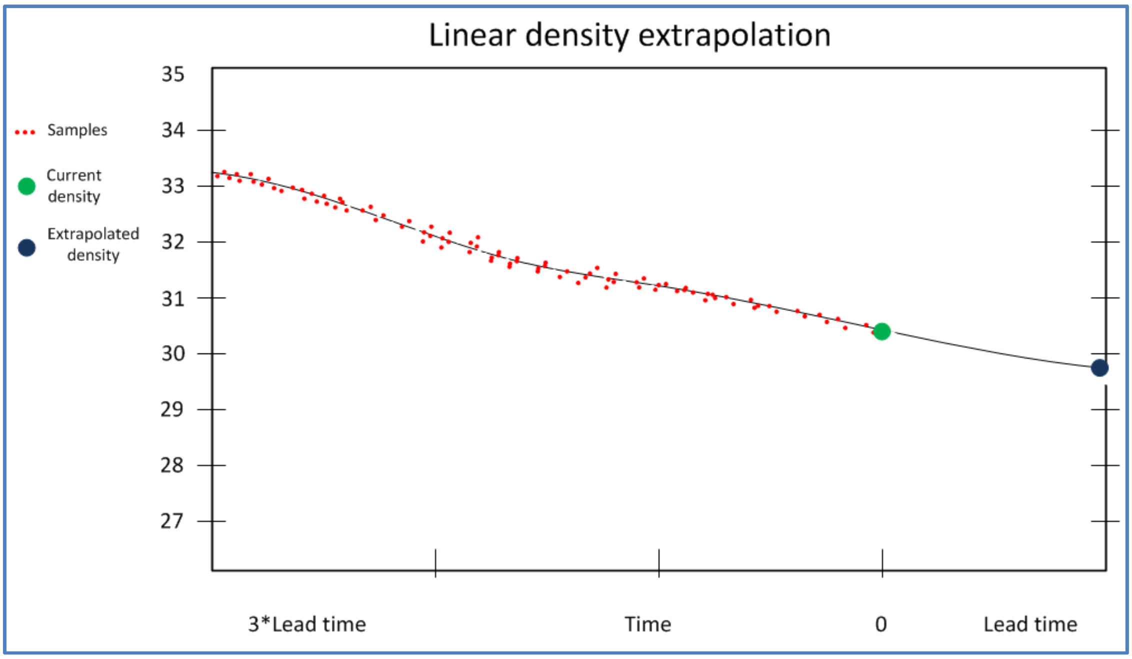


Figure 63 – HMI – Linear density extrapolation

5-1.5 Short term trend alarm before L2

While for long term trend, measurements at fixed regular intervals when external factors can be minimised are used. For the short term trend, the recordings are taken much more frequently and will therefore be sensitive to these external parameters. It therefore becomes much more difficult to evaluate a leakage rate by using a calculation equivalent to the one used for the long term trend.

In cases where the gas volumes of the 3 phases are monitored independently, a reliable detection of relatively rapid leaks is carried out by comparing the measured densities of the three phases taken two by two. By making the assumption that the leak will appear on only one of the three phases, the effect of external parameters can be removed when calculating the leakage rate.

This short term trend allows forecasting of what the value of the equivalent pressure at 20°C will be in the future. The short term future time horizon can be pre-set from 20 to 1,200 minutes (20 hours).

TIME EXTRAPOLATION

	Short-term (minutess)	Long-term (days)
Time projections	20 mn	20 j

Figure 64 – Future short term time horizon setup

A comparison is then made between this predicted short term value and threshold L2. An alarm (T2) is raised in case this threshold is reached or overshot.
This alarm indicates that at the calculated short term gas leak rate, threshold L2 will be reached within the short term time horizon that has been pre-set.

5-1.6 Liquefaction alarm

In order to detect any liquefaction of the gas, a comparison is continuously carried out between the pressure measured and the known saturation pressure at the measured temperature.
If the pressure falls below that level, then a liquefaction risk alarm is raised.

5-1.7 Sensor communication error counter

In case the system loses communication to the gas sensor (for example if the cable has been cut) and therefore there is no answer from the digital sensor, then the sensor power supply is turned off and on again to reset the communication protocol and ensure that it is not a software error. This procedure may be repeated 3 times before the sensor is declared faulty.

GAS PRESSURE AND TEMPERATURE SENSORS

	Pole A	Pole B	Pole C
Serial number	0	0	0
Sensor reset counter	3	3	3
Sensor no answer counter	5	5	5

Figure 65 – HMI – Sensor communication error counter

The serial numbers of each sensor are shown
Sensor no answer counter: Cumulative count of number of "no answer".
This counter is reset to zero as soon as the sensor answers

5-1.8 Alarm Summary

The following user defined alarms can be raised by the system and their status visualised here:

- 3x Threshold alarms
- Liquefaction alarm
- Short and long term trend alarms

There are also system alarms associated with gas monitoring:

- Sensor absence problem – no connection to or data from sensor
- Sensor data validity – there is data being received but it is corrupted
- Short term stack – no enough data points received to date to calculate short term trend
- Long term stack – not enough data points received to date to calculate long term trend

ALARMS RELATED TO GAS

	Pole A	Pole B	Pole C
Threshold 1	No Error	No Error	No Error
Threshold 2	No Error	No Error	No Error
Threshold 3	No Error	No Error	No Error
Liquefaction	No Error	No Error	No Error
Short term extrapolation (threshold 2)	No Error	No Error	No Error
Long term extrapolation (threshold 1)	No Error	No Error	No Error
Sensor absence	No Error	No Error	No Error
Sensor data validity	No Error	No Error	No Error
Filling status of short term stack	Stack Not Enough	Stack Not Enough	Stack Not Enough
Filling status of long term stack	Stack Not Enough	Stack Not Enough	Stack Not Enough

Figure 66 – HMI – Gas alarms

5-2 Control Circuit Monitoring

5-2.1 General description

This is about monitoring the command circuit and ensuring that any open or close command sent either manually or by any protection relay can be executed.

5-2.2 Presence of DC supply

While it is clear that the circuit breaker will fail to receive any command if there is no DC voltage present, as has been explained in the operation section, the timing of the operation may be affected by the presence of a lower than nominal DC voltage.
Both DC source 1 and DC source 2 (if present) are continually monitored and their value at each opening or closing operation stored with the other operation data.

Coils voltages	100.0 V
Coils voltages	100.0 V

Figure 67 – HMI – DC voltage for source 1 and 2

5-2.3 Continuity of circuit

While some modern relays already provide this functionality, this function may be useful as an option in older sub-stations.
This is about monitoring the continuity of the command line circuit from the relay to the trip or close coil including the coil. It will detect any cut wire or coil that has gone open circuit that would prevent the trip or close command from the protection relay being executed.

This function uses the TCW monitoring sensor which injects a small current in the control line, below the level needed to actuate the coil, in order to continually check the continuity of the circuit and that the coil is not open circuit.

The sensor has 3 channels and returns a digital true/false signal as to the good state of the circuit. If at least one control line goes opens for a period greater than a limit, then an alarm is emitted

A separate TCW sensor is required for each DC supply source and it can handle a maximum of 3 circuits so up to 3x TCW sensors may be needed for an IPO breaker.

5-2.4 Coil Integrity

The CBWatch3 can measure the current passing through the coil(s) during an opening or closing operations. This is useful to measure the integrity of the coil. Any partial reduction in the number of turns present (reducing the ability of the coil to trip the latch) will change the impedance of the coil and will be detected through a resulting change of the current.

You can see the coil current curve displayed on the HMI:

HMI CBWatch 3: Measurement / Operations charts / opening or closing

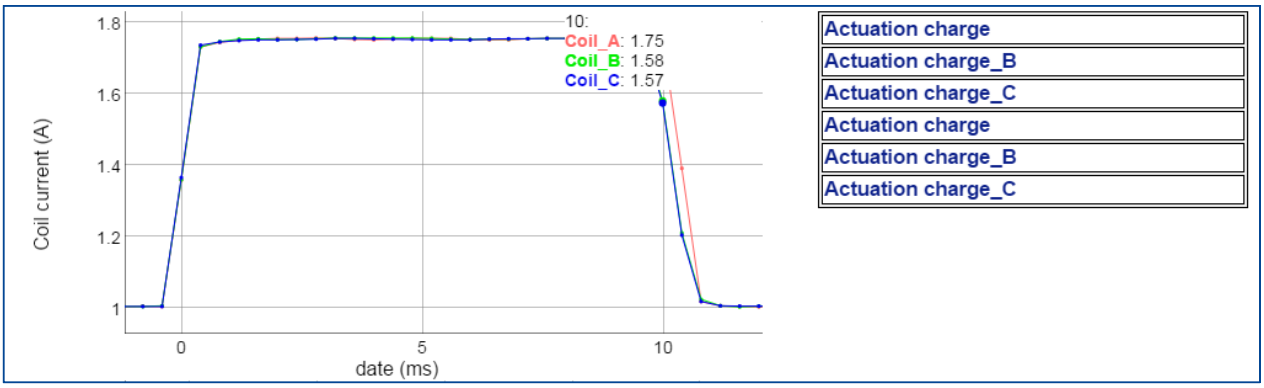


Figure 68 – Current through opening or closing coil

Previous curves are stored and the user is also able to display a previous curve saved by the CBWatch3:

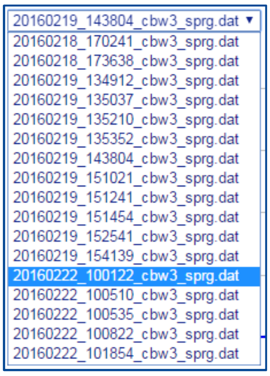


Figure 69 – Drop-down list of previous archives

The current information is also displayed in the HMI:

COIL CURRENT AND CHARGE

Coil charge O1	0.0 A.ms	0.0 A.ms	0.0 A.ms
Coil charge O2	0.0 A.ms	0.0 A.ms	0.0 A.ms
Mean coil current O1	0.0 A	0.0 A	0.0 A
Mean coil current O2	0.0 A	0.0 A	0.0 A

COIL CURRENT AND CHARGE

Coil charge	0.0 A.ms	0.0 A.ms	0.0 A.ms
Mean coil current	0.0 A	0.0 A	0.0 A

Figure 70 – HMI – Coil currents

- Coil charge O1: Coil charge (A x ms) during opening operation of trip 1 circuit
- Coil charge O2: Coil charge (A x ms) during opening operation of trip 2 circuit
- Mean coil current O1: Mean coil current during opening operation of trip 1 circuit
- Mean coil current O2: Mean coil current during opening operation of trip 2 circuit
- Coil charge: Coil charge (A x ms) during closing operation
- Mean coil current: Mean coil current during closing operation

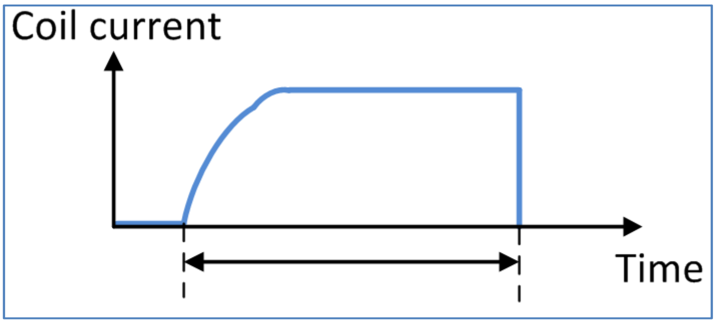


Figure 71 – HMI – Coil current measurement settings

Alarms can be set on:

- Min coil charge (A x ms) when opening
- Max coil charge (A x ms) when opening
- Min coil charge (A x ms) when closing
- Max coil charge (A x ms) when closing

	type	low value	high value	min charge O (A.ms)	max charge O (A.ms)	min charge C (A.ms)	max charge C (A.ms)
Coils current (X9)	0-10V	-2.00	2.00	20.00	70.00	60.00	200.00

Figure 72 – HMI – Coil current measurement settings

5-2.5 Alarm summary

All the alarms relating to the control circuit are summarized in a table on the HMI:

Alarms related to operations			
max coil charge O1	No Error	No Error	No Error
min coil charge O1	No Error	No Error	No Error
max coil charge O2	No Error	No Error	No Error
min coil charge O2	No Error	No Error	No Error
max coil charge cl	No Error	No Error	No Error
min coil charge cl	No Error	No Error	No Error
Overtravel O	No Error	No Error	No Error
Overtravel CL	No Error	No Error	No Error
Pole discrepancy			No Error
Coil circuit continuity			No Error

Figure 73 – HMI – Control circuit alarms

5-3 Operation Monitoring - Retrofit

5-3.1 General Description

The monitoring of the dynamic parameters during the operations of a circuit breaker (operating time, speed etc.) allows for a diagnosis to be made of any possible drift in its mechanical integrity.

- In the "Retrofit" version (often used when monitoring was not fitted during the manufacturing of the circuit breaker), auxiliary position sensors are used: 52a auxiliary position sensor "closed" and 52b auxiliary position sensor "open".
- In the "Original build" version (often used when monitoring was fitted during the manufacturing of the circuit breaker), a displacement/travel sensor can be used if it is already installed on the circuit breaker, which allows for a more refined analysis. The open and close position can be specified during setup. Please refer to next chapter.

5-3.2 Auxiliary contacts status

These are the key contacts that are a direct image of the circuit breaker position and indicate the status of the circuit breaker: 52A: circuit-breaker is closed, 52B: circuit breaker is open

POSITION CONTACTS 52A AND 52B

52a	ON	ON	ON
52b	OFF	OFF	OFF

Figure 74 – HMI – Auxiliary contact position

5-3.3 Number of operations

For each pole, the number of opening and closing operations are recorded and cumulated:

LAST OPENING MEASUREMENTS

	Pole A	Pole B	Pole C
record date	Sun Jan 0 00:00:00 1900		
Opening operations counter	0	0	0

LAST CLOSING MEASUREMENTS

	Pole A	Pole B	Pole C
record date	Sun Jan 0 00:00:00 1900		
Closing operations counter	0	0	0

Figure 75 – Number of opening/closing operation

An alarm can be set if either of the value exceeds a set threshold.

max number of opening operations	50

Figure 76 – HMI – Operation counter alarms

The date and time of the last opening and closing operation is also displayed

5-3.4 Operating times

For each opening operation and for each of the poles, a recording is made of:
- The date of the appearance of the command to open,
- The time t1 between the appearance of the command on the opening coil and the moment where the circuit breaker leaves the "closed" position,
- The time t2 between the appearance of the command on the opening coil and the moment where the circuit breaker arrives in the "open" position.

In the same way, for each closing operation, for each of the phases, a recording is made of:
- The date of the appearance of the command to close,
- The time t1 between the appearance of the command on the closing coil and the moment where the circuit breaker leaves the "open" position,
- The time t2 between the appearance of the command on the closing coil and the moment where the circuit breaker arrives in the "closed" position.

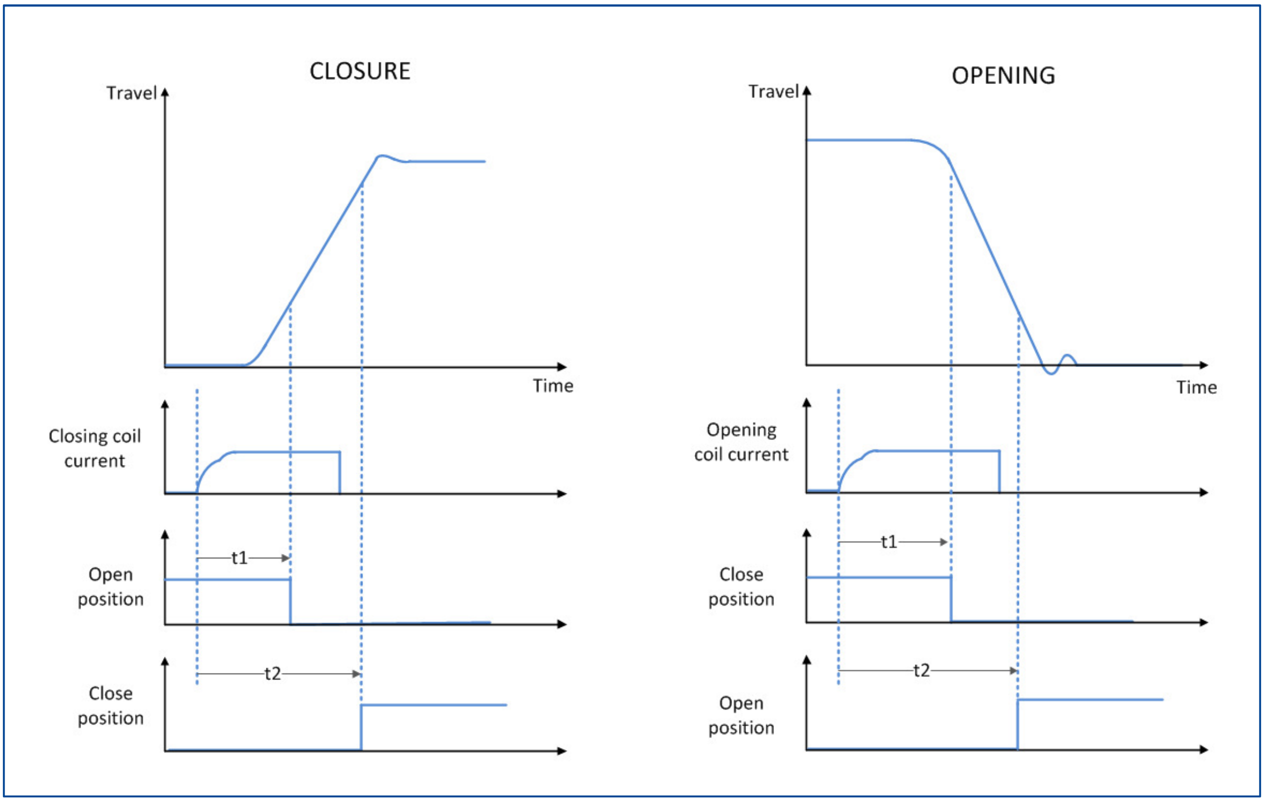


Figure 77 – Operating time measurement

For each operation and for each pole, the following information is stored and displayed. The last 50 operations are kept in memory

- Record date: Date and time of the last opening event
- Opening operation counter: Cumulated opening operations counter.
- Opening reaction time (t1):
- Operation time (t2):
- Contact separation time:
- Contact separation speed:
- Opening travel time: t2 - t1
- Time elapsed from previous operation: If time is too short, operation is not analysed.

LAST OPENING MEASUREMENTS *(G3.3.1)*

	Pole A	Pole B	Pole C
record date *(g3.2.2.1)*	Tue Nov 30 02:21:50 1999		
Opening operations counter *(g3.3.1.3)*	18 *(d3.55)*	18 *(d3.56)*	18 *(d3.57)*
Opening reaction time (t1) *(g3.3.1.1)*	15.2 ms *(d3.49)*	15.6 ms *(d3.50)*	17.2 ms *(d3.51)*
Operation time (t2) *(g3.3.1.2)*	30.0 ms *(d3.52)*	30.0 ms *(d3.53)*	29.2 ms *(d3.54)*
Contacts separation time *(g3.3.1.7)*	15.2 ms *(d3.76)*	15.6 ms *(d3.77)*	17.2 ms *(d3.78)*
Contact separation speed *(g3.3.1.4)*	7.1 m/s *(d3.61)*	7.3 m/s *(d3.62)*	8.8 m/s *(d3.63)*
Opening travel time *(g3.3.1.5)*	14.8 ms *(d3.64)*	14.4 ms *(d3.65)*	12.0 ms *(d3.66)*
Overtravel *(g3.5.2.7)*	0.0 mm *(d3.208)*	0.0 mm *(d3.209)*	0.0 mm *(d3.210)*
Electrical wear cumulation *(g3.3.1.8)*	0.00 kA^2.s *(d3.115)*	0.00 kA^2.s *(d3.116)*	0.00 kA^2.s *(d3.117)*
Time elapsed from previous closing operation *(g3.3.1.6)*	82.0 s *(d3.82)*	82.0 s *(d3.83)*	82.0 s *(d3.84)*

LAST CLOSING MEASUREMENTS *(G3.4.1)*

	Pole A	Pole B	Pole C
record date *(g3.2.2.1)*	Tue Nov 30 02:26:00 1999		
Closing operations counter *(g3.4.1.1)*	86 *(d3.58)*	86 *(d3.59)*	86 *(d3.60)*
Closing reaction time (t1) *(g3.4.1.2)*	48.0 ms *(d3.67)*	47.6 ms *(d3.68)*	51.6 ms *(d3.69)*
Closing operation time (t2) *(g3.4.1.3)*	92.4 ms *(d3.70)*	94.8 ms *(d3.71)*	96.4 ms *(d3.72)*
Auxillairy contacts 52a switching time *(g3.4.1.7)*	48.0 ms *(d3.160)*	47.6 ms *(d3.161)*	51.6 ms *(d3.162)*
Closing travel time *(g3.4.1.4)*	44.4 ms *(d3.73)*	47.2 ms *(d3.74)*	44.8 ms *(d3.75)*
Contact touching speed *(g3.4.1.8)*	2.4 m/s *(d3.229)*	2.2 m/s *(d3.230)*	2.3 m/s *(d3.231)*
Overtravel *(g3.5.2.7)*	0.0 mm *(d3.211)*	0.0 mm *(d3.212)*	0.0 mm *(d3.213)*
Time elapsed from previous opening operation *(g3.4.1.5)*	250.0 s *(d3.79)*	250.0 s *(d3.79)*	250.0 s *(d3.80)*
Drive reload time *(g3.4.1.6)*	0.0 s *(d3.154)*	0.0 s *(d3.155)*	0.0 s *(d3.156)*
Cumulated drive reload time *(g3.4.1.6.1)*	0.00 min *(d3.347)*	0.00 min *(d3.348)*	0.00 min *(d3.349)*
Number of drive reload *(g3.4.1.6.2)*	0 *(d3.350)*	0 *(d3.351)*	0 *(d3.352)*

Figure 78 – HMI – Last operation measurements

5-3.5 Timing alarms

At each operation (opening or closing), the values of t1, t2 and t2-t1 are compared with the minimum and maximum allowed times that have been setup during the configuration.

	max t1	min t1		max t2	min t2
Opening reaction time t1	21.0 ms	15.0 ms	Opening operation time t2	31.0 ms	23.0 ms
Max opening reaction time t1 discrepancy	5.0 ms		Max opening operation time t2 discrepancy	5.0 ms	
Max opening travel time t2-t1 discrepancy	5.0 ms		Minimum time since last closing	300.0 ms	
	max t2-t1	min t2-t1			
Opening travel time t2-t1	14.0 ms	5.0 ms	Min separation speed	3.50 m/s	

Figure 79 – HMI – Opening operations time alarms

The nominal values of t1 and t2 are usually available from the Factory Acceptance Test of the breaker. We recommend using +/-5% of the target for the minimum and maximum. t1 and t2 must be set on the linear portion of the curve.

An alarm can also be set on the minimum separation speed.

Please note that in the case of a cycle of operations, only the first operation of the cycle is analysed.

5-3.6 Discordance between poles

When poles are opened simultaneously the opening and closing operation timing are compared for each pole and any differences are highlighted.
There will always be small differences but if one phase experiences a delay greater than a threshold set by the user, than an alarm is raised so that the cause can be investigated.

OPERATION TIME DISCORDANCE BETWEEN POLES, OPENING OPERATIONS			
	Pole A	Pole B	Pole C
	|A-B|	|A-C|	|C-B|
Reaction time discordances (t1)	0.0 ms	0.0 ms	0.0 ms
Reaction time discrepancy (t1)			0.0 ms
Operation time discordances (t2)	0.0 ms	0.0 ms	0.0 ms
Operation time discrepancy (t2)			0.0 ms
Travel time discordances (t2-t1)	0.0 ms	0.0 ms	0.0 ms
Travel time discrepancy (t2-t1)			0.0 ms

OPERATION TIME DISCORDANCE BETWEEN POLES, CLOSING OPERATIONS			
	|A-B|	|A-C|	|C-B|
Reaction time discordances (t1)	0.0 ms	0.0 ms	0.0 ms
Reaction time discrepancy (t1)			0.0 ms
Operation time discordances (t2)	0.0 ms	0.0 ms	0.0 ms
Operation time discrepancy (t2)			0.0 ms
Travel time discordances (t2-t1)	0.0 ms	0.0 ms	0.0 ms
Travel time discrepancy (t2-t1)			0.0 ms

Figure 80 – HMI - Operating time discordances

For each value normally measured:

- Discordance indicates the 3 "pole to pole" differences
- Discrepancy is the maximum of the 3 discordance value

An alarm can be set if the maximum discrepancy recorded exceeds a pre-set limit for any of the times: t1, t2 and t2-t1:

	max t1	min t1		max t2	min t2
Opening reaction time t1	21.0 ms	15.0 ms	Opening operation time t2	31.0 ms	23.0 ms
Max opening reaction time t1 discrepancy	5.0 ms		Max opening operation time t2 discrepancy	5.0 ms	
Max opening travel time t2-t1 discrepancy	5.0 ms		Minimum time since last closing	300.0 ms	
	max t2-t1	min t2-t1			
Opening travel time t2-t1	14.0 ms	5.0 ms	Min separation speed	3.50 m/s	

Figure 81 – HMI – Opening operations discrepancy alarms

5-3.7 Timing compensation

The operating time of a circuit breaker varies depending on:

- the voltage made available to the coil (lower DC voltage will mean that the coil takes longer to energise to the required level)
- the ambient temperature (greater friction in the mechanical movement at low temperature).

These variations do not reflect any issue with the circuit breaker and therefore should be compensated for before triggering an alarm to avoid false alarms.

These compensations can be activated, both for opening and closing operations, during the setup depending on the presence of the necessary optional sensors and the availability of the necessary compensation information.

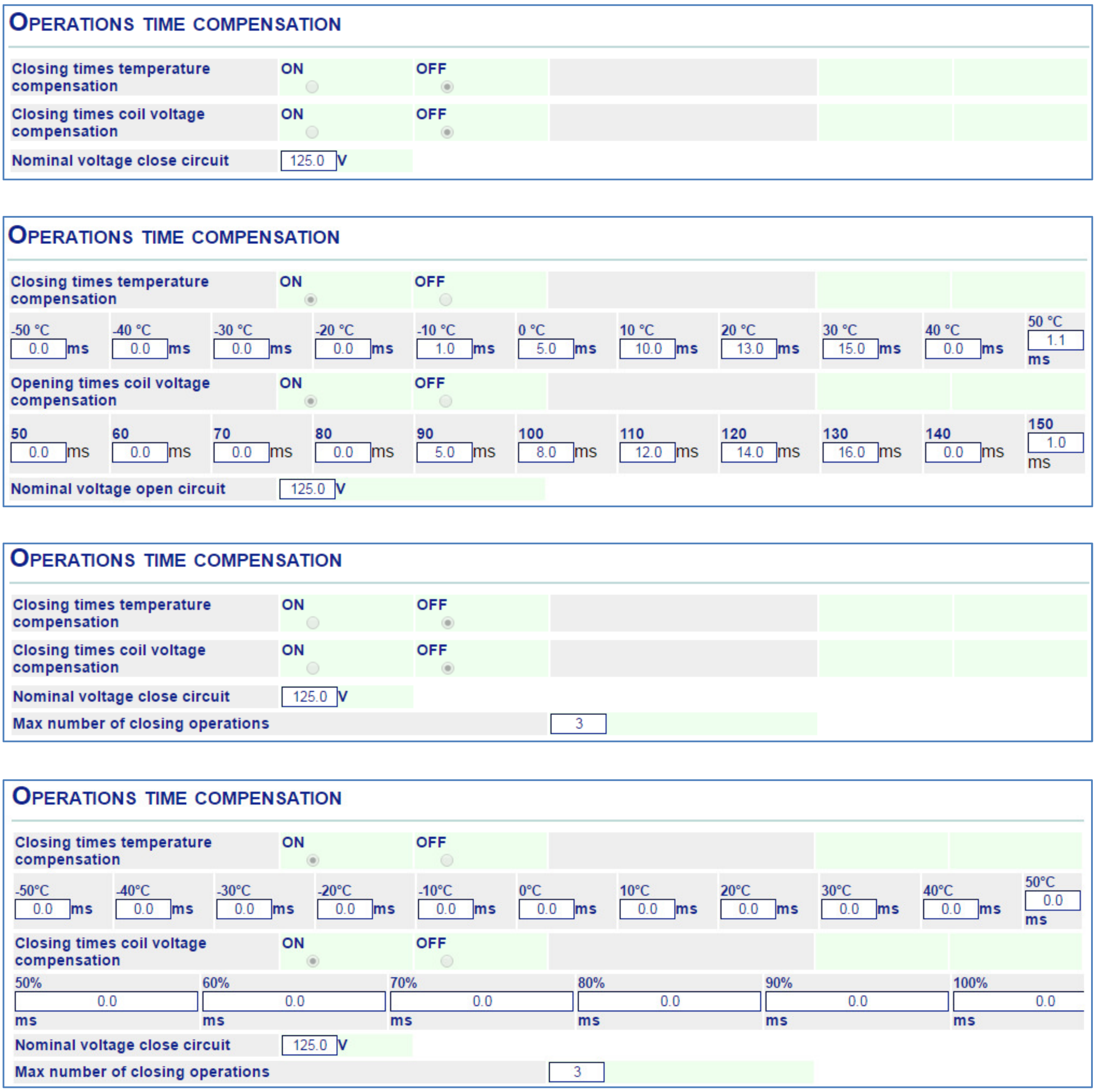


Figure 82 – HMI – Timing compensation

The operating time compensation for the control line voltage is a fixed rule and depends on the actual DC voltage being supplied to the coil. It required the presence of the DC voltage measurement sensor to provide the measured DC voltage information required.
The coil voltage compensation is computed by shifting the thresholds based on the nominal voltage of the circuit and the coil voltage measured when the operation took place.

The operating time compensation for temperature uses the ambient temperature value and a compensation table that you can customise for your individual circuit breaker type during setup. A default table is already entered but you can overwrite it using your own values.
The temperature compensation is computed by shifting the thresholds based on the recorded ambient temperature and a table provided during the set-up.

If no data is available from the manufacturer, then this table can be built up over time by reviewing the data of operations performed at different times and temperatures during the year.
Below are examples of compensation for the operating times depending on the ambient temperature for two different circuit breakers:

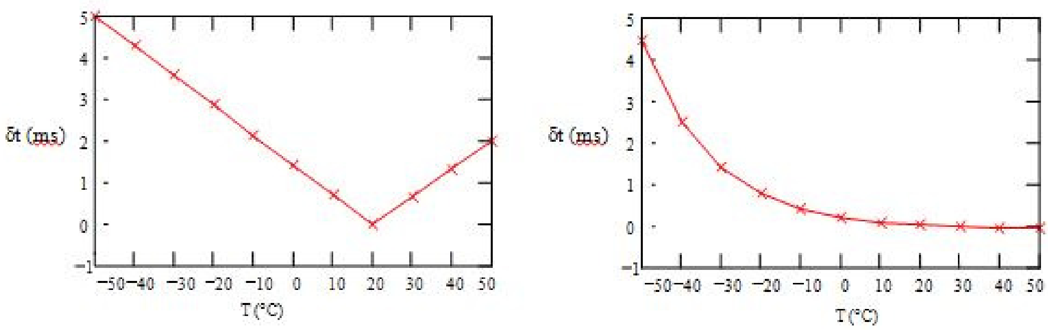


Figure 83 – Operating time temperature compensation

5-3.8 Operation Graphs

In the embedded web HMI, you can view the following operation graphs for each pole. The last 20 are stored and you can download them in COMTRADE format.

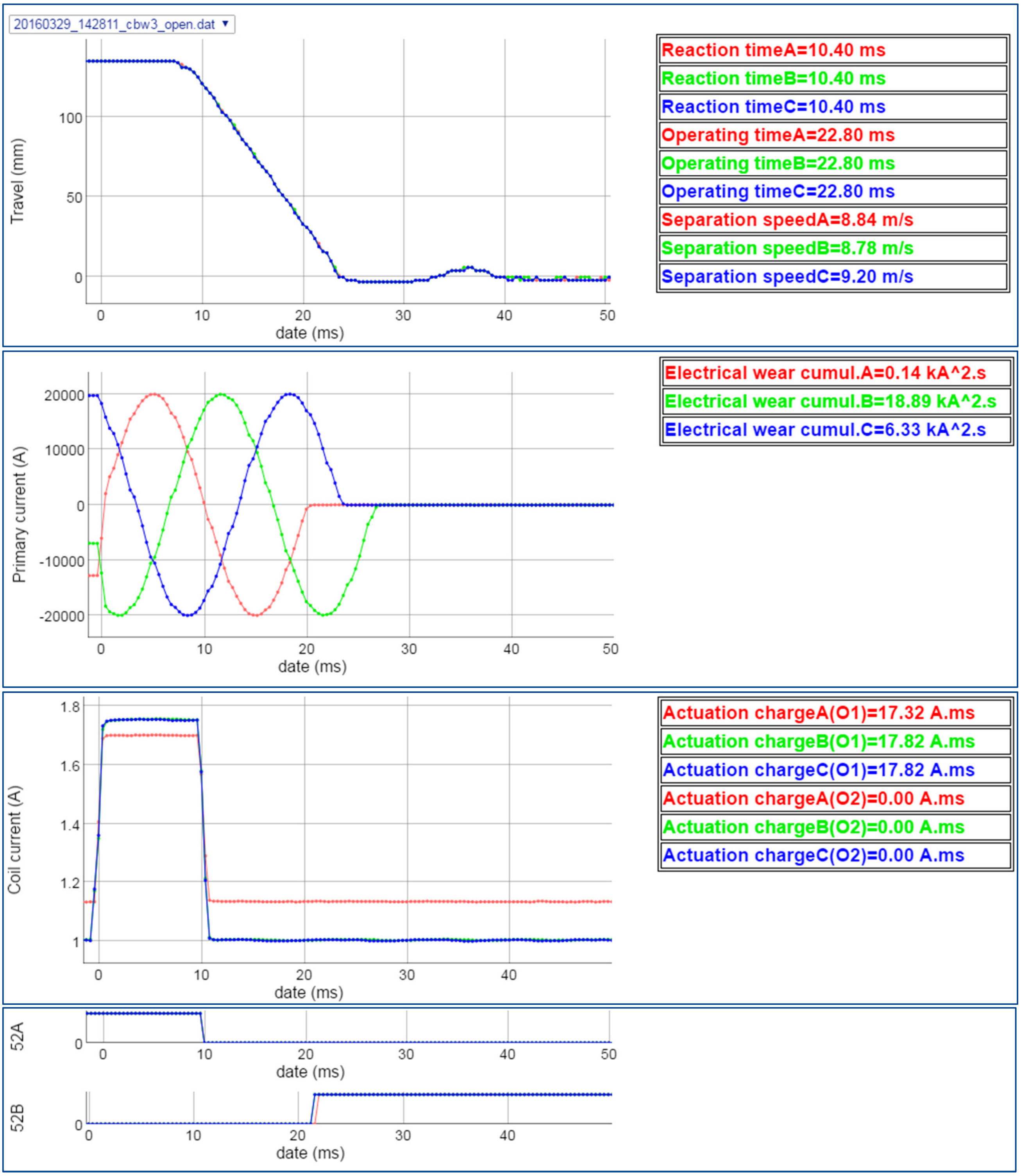


Figure 84 – HMI – Operation graphs for opening

In the embedded web HMI, you can view the following closing operation graphs, for each pole. The last 20 are stored and you can download them in COMTRADE format.

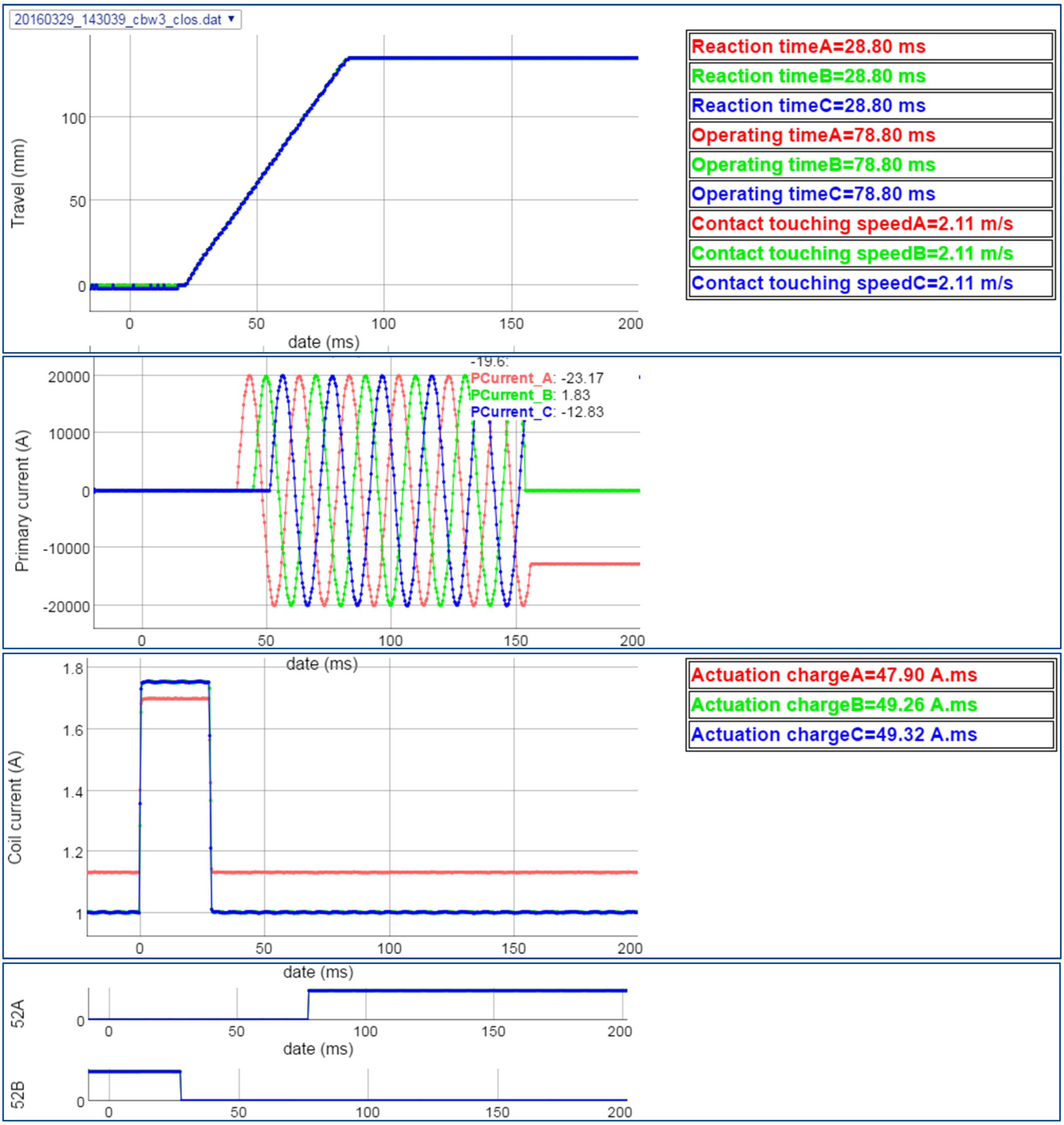


Figure 85 – HMI – Operation charts for closing

5-4 Operation Monitoring – New build*

*The presence of a travel sensor is required for all the following additional functionalities

5-4.1 General Description

The monitoring of the dynamic parameters during the operations of a circuit breaker (operating time, speed etc.) allows for a diagnosis to be made of any possible drift in its mechanical integrity.

- In the "Retrofit" version (often used when monitoring was not fitted during the manufacturing of the circuit breaker), auxiliary position sensors are used: 52a auxiliary position sensor "closed" and 52b auxiliary position sensor "open". See previous chapter.
- In the "New build" version (often used when monitoring was fitted during the manufacturing of the circuit breaker), a displacement/travel sensor can be used if it is installed on the circuit breaker. It allows for a more refined analysis. The open and close position can be precisely specified during setup. Please read this chapter for the extra functionalities afforded by the presence of a travel sensor.

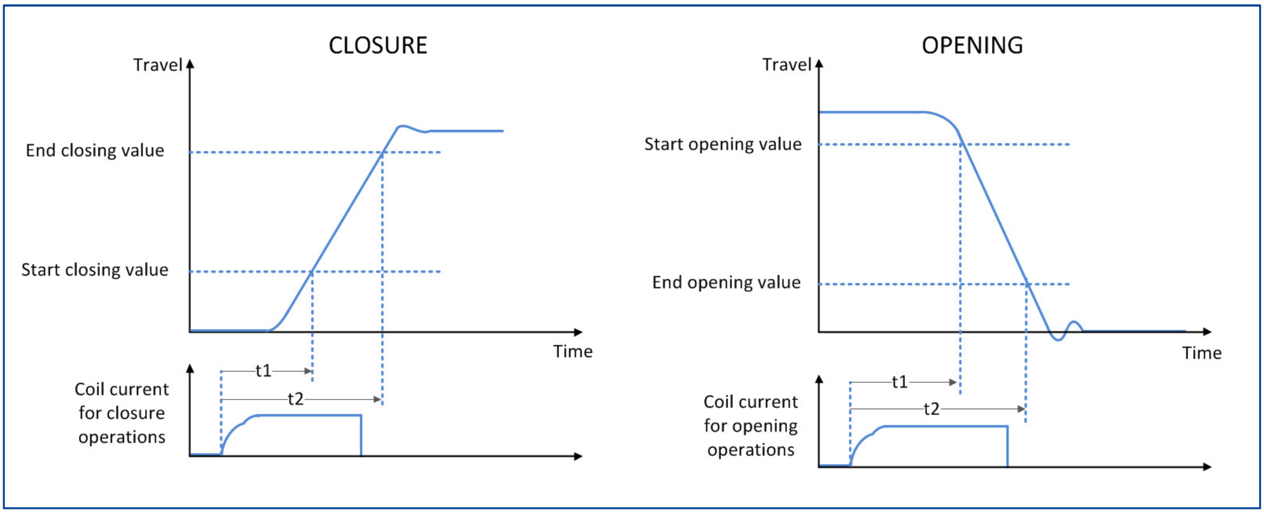


Figure 86 – Operating time measurement

The following additional monitoring and analysis functions are available if a travel sensor is fitted:

5-4.2 Travel sensor kinematics*

The measurement of the displacement is not made in the interrupting chamber itself but by using a travel sensor mounted usually on the output shaft of the mechanical control. It is therefore necessary to apply a correction to the displacement measured to compensate for the deformation due to the kinematics between the control's output shaft and the displacement of the contacts in the chamber. This correction of the kinematics is described by a curve giving the displacement of the contacts in the chamber depending on the sensor's travel.

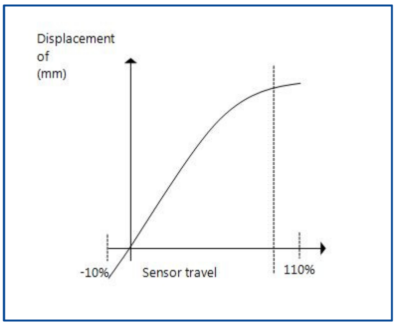


Figure 87 – Displacement sensor

The compensation parameters are specific to each circuit breaker travel sensor and are entered in a table during setup:

TRAVEL CONVERSION FROM % TO MM

-10%	-9.00 mm	-9%	-8.000 mm	-8%	-7.000 mm	-7%	-7.000 mm	-6%	-6.000 mm
-5%	-5.000 mm	-4%	-4.000 mm	-3%	-4.000 mm	-2%	-3.000 mm	-1%	-2.000 mm
0%	0.000 mm	1%	0.000 mm	2%	1.000 mm	3%	3.000 mm	4%	4.000 mm
5%	6.000 mm	6%	7.000 mm	7%	9.000 mm	8%	10.000 mm	9%	12.000 mm
10%	13.000 mm	11%	15.000 mm	12%	16.000 mm	13%	18.000 mm	14%	19.000 mm
15%	21.000 mm	16%	22.000 mm	17%	24.000 mm	18%	25.000 mm	19%	27.000 mm
20%	28.000 mm	21%	30.000 mm	22%	31.000 mm	23%	33.000 mm	24%	34.000 mm
25%	36.000 mm	26%	37.000 mm	27%	39.000 mm	28%	40.000 mm	29%	42.000 mm
30%	43.000 mm	31%	45.000 mm	32%	46.000 mm	33%	48.000 mm	34%	49.000 mm
35%	51.000 mm	36%	52.000 mm	37%	54.000 mm	38%	55.000 mm	39%	57.000 mm
40%	58.000 mm	41%	60.000 mm	42%	61.000 mm	43%	63.000 mm	44%	64.000 mm
45%	66.000 mm	46%	67.000 mm	47%	69.000 mm	48%	70.000 mm	49%	72.000 mm
50%	72.000 mm	51%	74.000 mm	52%	75.000 mm	53%	77.000 mm	54%	78.000 mm
55%	80.000 mm	56%	81.000 mm	57%	83.000 mm	58%	84.000 mm	59%	86.000 mm
60%	87.000 mm	61%	88.000 mm	62%	90.000 mm	63%	91.000 mm	64%	92.000 mm
65%	93.000 mm	66%	95.000 mm	67%	96.000 mm	68%	98.000 mm	69%	99.000 mm
70%	101.000 mm	71%	101.000 mm	72%	103.000 mm	73%	104.000 mm	74%	105.000 mm
75%	107.000 mm	76%	108.000 mm	77%	109.000 mm	78%	110.000 mm	79%	112.000 mm
80%	113.000 mm	81%	114.000 mm	82%	115.000 mm	83%	116.000 mm	84%	118.000 mm
85%	119.000 mm	86%	120.000 mm	87%	121.000 mm	88%	122.000 mm	89%	123.000 mm
90%	125.000 mm	91%	125.000 mm	92%	126.000 mm	93%	128.000 mm	94%	128.000 mm
95%	130.000 mm	96%	131.000 mm	97%	131.000 mm	98%	133.000 mm	99%	134.000 mm
100%	135.000 mm	101%	136.000 mm	102%	136.000 mm	103%	137.000 mm	104%	138.000 mm
105%	139.000 mm	106%	140.000 mm	107%	141.000 mm	108%	142.000 mm	109%	142.000 mm

Figure 88 – Travel conversion table

5-4.3 Contact separation speed*

During breaker opening, the speed at the moment of separation of the contacts is calculated. This speed is then compared to a minimum separation speed entered during setup.

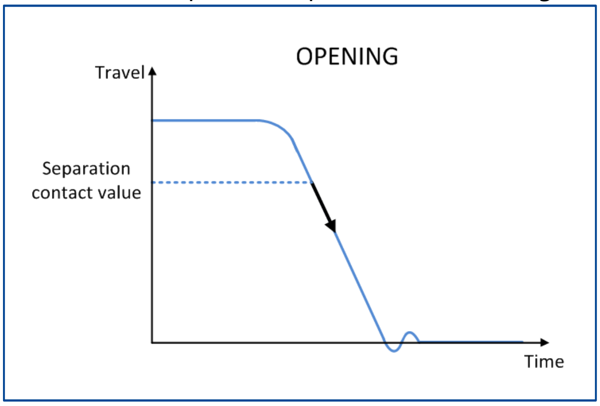


Figure 89 – Speed of separation of the contacts

5-4.4 Bounces and the final position*

Monitoring the final position

For each opening or closing operation, limits are set for position of the travel sensor at the end of the operation. This is to ensure that the breaker has fully opened or closed.

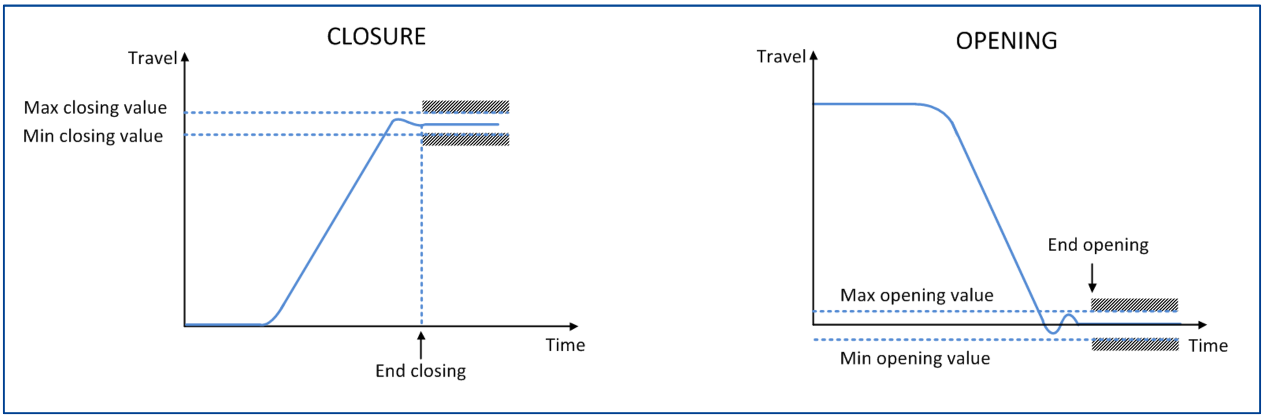


Figure 90 – Monitoring of the final position

Monitoring the bounces:

The bounces and overshoots at end of the contact travel are also monitored for each operation. This is to detect if the damping system that slows the breaker down at the end of its travel is still effective or needs to be replaced.

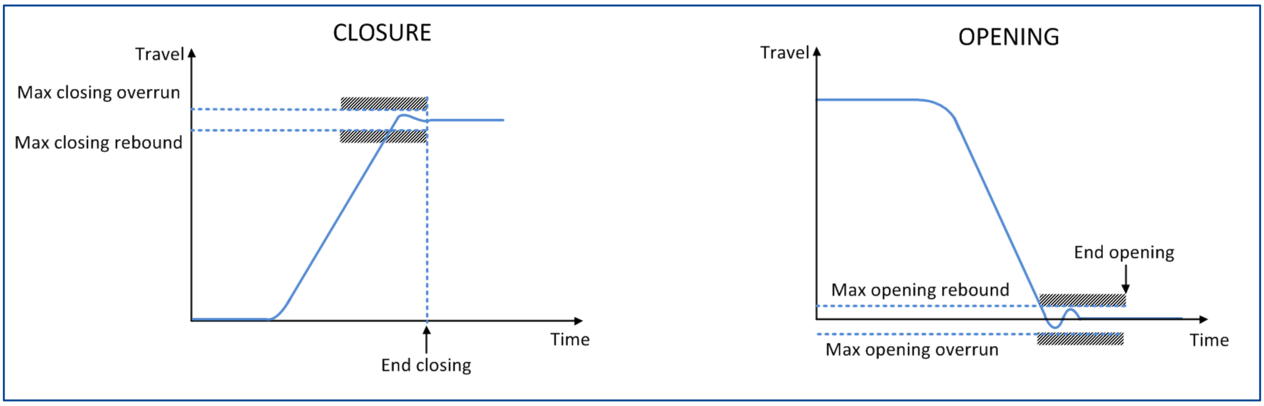


Figure 91 – Monitoring the bounces

5-4.5 Travel during a CO cycle*

During a CO cycle (Close followed by Open), a check is made that the dimension reached at the end of the Close operation is sufficient.

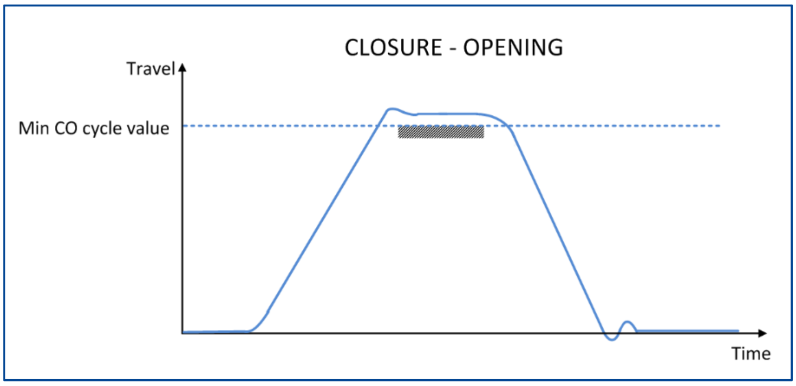


Figure 92 – Travel during a CO cycle

5-4.6 Auxiliary contact switches*

The inputs for the travel sensors can be used to check the position at which the auxiliary contacts switch over.
For each operation, the position/dimension at which the auxiliary contacts should switch over can be determined and compared to what they actually are to detect any issue.

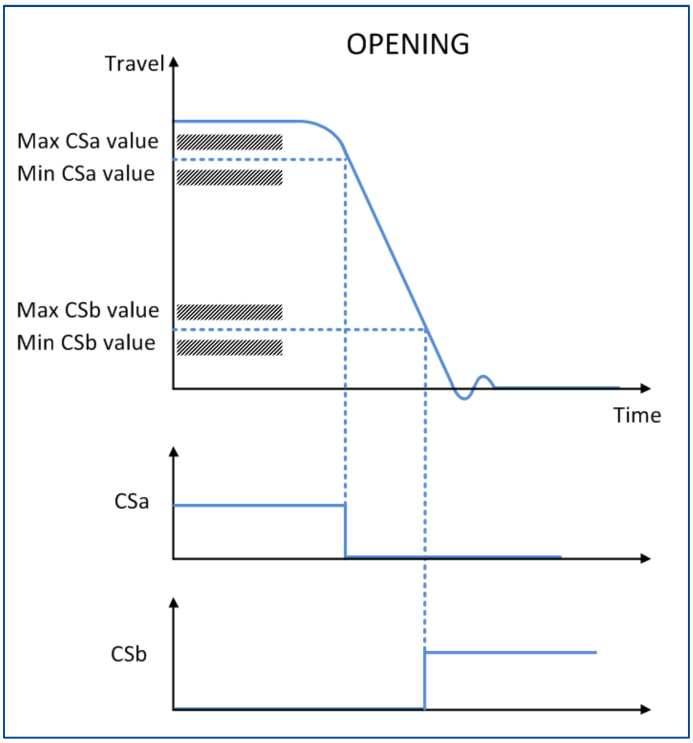


Figure 93 – Monitoring the auxiliary contacts

The following information is made available:

CIRCUIT BREAKER

Circuit breaker current	0.00 kA	0.00 kA	0.00 kA
Auxiliary contact 52a switching time	0.0 ms	0.0 ms	0.0 ms
Auxiliary contact 52b switching time	0.0 ms	0.0 ms	0.0 ms

Figure 94 – HMI – Auxiliary contact timing

- Auxiliary contact 52a switching time: Time duration between coil command and contact switching
- Auxiliary contact 52b switching time: Time duration between coil command and contact switching

5-5 Arcing Contact Wear Monitoring

5-5.1 General Description

Most circuit breakers use special arcing contacts specifically designed to withstand the high energy that occurs during arcing when opening a circuit breaker. They have a finite service life and therefore need to be replaced when it has been reached.

If we measure the current interrupted, square it and multiply it by the arcing time, we get the "I^2T" measure of the energy that the contact has been subjected to. By keeping a cumulative total of this energy throughout the life of the contact, we can estimate the "contact wear" due to electrical deterioration.

Moreover, during each interruption, monitoring of the arcing time is made to detect any degradation in the performances of the current interruption and possibly a "non-interruption".

5-5.2 Sampling of the current before and during the interruption

The current flowing through the breaker is monitored for each pole using the breaker's own primary current CTs which are connected through further CTs to the CBWatch3.

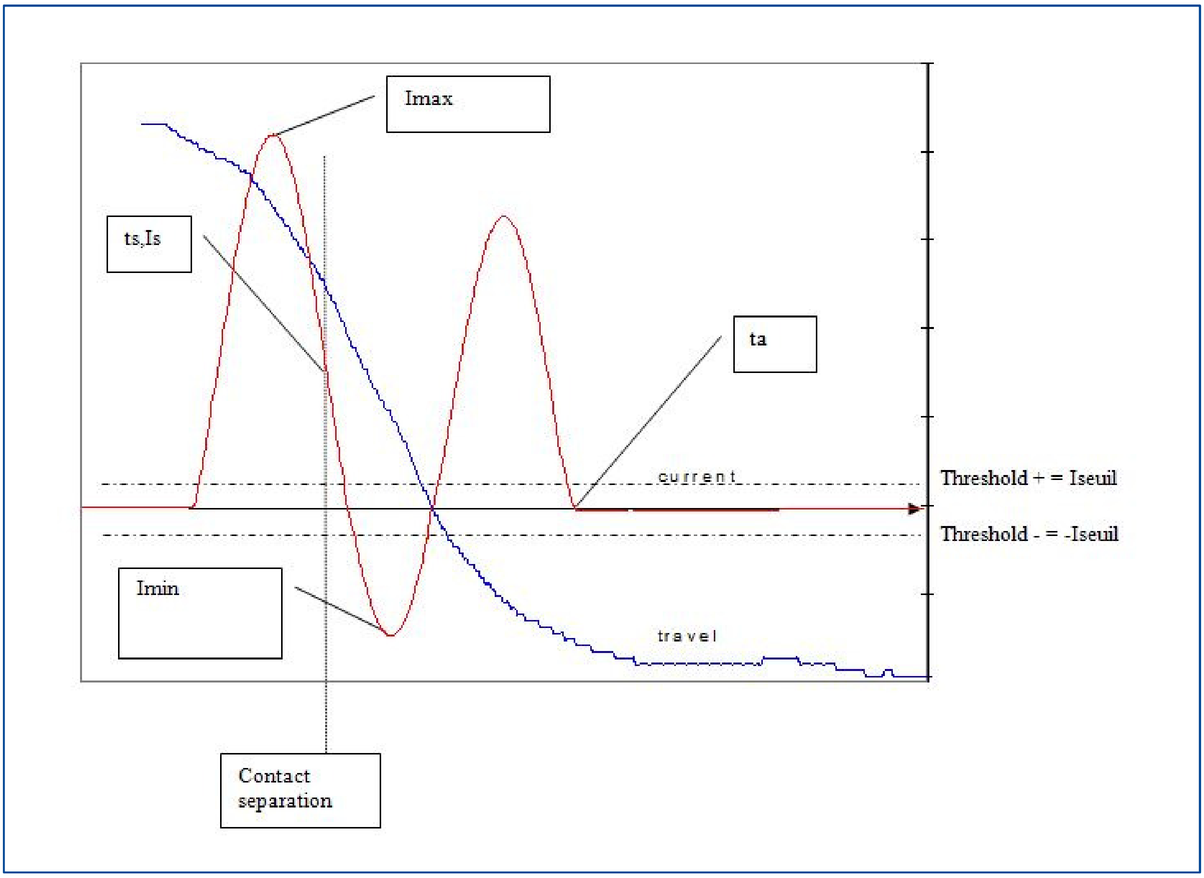


Figure 95 – Current before and during interruption

During the first 20 milliseconds following the command to the coil, the minimum and maximum peak current values (Imin and Imax) are determined. An estimate can be made of the interrupted current by the equation: $Irms=(Imax-Imin)/2\sqrt{2}$.

This RMS interrupted current value for each pole is both stored and displayed in the HMI:

CIRCUIT BREAKER *(G3.5.2)*

Circuit breaker current *(g3.5.2.2)*	0.01 kA *(d3.112)*	0.01 kA *(d3.113)*	0.01 kA *(d3.114)*

Figure 96 – Interrupted current value

We can determine the instant of the separation of the contacts (Ts):

- In cases where a travel sensor is available, detection can be made of the instant at which the dimension for separation of the contacts is reached.
- In cases where only auxiliary sensors are available, a time delay (part of settings) is counted from the instant at which the 52A auxiliary contact switches over.

A simplified current curve is archived with the operation (20 points by reason of 1 point every 2ms from the instant the contacts are separated).

5-5.3 Cumulative electrical wear

From the separation of the contacts (instant Ts) and until definitive extinction of the current (instant Ta), we cumulate the squared amps interrupted by the circuit breaker in order to estimate any electrical deterioration induced by the operation and by phase.

Electrical contact wear per operation = ∫ f(Irms).(i(t))2dt

This quantity represents the electrical deterioration for the operation under consideration. It is then added to the cumulative figure to obtain the total electrical wear per phase:

Cumulative electrical contact wear = Σ Electrical contact wear per operation

The function f by default will be: f(Irms)=1 for all Irms values. But other functions are programmable in such a way as to permit taking into account the cases where the electrical wear is not linear in terms of the current being interrupted. This function can be modified in the form of a magnifying coefficient (or vice versa) for a given amp rating using a table:

ELECTRICAL WEAR WEIGHTING TABLE

coeff_0kA	1.00	coeff_2kA	1.00	coeff_4kA	1.00	coeff_6kA	1.00	coeff_8kA	1.00
coeff_10kA	1.00	coeff_12kA	1.00	coeff_14kA	1.00	coeff_16kA	1.00	coeff_18kA	1.00
coeff_20kA	1.00	coeff_22kA	1.00	coeff_24kA	1.00	coeff_26kA	1.00	coeff_28kA	1.00
coeff_30kA	1.00	coeff_32kA	1.00	coeff_34kA	1.00	coeff_36kA	1.00	coeff_38kA	1.00
coeff_40kA	1.00	coeff_42kA	1.00	coeff_44kA	1.00	coeff_46kA	1.00	coeff_48kA	1.00
coeff_50kA	1.00	coeff_52kA	1.00	coeff_54kA	1.00	coeff_56kA	1.00	coeff_58kA	1.00
coeff_60kA	1.00	coeff_62kA	1.00	coeff_64kA	1.00	coeff_66kA	1.00	coeff_68kA	1.00
coeff_70kA	1.00	coeff_72kA	1.00	coeff_74kA	1.00	coeff_76kA	1.00	coeff_78kA	1.00
coeff_80kA	1.00	coeff_82kA	1.00	coeff_84kA	1.00	coeff_86kA	1.00	coeff_88kA	1.00
coeff_90kA	1.00	coeff_92kA	1.00	coeff_94kA	1.00	coeff_96kA	1.00	coeff_98kA	1.00
coeff_100kA	1.00	coeff_102kA	1.00	coeff_104kA	1.00	coeff_106kA	1.00	coeff_108kA	1.00
coeff_110kA	1.00	coeff_112kA	1.00	coeff_114kA	1.00	coeff_116kA	1.00	coeff_118kA	1.00
coeff_120kA	1.00	coeff_52kA	1.00	coeff_124kA	1.00	coeff_126kA	1.00	coeff_128kA	1.00
coeff_130kA	1.00	coeff_132kA	1.00	coeff_134kA	1.00	coeff_136kA	1.00	coeff_138kA	1.00
coeff_140kA	1.00	coeff_142kA	1.00	coeff_144kA	1.00	coeff_146kA	1.00	coeff_148kA	1.00
coeff_150kA	1.00	coeff_152kA	1.00	coeff_154kA	1.00	coeff_156kA	1.00	coeff_158kA	1.00
coeff_160kA	1.00	coeff_162kA	1.00	coeff_164kA	1.00	coeff_166kA	1.00	coeff_168kA	1.00
coeff_170kA	1.00	coeff_172kA	1.00	coeff_174kA	1.00	coeff_176kA	1.00	coeff_178kA	1.00
coeff_180kA	1.00	coeff_182kA	1.00	coeff_184kA	1.00	coeff_186kA	1.00	coeff_188kA	1.00
coeff_190kA	1.00	coeff_192kA	1.00	coeff_194kA	1.00	coeff_196kA	1.00	coeff_198kA	1.00
coeff_200kA	1.00								

Figure 97 – HMI – Electrical wear weighting table

5.5.4 Alarm summary

In order to receive a warning when we are approaching the time when contacts need to be replaced due to wear, a comparison is made between the cumulative electrical wear and the maximum value specified by the manufacturer for the arcing contacts used. Two alarm thresholds can be set for the electrical wear.

In addition, an alarm can also be set on the maximum number of operation performed by the breaker as a failsafe alarm or for scheduling certain other mechanical maintenance.

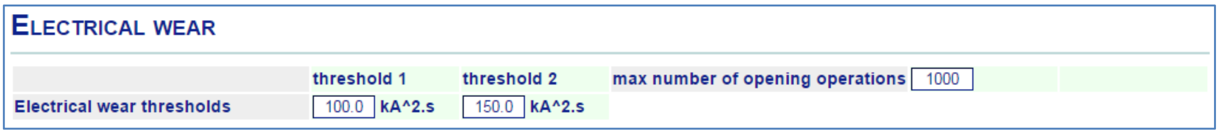


Figure 98 – HMI – Opening electrical wear settings

For each of the phases, a comparison is also made of the arcing time (t_a-t_s) with a maximum arcing time and an alarm is set off if there is any overshoot.

5-6 Stored Energy Motor Monitoring

5-6.1 General Description

A circuit breaker uses stored energy to open and close the contacts at speed. This stored energy is often supplied by a spring rewound/rearmed by an electric motor. But it can also take the form of a pneumatic/hydraulic piston where the pressure is built-up by an electric pump motor. The CBWatch3 attempts to cover most possibilities, whether there is one motor for all 3 poles or one motor per pole.

Following a closing operation, a contact starts up the rearming motor for the opening spring or the hydraulic/pneumatic pump in order to regenerate the stored energy. When the spring reaches its fully armed position or the required pressure is reached, then the same contact is triggered and stops the rearming motor.

5-6.2 Motor run time

Provided the motor on/off contacts are connected to the DI16 module, then we can acquire the time at which these contacts are activated. A measurement is taken of the duration of the rearming phase (operating time of the rearming motor) for the single motor or the motor for each of the poles.

One can compare this time with a minimum duration and a maximum duration. Any shortening of the time may indicate a partially broken spring or lengthening may indicate additional friction or a problem with the motor itself. More pump time may highlight a leak in the circuit or a problem with the pump.

The number of time the motor starts is also recorded. It can be significant for a pump, as it could indicate that the pump is fighting a leak in the circuit.

The cumulated motor run time is also stored so that maintenance of the motor(s) can be performed when the prescribed number of run time hours has been reached.

HMI CBWatch 3: Settings \ Closing \ Operations Time

Drive reload time *(g3.4.1.6)*	0.0 s *(d3.154)*	0.0 s *(d3.155)*	0.0 s *(d3.156)*
Cumulated drive reload time *(g3.4.1.6.1)*	0.00 min *(d3.347)*	0.00 min *(d3.348)*	0.00 min *(d3.349)*
Number of drive reload *(g3.4.1.6.2)*	0 *(d3.350)*	0 *(d3.351)*	0 *(d3.352)*

Figure 99 – HMI – Part of last closing measurement

5-6.3 Motor voltage

If the motors are DC motors, the sub-station DC supply is already monitored.
If the motor(s) is an AC motor(s), then the AC supply can also be monitored to check that it is present and that it is not too low or too high.

HMI CBWatch 3: Settings \ Additional Channels

Motor Voltage	241.1 Vac

Figure 100 – HMI – Part of additional channels

5-6.4 Motor current

The CBWatch3 is able to measure the current used by the rearming motor/pump in order to notice any changes, possibly highlighting additional friction requiring more torque or a problem with the motor itself.
The motor current curve is displayed on the HMI and stored:

HMI CBWatch 3: Measurement / Operations charts / spring

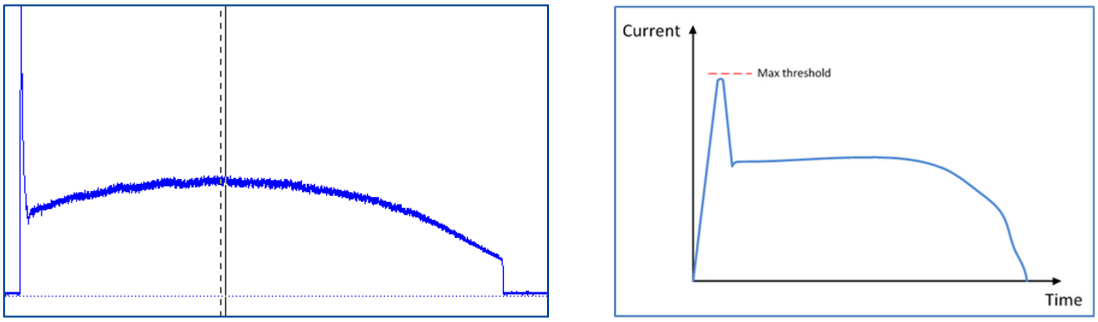


Figure 101 – Current of the motor during rearming

Via the HMI the user is also able to display a previous curve saved in the CBWatch3:

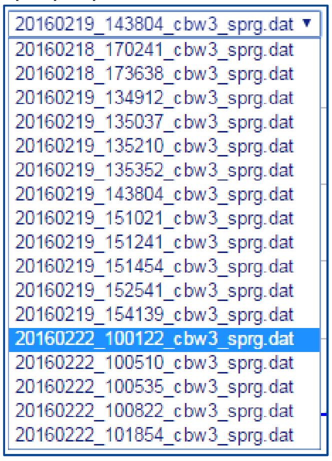


Figure 102 – Drop-down list of previous archives

Both the mean (average) motor current and the maximum motor current (peak inrush current) are recorded and displayed in the HMI:

MOTOR CURRENT

Mean motor current	0.0 A	0.0 A	0.0 A
Max motor current	0.0 A	0.0 A	0.0 A

Figure 103 – HMI – Motor current measurement

An alarm can be set on the maximum inrush current for the motor. Max threshold: inrush current value above which an alarm will be generated:

Figure 104 – HMI – Motor current alarm setting

During the commissioning, a real-time measurement can be performed to set the threshold.

5-7 Spare Analogue Channels Monitoring

5-7.1 General Description

Depending on the configuration, there may be up to 4 spare analogue channels that can be assigned to measure and monitor other values as per customer requirements.

The name and the measurement units of the measured value can be specified by the user.
The signal type can be either: 0-10V; +/-10V; 0-5V; +/-5V; 0-20mA; +/-20mA; 4-20mA.
Minimum and maximum alarms can be set on these values and a trace recoding can also be started based on a selectable trigger (Open, Close, Spring reload, Open-Close, Open-Close –Spring reload)

	type	low value	high value	min threshold	max threshold	unit	name	record
Generic channels (X4)	0-10V	0.00	280.00	200.00	240.00	V	Voltage	None
Generic channels (X4)	None	0.00	0.00	0.00	0.00		GEN 2	None
Generic channels (X4)	None	0.00	0.00	0.00	0.00		GEN 3	None
Generic channels (X4)	None	0.00	0.00	0.00	0.00		GEN 4	None
Set								

Figure 105 – Additional analogue channels configuration

Typical use for these spare analogue channels would be:

- AC voltage monitoring
- AC rewind motor current
- Pneumatic pressure
- Barometric pressure
- ....

The real-time values are displayed in the HMI:

ADDITIONAL CHANNELS (G3.5.6)

Supply2	134.6 Vdc
Motor Voltage	241.1 Vac

Figure 106 – HMI – Additional analogue channels

5-8 Temperature monitoring

5-8.1 Ambient

Ambient temperature is measured in several ways depending on the configuration.
If gas sensors are present, then because they are usually mounted away from direct sunlight an underneath the breaker, the temperature sensor of the gas sensor is used as the ambient temperature reference. If there are 3x gas sensors, then the average of the 3 measurements is used.
If no gas sensor is used in the configuration, then the ambient temperature sensor is taken as being the PT100 sensor connected as the first input of the RTD8 module.

TEMPERATURE SENSORS

Ambiant temperature	22.13 °C

Figure 107 – HMI - Ambient temperature

5-8.2 Monitoring heating of cabinets

When faced with maintaining circuit breakers operational in harsh winter conditions, making sure that the various drive cabinets and control cabinets are adequately heated and maintained at the proper temperature becomes key.
While some systems rely on monitoring that the heaters are operating correctly by measuring the heater current when on and the switching of heaters on and off, the logic can be difficult to implement and can lead to inaccurate information.
The CBWatch3 prefers instead to monitor that the end result, keeping the correct temperature, is achieved or that the temperature is starting to drift.

The RTD8 temperature sensing module can be equipped with up to 8 sensors measuring different points. The temperature of each of these points is displayed and is compared with a minimum and a maximum temperature, which can be set by the user to diagnose any possible heater failure or overheating situation.

TEMPERATURE SENSORS

Ambiant temperature	27.48 °C
Temperature 1	27.50 °C

Figure 108 – HMI – Temperature sensors

For each PT100 sensor added, it is possible to set a delta positive and delta negative value used for the alarms (note that delta positive and negative values are always positive).
An alarm will be raised if:

- Measured value > Ambient + Delta positive
- Measured value < Ambient – Delta negative

	delta negative	delta positive
Temperature 1	20 °C	20 °C
Set		

5-9 Monitoring Alarms

As seen throughout this manual, alarms can be set on a long list of parameters. These alarms are available in three different ways through:

- the HMI, and the colour coded notifications flags
- the digital interface to the CBWatch3, depending on the protocol used,
- their assignment to dry contact relays.

5-9.1 Alarm visualisation in HMI

Alarms will appear in red and warnings in yellow, otherwise all will be green:

ALARMS RELATED TO GAS

	Pole A	Pole B	Pole C
Threshold 1	No Error	No Error	No Error
Threshold 2	No Error	No Error	No Error
Threshold 3	No Error	No Error	No Error
Liquefaction	No Error	No Error	No Error
Short term extrapolation (threshold 2)	No Error	No Error	No Error
Long term extrapolation (threshold 1)	No Error	No Error	No Error
Sensor absence	No Error	No Error	No Error
Sensor data validity	No Error	No Error	No Error
Filling status of short term stack	Stack Not Enough	Stack Not Enough	Stack Not Enough
Filling status of long term stack	Stack Not Enough	Stack Not Enough	Stack Not Enough

Figure 109 – HMI alarm example: Gas alarms

5-9.2 Relay alarms from ProWatch module

Two relay alarms, K1 and K2, are provided as standard on the base ProWatch module:

The K2 output is used to provide the state of the CBWatch3 as a self-control function. It can inform the maintenance service and/or supervision system of an internal malfunction.

The K1 output is programmable and can be set against any of the alarm parameters available. For example, in the context of gas supervision, it is possible to assign the output to one of the gas thresholds.

5-9.1 Relay alarms with optional alarm modules DO16

Up to 16 different alarm relays are available with the DO16 optional module.
Each one can be triggered by one or a set of alarm parameters available as specified by the user. These alarm parameters are listed by monitoring function in the following sections.

5-9.2 Relay alarms assignment

Each possible alarm can be assigned to one of the 16 relays or to K1 by filling the associated matrix for these alarms in the set-up.

This example shows the matrix for the gas alarms used in the example above

GAS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	K1
Threshold 1, A	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Threshold 2, A	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
/Threshold 2, A	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Threshold 3, A	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Threshold 1, B	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Threshold 2, B	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
/Threshold 2, B	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Threshold 3, B	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Threshold 1, C	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Threshold 2, C	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
/Threshold 2, C	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Threshold 3, C	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Short term trend	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Long term trend	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Liquefaction risk	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sensor status	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Set

Figure 110 – HMI – Gas alarm settings

All the other alarms can be assigned in the same way to one of the 16 relays or K1:

ALARMS RELATED TO OPERATIONS

	Pole A	Pole B	Pole C
Reaction time t1 (open)	No Error	No Error	No Error
Operating time t2 (open)	No Error	No Error	No Error
Reaction time t1 (close)	No Error	No Error	No Error
Operating time t2 (close)	No Error	No Error	No Error
Travel time t2-t1 (open)	No Error	No Error	No Error
Travel time t2-t1 (close)	No Error	No Error	No Error
Contact separation speed (open)	No Error	No Error	No Error
Circuit breaker position contact 52a	No Error	No Error	No Error
Circuit breaker position contact 52b	No Error	No Error	No Error
Reaction time t1 discrepancy (open)	No Error	No Error	No Error
Operation time t2 discrepancy (open)	No Error	No Error	No Error
Travel time t2-t1 discrepancy (open)	No Error	No Error	No Error
Reaction time t1 discrepancy (close)	No Error	No Error	No Error
Operation time t2 discrepancy (close)	No Error	No Error	No Error
Travel time t2-t1 discrepancy (close)	No Error	No Error	No Error
Electrical wear, threshold 1	No Error	No Error	No Error
Electrical wear, threshold 2	No Error	No Error	No Error
Number of opening operations	No Error	No Error	No Error
Number of closing operations	No Error	No Error	No Error
Spring reload time	No Error	No Error	No Error
Close position	No Error	No Error	No Error
Open position	No Error	No Error	No Error
motor current high	No Error	No Error	No Error
max coil charge O1	No Error	No Error	No Error
min coil charge O1	No Error	No Error	No Error
max coil charge O2	No Error	No Error	No Error
min coil charge O2	No Error	No Error	No Error
max coil charge cl	No Error	No Error	No Error
min coil charge cl	No Error	No Error	No Error
Overtravel O	No Error	No Error	No Error
Overtravel CL	No Error	No Error	No Error
Cumulated drive reload time	No Error	No Error	No Error
Pole discrepancy	No Error		
Coil circuit continuity	No Error		

Figure 111 – HMI – Operation alarms

6 COMMUNICATION

6-1 Protocols

Depending on the configuration of your system, one or several communication protocols may be available from:

- Modbus
- DNP3
- IEC 61850

Please refer to the documentation of that protocol for further information.