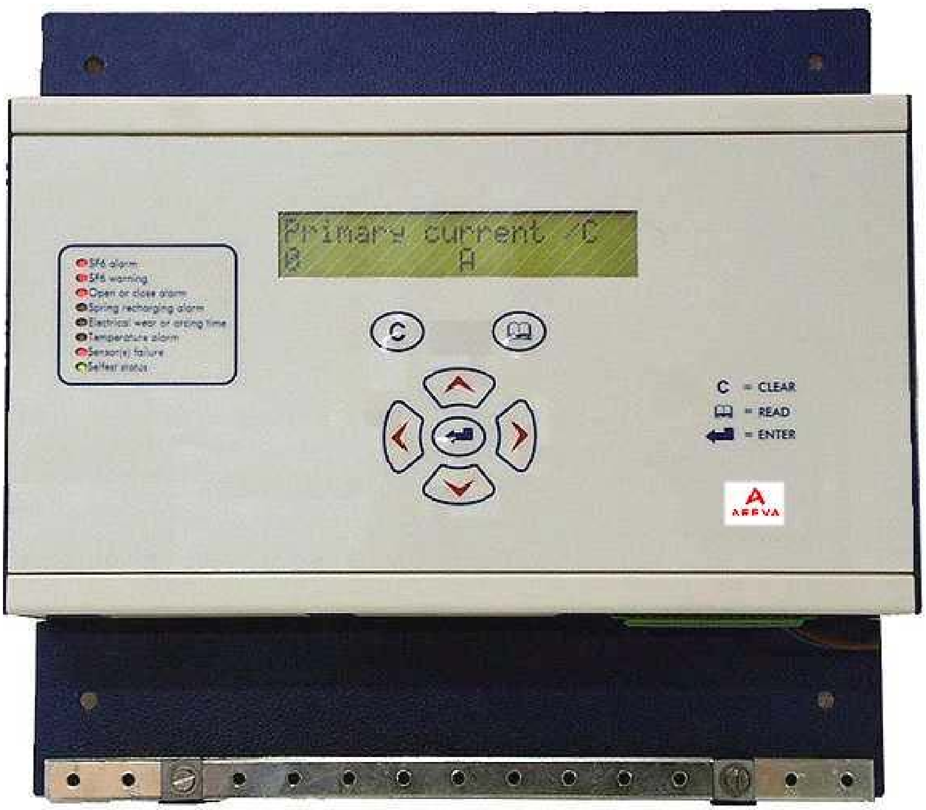
CBWatch-2

MODULAR MONITORING SYSTEM

USER'S MANUAL



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CONTENTS

1 REFERENCES

[1] CBW2TOOL Human Machine interface software user's manual
Reference : D1103EN

[2] CBWATCH-2 Modbus interface reference manual
Reference : D1104EN

2 OVERVIEW

2.1 Basic scheme

The processing module is installed in the control mechanism, in the main cubicle or in a separate box mounted on the circuit breaker frame.

All the sensors are connected to this processing module.

Ouput interfaces (dry contacts and MODBUS ports) may be used to connect the CBWatch-2 to substation control.

MODBUS port may also be used to connect CBW2Tool Human-Machine Interface software running on PC computer. CBW2Tool software allows parameter setting, and access to CBWatch-2 data.

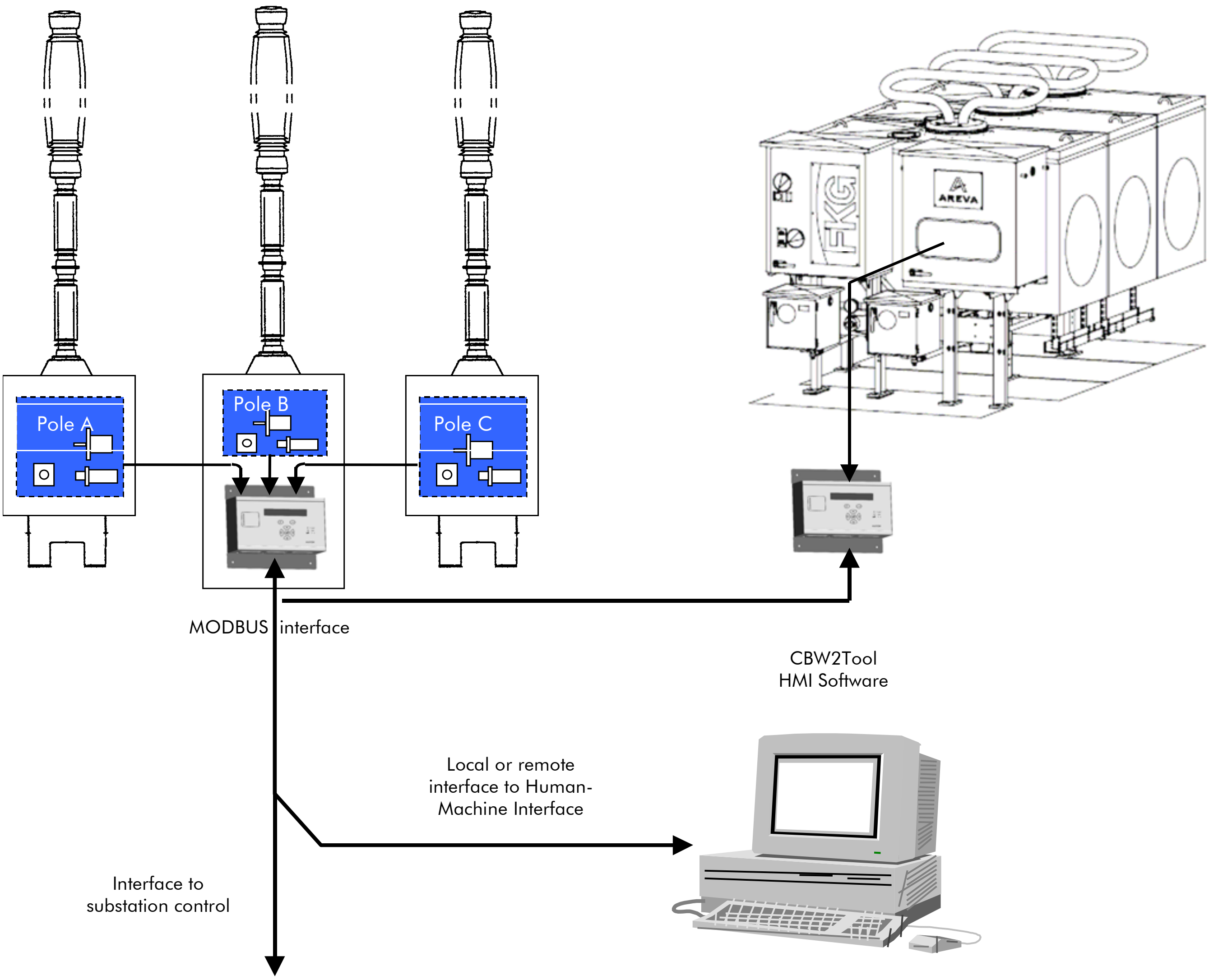


Figure 1 – Basic scheme

2.2 Available functions

The same module CBWatch-2 is capable of performing the set of functions described in Table 1.
To perform a particular function, simply connect the corresponding sensors and set the system parameters.

Table 1: available functions

Supervision of operations : Monitors operation times. Allows the use of conventional auxiliary switches, static auxiliary switches or a main contact travel curve sensor. Supervises the separation speed of the main contacts, damping and rebounds at end of travel. Detects degradation of performance (friction, corrosion, rupture, gas leakage, spring fatigue, damper defect). Detects incorrect actuation of the auxiliary contacts.
SF_6 supervision : Measures the pressure and temperature of the SF_6 or of the mixture and calculates the density according to the Beattie - Bridgeman law. Detects liquefaction and blocks false alarms in case of liquefaction. Calculates the SF_6 density trend in order to anticipate crossing of thresholds.
Breaking supervision : Measures the current during breaking. Cumulates electrical wear ($\int i^2 dt$). Supervises arcing time.
Supervision of the auxiliary and control circuits : Supervises the continuity of the coils, the presence of the auxiliary voltages and the heating.
Supervision of a spring-loaded control mechanism : Measures the operating time of the reloading motor. Detects a fault in the motor or in the limit switch.
Supervision of a hydraulic control mechanism : Measures the times between pump starts and measures the re-inflation times. Detects the internal and external hydraulic leaks. Detects nitrogen leakage from the accumulator . Continuously measures hydraulic pressure. Detects the hydraulic locking thresholds.

2.3 Application

CBWatch-2 permanently evaluates the circuit breaker state. It alerts the maintenance teams remotely and in real time to any deviation. CBWatch-2 thus minimises failure risks and cuts maintenance costs.

Telediagnosis optimises maintenance actions mainly in two ways :
- Optimisation of corrective actions following a fault,
- Application of predictive maintenance techniques.

2.3.1 Optimisation of corrective actions following a fault

In case of a failure detected on the high-voltage device, the system automatically sends an alarm to the telediagnosis station. This alarm may be relayed to the person on duty by a pager type system.

In this way, the maintenance service is immediately informed of the failure. It can use the analysis supplied to it by the remote diagnosis system to determine the best action to take. It can decide on an immediate action or else plan a delayed action after due consideration. It can prepare the spare parts and tools which will be needed and dispatch to site the technician who best knows how to remedy the fault.

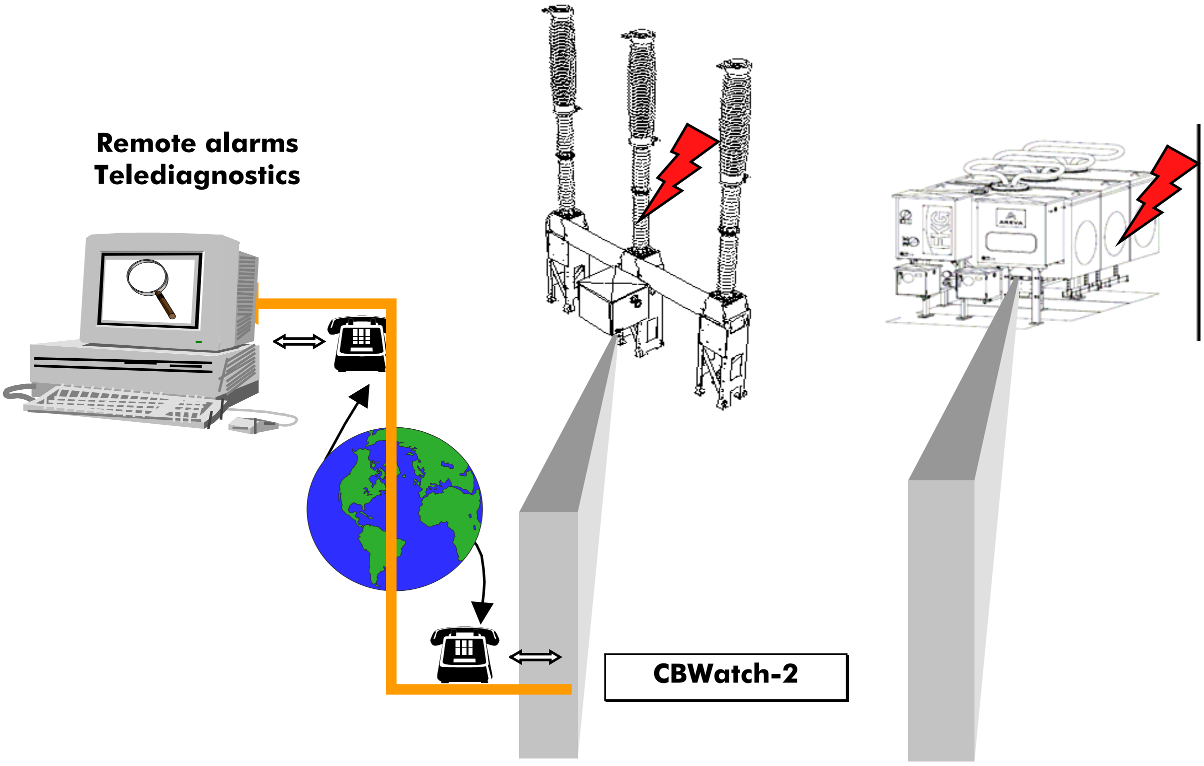


Figure 2 – Remote alarms

2.3.2 Application of predictive maintenance techniques

Continuous monitoring of the main circuit breaker process parameters allows immediate detection of any malfunction. Above all, this supervision makes it possible, by means of trend calculations on these parameters, to predict and therefore to forestall the occurrence of these malfunctions. Predictive maintenance involves not performing any maintenance operation until the telediagnosis system has detected a malfunction. In this way, the maintenance services have a tool which enables them to service only the circuit breakers which need it.

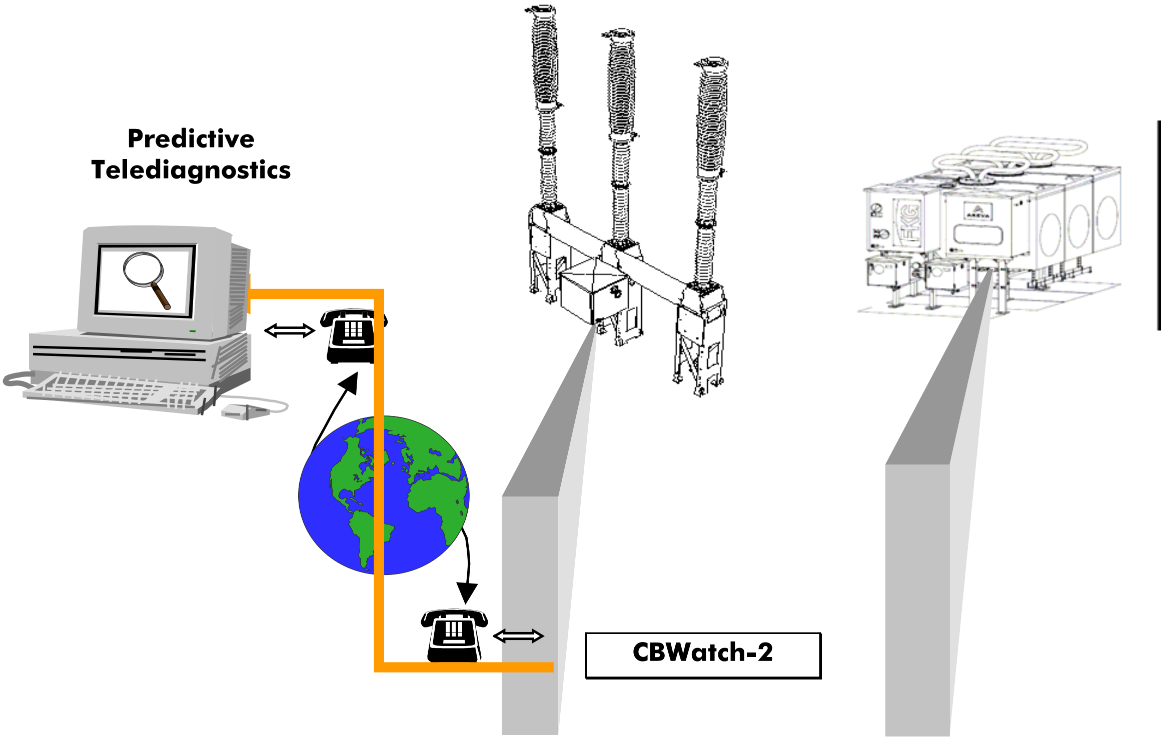


Figure 3 - Telediagnostics

2.4 Technical characteristics

Dimensions (LxHxW)
310mm x 300mm x 95mm

Room temperature
-40°C to +55°C
(option -50°C with heating)

Supply
Range 1 : 48 to 125V DC and 48 to 120V AC
Range 2 : 150 to 250V DC and 150 to 240VAC
Tolerance : -30% to +15%
Consumption : 30VA max.

Electromagnetic compatibility
Impulse voltage withstand test :
IEC 255-5 ; 2kV 50Hz, 5kV impulse (wave 1.2µs/50µs)

Fast transients:
IEC 1000-4-4 to 4kV and ANSI C37-90-1

Damped oscillatory wave 100kHz and 1MHz :
IEC 1000-4-12 ; 2.5kV in common mode ; 1kV in differential mode.

Electromagnetic radiation :
IEC 255-22-3 10V/m from 20 to 1000MHz

Output relay
1 relay corresponding to system self-test (two-way contact)
4 adaptable alarm contacts (two-way contacts)
Maximum voltage : 250V DC
Current : 8A dc
Insulation : 4kV in common mode, 1kV in differential mode
Breaking capacity 10VA L/R 20ms
Max instantaneous current during 4s : 30 A

Alarm diodes
1 diode corresponding to system self-test
7 adaptable red alarm diodes

Local readout
LCD display of 2 x 20 characters linked to a small keyboard for access to on-going alarms and measurements

Local Interface RS232
Link RS232 9600 bauds, 8bits, no parity bit, 1 stop bit.
Protocol MODBUS
(Access to measurements, alarms, parameters and archives)

Interface RS485 MODBUS
Link RS485 insulated 2kV 50Hz.
Protocol MODBUS
(Access to measurements, alarms, parameters and archives)

Terminal blocks withdrawable for wires of maximum cross-section 1.5 mm^2

Sensor interfaces

- Coil impulse sensor : Current transformer ring 5A/2.5mA
- Main contact travel curve sensor : Absolute position 4-20mA transmitter
- Conventional auxiliary contacts or static auxiliary contacts
- SF6 sensor : Pressure 4-20mA transmitter or density 4-20mA transmitter
- Temperature sensor : 3-wire output PT100 Probes
- Hydraulic pressure sensor : Pressure 4-20mA transmitter
- Sensor for operation of reloading or reinflation motor : Limit switch contact
- Main current sensor : Current transformer ring 5A/2.5mA
- Coil continuity sensor : Conventional relay for coil supervision

Battery

Battery LITHIUM 3.5V type ½ AA (reference SAFT : LS14250).

3 VERSIONS AND OPTIONS

The system is available in 2 versions :

- Version P1 : for circuit breaker with an operating mechanism for the three poles and 1 gas volume,
- Version P3 : for circuit breaker with an operating mechanism per pole, or with 3 gas volumes.

Supply voltage :

- The box power supply accommodates as a standard 48 to 125V DC and 48 to 120V AC ; Tolerance : -30% to +15%
- As an option, the box can be delivered with a power supply of 150 to 250V DC and 150 to 240VAC ; Tolerance : -30% to +15%

Language :

The language of the menus will be defined in the order (English, French, Spanish, German).

The activation of the supervision functions in CBWatch-2 calls for the installation of the corresponding sensors as per Table 2.

Table 2 – Sensors needed for the various options

		SF6 pressure or density	Ambient temperature	Coil impulse	Auxiliary contacts	Travel of the main contacts	Motor limit switch	Hydraulic threshold contacts	Hydraulic pressure	Main current	Coil supervision relay	Voltage presence relay	Box temperature
SF6 supervision	Density, Liquefaction, Leakage rate, Trends	X	X										
Supervision of operations	- Number of operations, - Operation times		X	X	X								
	- Number of operations, - Operation times, - Travel curve analysis (speed, damping …)		X	X		X							
Supervision of a spring-loaded control mechanism (*)	Reloading motor operating time						X						
Supervision of a hydraulic control mechanism (*)	- Reinflation motor operating time - Number of starts per day - Reinflation time		X				X						
	- Pressure thresholds							X					
	- Hydraulic pressure continuous measurement								X				
Supervision of broken current	- Electrical wear (i^2t) - Broken current - Arcing time				(1)	(1)				X			
Supervision of auxiliary and control circuits	Coil continuity										X		
	Actuation position of auxiliary contacts				X	X							
	Presence AC and DC voltage											X	
	Heating												X

Caution :
(*) supervision of the mechanism (whether hydraulic or spring operated) is mandatory for the supervision of operations .

(1) The supervision of the broken current calls for the connection either of the auxiliary contacts or of a main contact travel sensor.

4 INSTALLATION

The electronic module is to be installed either in the control mechanism, in the electrical cubicle or in a separate cabinet.

The earth bar located at the base of the cabinet must be connected to the cubicle's local earthing point.

The sensors must be installed on the circuit breaker. The sensors are energised by the CBWatch-2 (see the instructions for connecting the sensors in Chapter 11).

The connecting cables installed between the poles for connecting up the sensors must be of the "shielded twisted pairs" type (with braided shielding) and their shielding must be connected to earth at both extremities. The same cable may group together several pairs corresponding to several sensors.

In the case of cables running between the poles of the circuit breaker, we recommend you install a large cross-section parallel ground-continuity conductor in parallel with the cable.

The cable shielding coming from the sensors must be connected to the earth bar located at the base of the CBWatch-2 case.

5 COMMISSIONNING TESTS

After installing the CBWatch2 and its sensors, it is necessary to perform certain tests and inspections before commissioning.

CAUTION : DURING THE REQUIRED OPERATIONS, AS PART OF THE TEST AND INSPECTION PROGRAMME, ALL POSSIBLE SAFETY PRECAUTIONS SHOULD BE TAKEN TO PROTECT PERSONNEL WORKING ON THE EQUIPMENT.

The readings asked for below are to be entered in the CBWatch-2 Commissioning Test Report which should be then transmitted to AREVA T&D After Sales Service for approval.

5.1 Checking conformity to wiring diagram

Record on the report wiring diagram references.
Check conformity to the wiring diagrams and record comments on the report.

5.2 Energizing the CBWatch-2

Check that the CBWatch-2 power supply voltage corresponds with that for which it has been designed (see chapter 3).
Record CBWatch-2 power supply voltage and type (AC/DC) in the report.
After installation of the CBWatch-2, installation of the sensors, wiring and checking the wiring, energise the CBWatch-2 - The CBWatch-2 launches its initialisation phase (all the LEDs light up), then switches to the operation phase (lighting up green LED, screen display by default, lighting up of the LEDs and activation of the relays as programmed).

Check that green LED is light up and record in the report.

5.3 CBWatch-2 Software update

CBWatch-2 software is configured in factory. However if for any reason software update is necessary this can be done using CBWatch-2 program loader available on CBW2Tool CD-ROM.

- Install CBWatch-2 program loader by running setup.exe in the CD-ROM CBWatch-2 program loader directory
- Connect the PC and the CBWatch-2 using the RS-232 port,
- Run the CBWatch-2 software loader and follow the instructions

If CBWatch-2 software update is done, record version and date of version in the report.

5.4 Date and time setting

For setting up date and time, see section 5.6 of CBW2TOOL Human Machine interface software user's manual [1].
Record date and time in the report.

5.5 CBWatch-2 parameters setting

If it has not already been done, the CBWatch-2 must be configured using the CBW2Tool software (see the CBW2Tool human Machine interface software user's manual [1]).
The configuration of the CBWatch-2 consists in :
- Defining the functions to be carried out and the corresponding sensors which are installed,
- Defining the corresponding monitoring criteria (pressure and time thresholds…).

After setting up CBWatch-2 parameters, record corresponding configuration file name in the report.

5.6 Functional tests

Functional test consist in two stages:
- Stage 1: validation of the smooth running of the data acquisitions that correspond to the different sensors installed.
- Stage 2: validation of behaviour of different functions by artificially creating alarm conditions

These tests require the CBWatch-2 to be connected to a PC and the use of the CBW2Tool software (See [1]).

5.6.1 SF6 Monitoring Function stage 1Test

Each pole of circuit breaker should be filled at rated density.

Connect CBW2Tool software to CBWatch-2 (see CBW2TOOL Human Machine interface software user's manual [1])

Check the ambient temperature measurement :
Move to " Display of auxiliary circuits alarms and measurements in progress " screen (see section 5.6.7 of [1]). Check that the LED corresponding to the alarm "ambient temperature sensor failure" is green.
In case of an alarm check sensor and wiring until the LED switches to green.
Once this LED is green, check that the displayed "ambient temperature" measurement is correct and record it in the report.

Check the SF6 pressure or density measurement:
Move to "Display of SF6 alarms and measurements in progress" screen (see section 5.6.1 of [1]). Check that for each pole, the LED corresponding to the alarm "pressure or temperature sensor failure" is green.
In case of an alarm check sensor and wiring until the LED switches to green.
Once these LED are green, check that the displayed "SF6 pressure" measurements are correct and record them in the report. Also record the "SF6 density" measurements in the report.

5.6.2 Operations Monitoring Function stage 1 Test

Connect CBW2Tool software to CBWatch-2 (see CBW2TOOL Human Machine interface software user's manual [1])

Check the coil voltage:
Move to " Display of opening alarms and measurements " screen (see section 5.6.2 of [1])
Check the "coil voltage" measurement (this corresponds to the CBWatch-2 power supply voltage in case of DC voltage) and record it in the report.

Check coils power supply circuits:
CBWatch2 compensate circuit breaker operating times with coil voltage for coils that are supplied by same power source as the CBWatch2. Therefore CBWatch-2 configuration should describe which coils are powered by the same power source as CBWatch-2.
Check for power supply circuits and record which coils are powered on same power source as CBWatch-2 in the report.

Check the configuration file on "Configuration of operations monitoring" screen (see section 5.4.8 in [1]) that the "type of coil voltage compensation" corresponds to "%Un" for coils powered on same power supply as CBWatch-2 and corresponds to "max" for coils powered on different power supply.

Check the ambient temperature measurement:
Move to " Display of auxiliary circuits alarms and measurements in progress " screen (see section 5.6.7 of [1])
Check that the LED corresponding to the alarm "ambient temperature sensor failure" is green.
In case of an alarm check sensor and wiring until the LED switches to green.
Once this LED is green, check that the displayed "ambient temperature" measurement is correct and record it in the report.

Check the travel sensors tuning:
Proper operation of contacts travel monitoring is conditioned by proper tuning of travel sensors.

Check the configuration file on "Configuration of travel curve monitoring" screen (see section 5.4.9 in [1]) the travel sensor calibration data:
- The output current at 0% travel is the travel sensors output current with circuit breaker in open position
- The output current at 100% travel is the travel sensors output current with circuit breaker in closed position

It has to be checked that output current of travel sensors for each one of the pole correspond to these values. Sensor's output current is measured using a voltmeter connected between 0V and SIG sensors terminals considering that the CBWatch-2 input is 100 Ohm (for example, 17.1 mA output current will lead to a 1.71V voltage between terminals).
Using this method, check that output current of each one of travel sensors with circuit breaker both in open and closed position and record in the report.

In case output current does not correspond to configuration data, the mechanical position of travel sensor has to be adjusted with circuit breaker in open position. CAUTION: THESE TRAVEL SENSOR ADJUSTEMENT HAS TO BE DONE WITH SPRING DISCHARGED: Un-tighten the screws holding the sensor and rotate the sensor until the output voltage corresponds to the configuration data.

Check CBWatch-2 travel and position measurements with circuit breaker in open position:

Circuit breaker should be in open position.
Move to " Display of closing alarms and measurements " screen (see section 5.6.2 of [1])

Check for each pole that contact travel, 52a and 52b position are correct and record them in the report.
In case of an alarm on travel sensor, check sensor and wiring until the LED switches to green.

Check CBWatch-2 travel and position measurements with circuit breaker in closed position:

Circuit breaker should be in closed position.
Move to " Display of closing alarms and measurements " screen (see section 5.6.3 of [1])

Check for each pole that contact travel, 52a and 52b position are correct and record them in the report.
In case of an alarm on travel sensor, check sensor and wiring until the LED switches to green.

Check measurements during an open operation (coil 1):

Operate the breaker and then download the event records form the CBWatch-2 using the CBW2TOOL software (see [1], section 5.5)

Double click on the last open operation record (see [1], section 5.5.4) to display recorded measurements.
For each pole, check and record in the report the following measurements:
- Coil signal sensor alarm status (in case of an alarm, check wiring of coil signal sensor)
- Reaction time t1 (the corresponding alarm should not occur, showing that this value is within monitoring criteria)
- Operating time t2 (the corresponding alarm should not occur, showing that this value is within monitoring criteria)
- 52a switching position (the corresponding alarm should not occur, showing that this value is within monitoring criteria)
- 52b switching position (the corresponding alarm should not occur, showing that this value is within monitoring criteria)

- End of switching position (the corresponding alarm should not occur, showing that this value is within monitoring criteria)

Check measurements during close operation:

Operate the breaker and then download the event records form the CBWatch-2 using the CBW2TOOL software (see [1], section 5.5)

Double click on the last close operation record (see [1], section 5.5.4) to display recorded measurements.
For each pole, check and record in the report the following measurements:
- Coil signal sensor alarm status (in case of an alarm, check wiring of coil signal sensor)
- Reaction time t1 (the corresponding alarm should not occur, showing that this value is within monitoring criteria)
- Operating time t2 (the corresponding alarm should not occur, showing that this value is within monitoring criteria)
- 52a switching position (the corresponding alarm should not occur, showing that this value is within monitoring criteria)
- 52b switching position (the corresponding alarm should not occur, showing that this value is within monitoring criteria)
- End of switching position (the corresponding alarm should not occur, showing that this value is within monitoring criteria)

Check measurements during an open operation (coil 2):

Operate the breaker and then download the event records form the CBWatch-2 using the CBW2TOOL software (see [1], section 5.5)

Double click on the last open operation record (see [1], section 5.5.4) to display recorded measurements.
For each pole, check and record in the report the following measurements:
- Coil signal sensor alarm status (in case of an alarm, check wiring of coil signal sensor)
- Reaction time t1 (the corresponding alarm should not occur, showing that this value is within monitoring criteria)
- Operating time t2 (the corresponding alarm should not occur, showing that this value is within monitoring criteria)
- 52a switching position (the corresponding alarm should not occur, showing that this value is within monitoring criteria)
- 52b switching position (the corresponding alarm should not occur, showing that this value is within monitoring criteria)
- End of switching position (the corresponding alarm should not occur, showing that this value is within monitoring criteria)

5.6.3 Breaking Current Monitoring Function stage 1 Test

Connect CBW2Tool software to CBWatch-2 (see CBW2TOOL Human Machine interface software user's manual [1])

Check of main CT nominal primary current:

The auxiliary CTs for transmitting the line current measurement to CBWatch-2 are installed in the HV CT marshalling box. Check the HV CT nominal current and record it in the report.

Check in the configuration file on "Configuration of switching monitoring" screen (see section 5.4.10 in [1]) that the configured "main CT nominal primary current" corresponds to the one at site.

Check of current measurement:

Move to " Display of switching alarms and measurements " screen (see section 5.6.4 of [1]).
When the circuit breaker is de-energized, check that the measured value is really nil or near to zero.
When the circuit breaker is energized, check the value of the RMS current
Record the result in the report.

5.6.4 Spring Rearming Monitoring Function stage 1 Test

Connect CBW2Tool software to CBWatch-2 (see CBW2TOOL Human Machine interface software user's manual [1])
Close the breaker and then download the event records form the CBWatch-2 using the CBW2TOOL sofwtare (see [1], section 5.5)
Double click on the last "spring recharging" operation record (see [1], section 5.5.4) to display recorded measurements.
For each pole, record spring recharging time in the report and check that the CBWatch-2 did not generate any alarm on spring recharging time.

5.6.5 Hydraulics Monitoring Function Test

Connect CBW2Tool software to CBWatch-2 (see CBW2TOOL Human Machine interface software user's manual [1])

Check with hydraulic circuit unpressurised:
Move to " Display of hydraulic alarms and measurements " screen (see section 5.6.6 of [1])
Check the position of the motor contact as read by the CBWatch-2 and record in the report
Check hydraulics pressure measurements and record in the report
In case of an alarm on an hydraulic pressure sensor, check sensor and wiring util the LED switches to green.
Check the Interlocking thresholds O, C, as read by the CBWatch-2 and record in the report
Check that there is no Nitrogen loss or oil level alarm

Check with hydraulic pressurised (after pump stop):
Move to " Display of hydraulic alarms and measurements " screen (see section 5.6.6 of [1])
Check the position of the motor contact as read by the CBWatch-2 and record in the report
Check hydraulics pressure measurements and record in the report
In case of an alarm on an hydraulic pressure sensor, check sensor and wiring util the LED switches to green.

Check the Interlocking thresholds O, C, as read by the CBWatch-2 and record in the report

Check during an operation:
Check the measured repressurisation time after an O, C, OC, CO and OCO operation cycle and record in the report and check that the CBWatch-2 did not generate any alarm on pump running time.

5.6.6 Auxiliary and Control circuits monitoring Function stage 1 Test

Connect CBW2Tool software to CBWatch-2 (see CBW2TOOL Human Machine interface software user's manual [1])

Check the generic temperature measurements:

Move to "Display of auxiliary circuits alarms and measurements " screen (see section 5.6.7 of [1])
Check for each generic temperature sensor installed that the LED corresponding to the alarm "generic x temperature sensor failure" is green.
In case of an alarm check sensor and wiring util the LED switches to green.
Once this LED is green, check that the displayed "generic x temperature" measurement is correct and record it in the report.

Check the coil continuity monitoring contact input:
Move to "Display of auxiliary circuits alarms and measurements " screen (see section 5.6.7 of [1])
Check that the LED corresponding to the alarm "Coils continuity" is green.

Check the AC Voltage presence monitoring contact input:
Move to "Display of auxiliary circuits alarms and measurements " screen (see section 5.6.7 of [1])
Check that the LED corresponding to the alarm "AC voltage presence" is green.

5.6.7 SF6 Monitoring Function stage 2 Test

Stage 1 of SF6 monitoring function test has verified proper operation of data acquisition.

Purpose of stage 2 of SF6 monitoring function test is to artificially activate SF6 alarms by modifying alarm 1 and alarm 2 density thresholds:

- Modify alarm 1 density threshold above current measured density, and check that alarm 1 is activated, (see [1], section 5.4.7 for modifying configuration, see section 5.4.3 for transferring configuration to CBW2 and see section 5.6.1 for viewing SF6 alarms),
- Modify alarm 2 density threshold above current measured density, and check that alarm 2 is activated (see [1], section 5.4.7 for modifying configuration, see section 5.4.3 for transferring configuration to CBW2 and see section 5.6.1 for viewing SF6 alarms),
- Restore original values of alarm 1 and alarm 2 thresholds (see [1], section 5.4.7 for modifying configuration, see section 5.4.3 for transferring configuration to CBW2),

Record test results in the report.

5.6.8 Operations Monitoring Function stage 2 Test

Stage 1 of operations monitoring function test has verified proper operation of data acquisition.

Purpose of stage 2 of operations monitoring function test is to artificially activate operations alarms by modifying operating time limits (times t1 and t2), both for closing and for opening:

- Modify reaction time t1 min. and max. limits both for open and for close (see [1], section 5.4.8 for modifying configuration, see section 5.4.3 for transferring configuration to CBW2),
- Perform one close and one open operations and check that corresponding alarms are activated (see [1] in section 5.6.2/5.6.3 for viewing opening/closing alarms).
- Restore original values of reaction time t1 min. and max. limits both for open and for close operations (see [1], section 5.4.8 for modifying configuration, see section 5.4.3 for transferring configuration to CBW2).

5.6.9 Spring Rearming Monitoring Function stage 2 Test

Stage 1 of spring rearming monitoring function test has verified proper operation of data acquisition.

Purpose of stage 2 of spring rearming monitoring function test is to artificially activate operations alarms by modifying rearming time limits:
- Modify spring rearming time limits (see [1], section 5.4.11 for modifying configuration, see section 5.4.3 for transferring configuration to CBW2),
- Perform one spring rearming operation and check that corresponding alarms are activated (see [1] in section 5.6.5 for viewing spring rearming alarms).
- Restore original values of spring rearming time limits (see [1], section 5.4.11 for modifying configuration, see section 5.4.3 for transferring configuration to CBW2).

5.6.10 Hydraulics Monitoring Function stage 2 Test

Stage 1 of hydraulic monitoring function test has verified proper operation of data acquisition.

Purpose of stage 2 of hydraulic monitoring function test is to artificially activate operations alarms by:
- modifying pump running time limits,
- modifying hydraulic pressure locking thresholds

The procedure is as described hereafter:
- Modify pump running time limits (see [1], section 5.4.12 for modifying configuration, see section 5.4.3 for transferring configuration to CBW2),
- Perform one circuit breaker operation and check that corresponding alarms are activated (see [1] in section 5.6.6 for viewing pump running time alarms).
- Restore original values of pump running time limits (see [1], section 5.4.12 for modifying configuration, see section 5.4.3 for transferring configuration to CBW2).
- Modify O, C and OCO pressure locking thresholds to a value below the current measured hydraulic pressure (see [1], section 5.4.12 for modifying configuration, see section 5.4.3 for transferring configuration to CBW2),
- Check that corresponding alarms are activated (see [1] in section 5.6.6 for viewing pump running time alarms).
- Restore original values of O, C and OCO pressure locking thresholds (see [1], section 5.4.12 for modifying configuration, see section 5.4.3 for transferring configuration to CBW2).

5.6.11 Auxiliary and Control circuits monitoring Function stage 2 Test

Stage 1 of Auxiliary and Control circuits monitoring function test has verified proper operation of data acquisition.

Purpose of stage 2 of Auxiliary and Control circuits monitoring function test is to artificially activate operations alarms by:
- modifying temperature limits,
- disconnect coil
- remove AC power supply

The procedure is as described hereafter:
- Modify temperature limits so that current measured temperatures are outside limits (see [1], section 5.4.13 for modifying configuration, see section 5.4.3 for transferring configuration to CBW2),
- Check that corresponding alarms are activated (see [1] in section 5.6.7 for viewing Auxiliary and Control circuits alarms).
- Restore original values of temperature limits (see [1], section 5.4.13 for modifying configuration, see section 5.4.3 for transferring configuration to CBW2).
- Disconnect coil and check that corresponding alarms are activated (see [1] in section 5.6.7 for viewing Auxiliary and Control circuits alarms). Reconnect coil and check that the corresponding alarm has disappeared
- Remove AC power supply and check that corresponding alarms are activated (see [1] in section 5.6.7 for viewing Auxiliary and Control circuits alarms). Reestablish AC power supply and check that the corresponding alarm has disappeared

5.7 End of tests records

After completion of functional tests, events recorded by CBWatch-2 should be recorded using the CBW2TOOL software:
- load the event records from the CBWatch-2 (see [1], section 5.5.1),
- Check operation counters on last open and close operations records and record them in the report,
- Save event records in a file on the PC hard disk (see [1], section 5.5.2) and record the file name in the report.

6 MAINTENANCE

When the module is switched on, a complete test of the hardware and software functions is run. Afterwards, during operation, permanent self-tests watch the electronic module and the sensors.

6.1 Alarm is detected on the electronic module

In case an alarm is detected on the electronic module (green LED goes out) :

Identify the sub-system in breakdown by accessing the alarm details, using :
- either the screen/keyboard module,
- or the local communication port,
- or the network communication port.

Then contact the AREVA T&D after sales service.

6.2 Alarm is detected on one of the sensors

If an alarm is detected on one of the sensors :
- check the sensor wiring,
- for on-off sensors, check the contact switching by means of a voltmeter,
- for sensors with 4-20mA outputs, check the output current by means of an ammeter,
- for the temperature probes, check the resistance by means of an ohmmeter.

6.3 Procedure for changing the battery

6.3.1 Role of the battery

Whenever there is no power supply to the CBWatch-2, the battery serves to save the date and the data stacks (the CBWatch-2 parameters are moreover saved in an EEPROM memory which preserves its data even in the absence of any power whatsoever).
- life of the battery with CBWatch-2 energised : 93 450 hours,
- life of the battery with CBWatch-2 de-energised : 6 750 hours,
- life of the battery with CBWatch-2 de-energised for 10% of the time : 38 540 hours.

It is possible to change the battery when the CBWatch-2 is energised without losing the information stored in the stacks.

6.3.2 Replacement of the battery

The battery is accessible after having pivoted the small trap located on the left side of the case.

If the CBWatch-2 is energized :

In this case, all of the data is kept.

If the CBWatch-2 is de-energized :

In this case the stacks and the time on the CBWatch-2 are lost.
In order to preserve the CBWatch-2 stacks, and before proceeding to change the battery, load these data stacks with the aid of the CBW2Tool software, then save them in a file.

After each battery change, the time on the CBWatch-2 must be reset with the aid of the CBW2Tool software.

7 INTERFACES

The processing module offers the following interfaces (see Figure 4) :

- Inputs for analog and on-off sensors ,
- 7 light-emitting diodes (LED) for alarm signalling,
- 4 alarm indication relays,
- A screen/keyboard assembly,
- A local communication port,
- A network communication port (MODBUS).

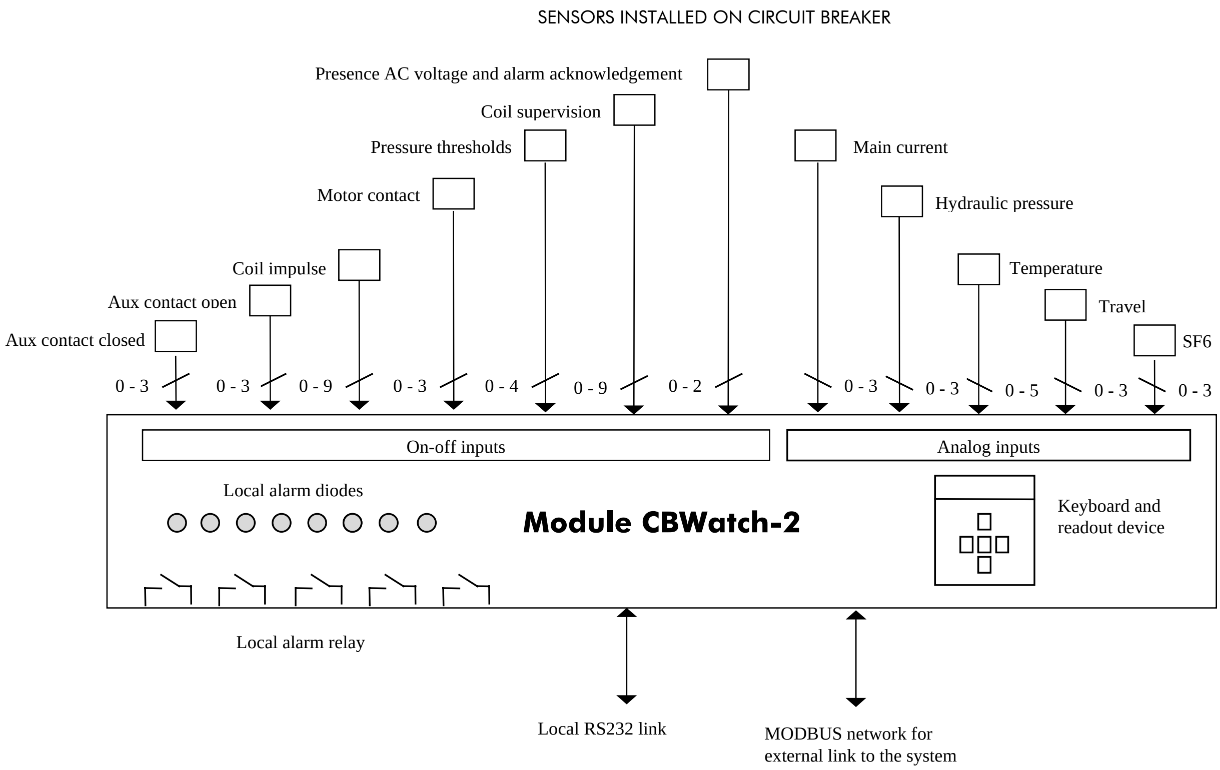


Figure 4 : Interfaces

7.1 Sensors

The characteristics of the sensors used are given in Table 3 :

Table 3 – Characteristics of the sensors

Sensor	Type	Installation	Standard measurement range	Signal	Measurement accuracy	Data collection rate	Maximum number of sensors in version P1	Maximum number of sensors in version P3
SF6 density or pressure	Transmitter 4-20mA	On filling block	0 to 10 bar absolute	4-20mA	2%	0.5 s	1	3
Ambient temperature	RTD	Mounted under a shelter on a solid part	-50°C to +100°C	PT100 3 wires	1°C	1s	1	1
Coil impulse	Ring 2000 turns	In electrical cubicle	6 à 10 amperes x turns	Voltage pulse (threshold 2.5V)		0.2ms	3	9
Auxiliary contacts	Auxiliary contacts or magnetic sensor	Pole support or control mechanism	On-off	Dry contact or open Collector (PNP)		0.2ms	2	6
Travel of main contacts	Travel sensor 4-20mA	Pole support or control mechanism	-60° to +60°	4-20mA	2%	0.2ms	1	3
Oil pressure	Pressure transmitter	Reinflation set	0 to 400 bar	4-20mA	2%	0.1s	1	3
Main current	Ring 2000 turns	Junction box of high voltage current transformers	5 to 200 amperes x turns	2.5 to 100mA	5%	0.2ms	3	3
Temperature	RTD	Box or casing	-50°C to +100°C	PT100 3 wires	<2°C	1s	4	4

7.2 Keyboard and display

A display 2 x 20 characters linked to a small keyboard allows access to the on-going measurements and alarms.

Figure 5 hereunder symbolises the procedure for using the display-keyboard module.

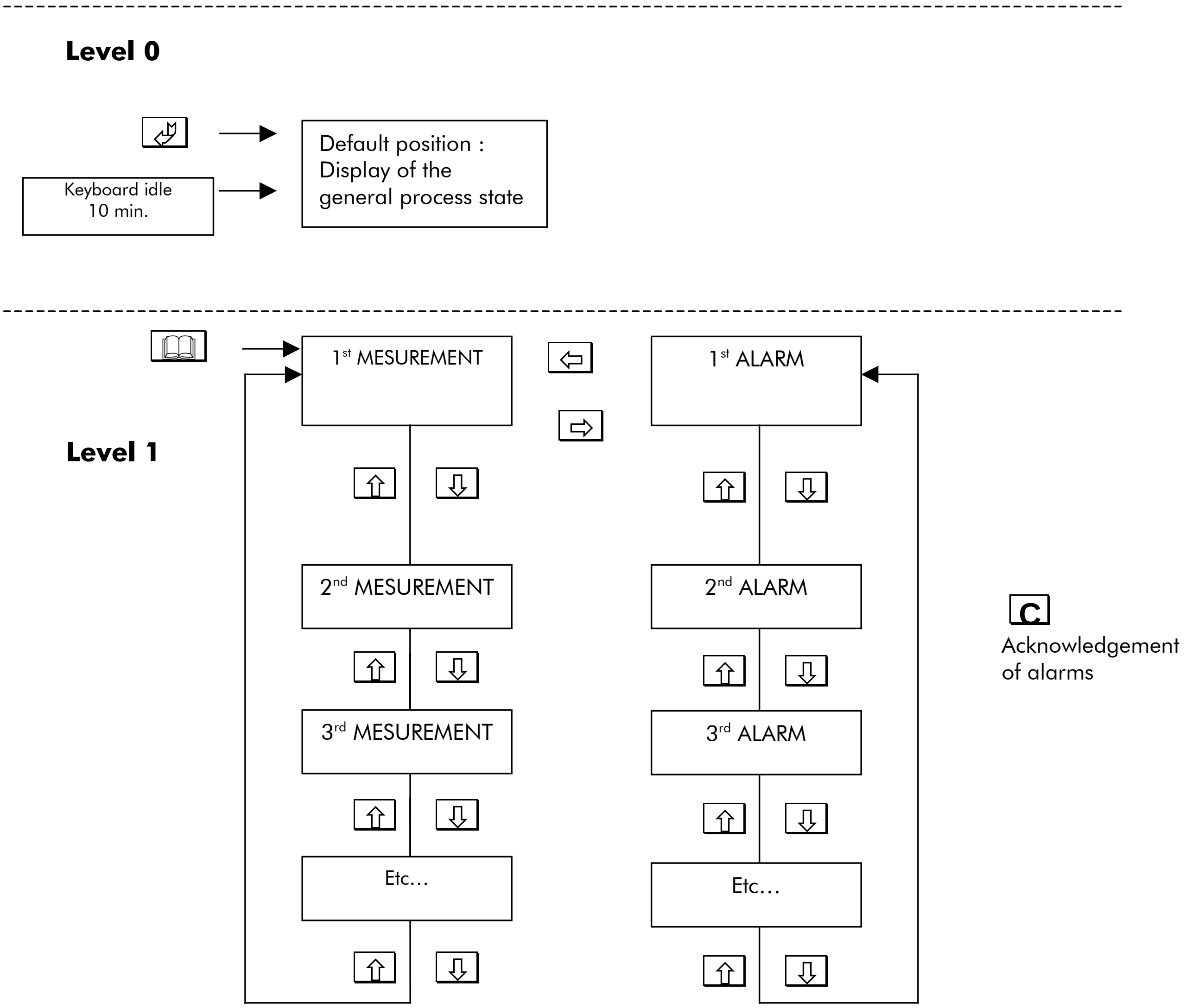


Figure 5 - Procedure for using the display

7.3 Alarm acknowledgement input

An additional on-off input allows the connection of an alarm acknowledgement contact.

7.4 Connectors

The connectors are used for sensor connection, terminal block supply and serial links.
The shielding of the sensor links is cabled to an earth bar integrated in the CBWatch-2.
The connector of local link RS232 is a female 9 pin sub-D.
The connector of the MODBUS RS485 serial link is a screw-on terminal block of the same type as those used for the sensors and the power supply.

The terminal blocks are of the withdrawable type.

7.5 Output relays and alarm diodes

One or more of the alarms generated by CBWatch2 can be assigned to each relay or each alarm diode by means of a configuration table (see Table 4).

Further, for each alarm, it is possible to define a filtering function which can be of two types (depending on the alarm) :
- Time filtering : The output relay or LED is only effectively activated if the alarm stays on for some time,
- Counter filtering : The output relay or LED is only effectively activated if the alarm is generated a given number of consecutive times.

Lastly, for each alarm, an acknowledgement can be requested.

Table 4 – Configuration of relays and alarm diodes

	Time filtering or Counter filtering	Acknowledgement necessary	Assigned relay 1	Assigned relay 2	Assigned relay 3	Assigned relay 4	Assigned LED1	Assigned LED2	Assigned LED3	Assigned LED4	Assigned LED5	Assigned LED6	Assigned LED7
Alarm 1	n cycles or n events	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no
Alarm 2	n cycles or n events	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no
…	…	…	…	…	…	…	…	…	…	…	…	…	…
Alarm n	n cycles or n events	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no	Yes/ no

7.6 Communication interfaces

CBWatch-2 offers two communication interfaces with MODBUS RTU protocol :

- One RS485 2 wires interfaces on terminal block,
- One RS232 interface with connector on the top of the casing.

Details of MODBUS implementation for CBWatch-2 can be found in CBWatch-2 Modbus interface reference manual [2].

8 CBW2TOOL HUMAN-MACHINE INTERFACE SOFTWARE

The CBW2Tool software is used on a PC Pentium II 233 MHz type microcomputer with 8 Mb of RAM equipped with an RS232 or RS485[(1)]serial link or a modem[(2)] dedicated to communications with the CBWatch-2 and a colour monitor having an 800x600 minimum sized display screen. The use of portable microcomputers is possible.

The CBW2Tool application is designed to function in the Windows 95, NT environment or higher (32 bits application).

The instructions for both installation and use of the CBWatch-2 software are given in the CBW2Tool [1] user's manual.

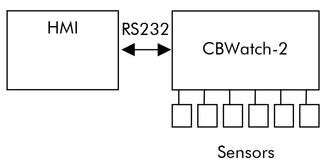
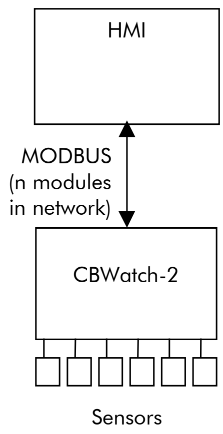
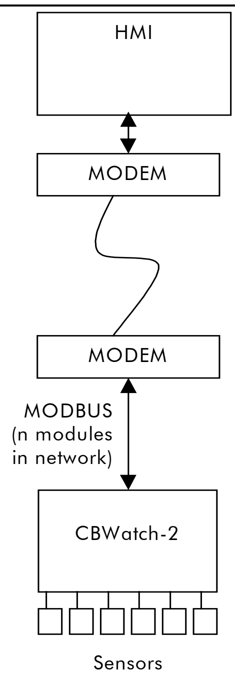
The CBW2Tool software enables the following functions to be carried out:

– Connection to a CBWatch-2 via an RS232 , an RS485 serial link or by MODEM,
– Parametering of the CBWatch-2,
– Access to the alarms, measurements and data stacks.

8.1 Connection to CBWatch-2

Management of the CBWatch-2 operations by applying CBW2Tool software is possible depending on the choice of the following 3 configurations:

– Temporary connection via the RS232 local port,
– Permanent connection via the MODBUS network,
– Temporary connection via modem and the MODBUS network.

Local Connection	**Permanent MODBUS connection**	**Temporary Connection via MODEM and MODBUS**
		

The software manages a database of the communication data towards the different CBWatch-2 modules (Name, Telephone Number, and MODBUS parameters).

(1) This interface can be supplied by an additional conversion module RS232C ↔ RS485.
(2) The modem can be internal or external to the PC; in any case it is regarded by the system as an RS232 port.

8.2 Configuration of a CBWatch-2

The software enables the CBWatch-2 configuration data to be edited by the means of a user-friendly interface, to transfer the data from and towards a connected CBWatch-2, to save them in a file in EXCEL format and to print them.

8.3 Access to the alarms and to the measurements

The software allows for the visual display of the state of the ongoing alarms and measurements on the connected CBWatch-2 to be shown.

8.4 Access to the data stacks (recordings of events)

The software enables the data archived in the connected CBWatch-2 to be loaded. It allows them to be visualised, for them to be saved in EXCEL format and to print out the list of the archived events.

The following data can be accessed in the archives :

- Stack of short term SF6 data (100 points),
- Stack of long term SF6 data (100 points),
- Stack of the last 50 SF6 alarms,
- Stack of the last 50 closing operations,
- Stack of the last 50 opening operations,
- Stack of the last 50 spring rearming operations,
- Stack of the last 50 hydraulic repressurisations during an operation,
- Stack of the last 50 hydraulic repressurisations where no operation has occurred,
- Stack of the last 50 hydraulics alarms,
- Stack of the last 50 auxiliary alarms.

9 DETAILED DESCRIPTION OF FUNCTIONS

9.1 « SF6 supervision » function

9.1.1 General description

The performance ratings of an SF6 circuit breaker are directly correlated to the density of the SF6 gas contained in the circuit breaker. Upon commissioning, the circuit breaker is filled to its filling density. Afterwards, due to leaks, the density will steadily decrease. The SF6 density must then be watched with the following aims in mind :

- Inform the utility of the need to perform a top-up when the density crosses a given threshold,
- Take precautionary measures concerning the circuit breaker control mechanism (locking or automatic operation) if the density drops below a minimum threshold allowing the circuit breaker to fulfil its function,
- Analyse the SF6 density trend in order to make forecasts.

For very low temperature applications, it sometimes happens that the SF6 is mixed with another gas (nitrogen or CF4).

The procedure adopted for density measurement is: pressure and temperature measurement, then calculation of density with allowance for the thermodynamic laws of gas.

In order to detect the liquefaction of the SF6, the SF6 pressure measured is continuously compared with the saturation pressure at the measured temperature.

9.1.2 Thresholds

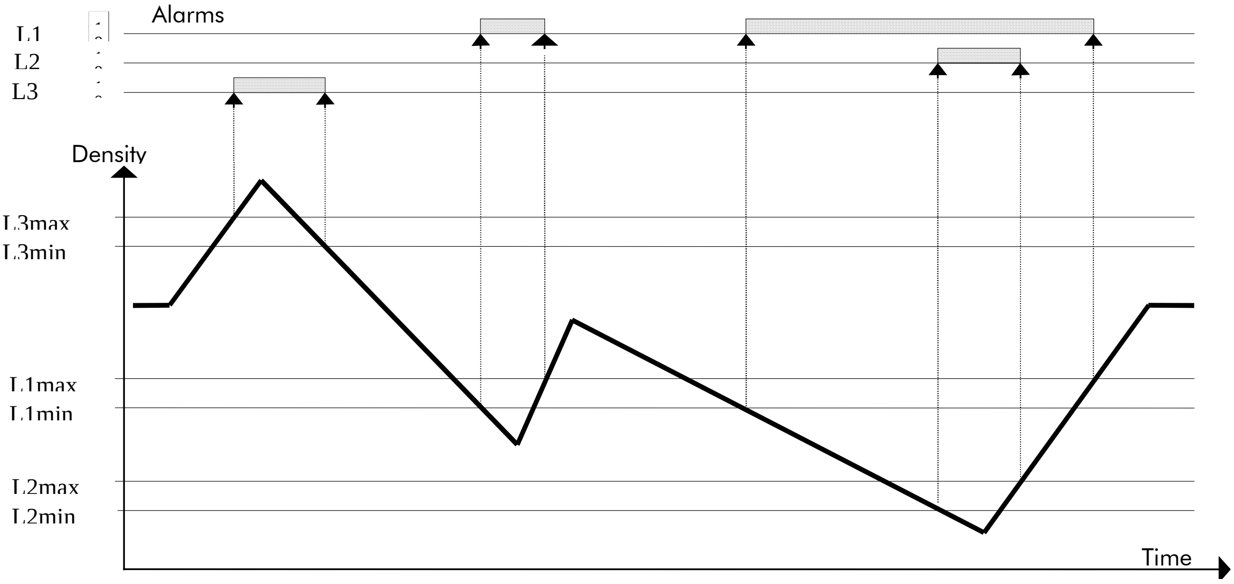
The SF6 density expressed in terms of equivalent pressure at 20°C is compared with a certain number of thresholds. Each of these thresholds is parametrable in value and in hysteresis.

Threshold L1 « top-up »: Below this threshold, the circuit breaker is always capable of fulfilling its function but a filling action is required.

Threshold L2 « Locking or automatic operation »: Below this threshold, the circuit breaker is no longer capable of fulfilling its function. Depending on the operating schemes, when the threshold is crossed it is possible to either lock or automatically operate the circuit breaker.

Threshold L 3 « overfilling »: Should the quantity of gas in the circuit breaker be too large, there is a risk of overpressure during heating.

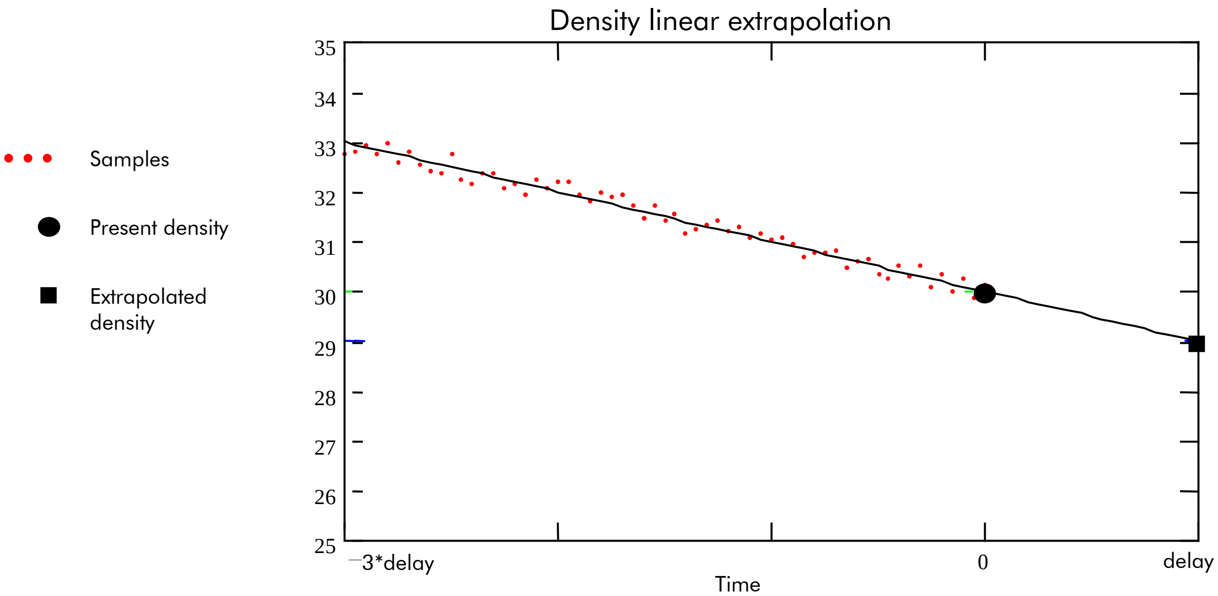
The figure below illustrates the crossing of the various thresholds with their hysteresis during the density variation:



9.1.3 Calculation of long-term trend and alarm before threshold L1

The equivalent pressure at 20°C of each of the poles is recorded. The recordings are made at midnight. These recordings are used to make a linear extrapolation of equivalent pressure at 20°C in the future . This allows anticipation of what will be the equivalent pressure value at 20°C in the future (length parametrable from 20 to 200 days).

This predicted value is then compared with the first SF6 threshold and an alarm is transmitted (T1) in case of overstep.



9.1.4 Calculation of short-term trend and alarm before threshold L2

For long-term trend calculations, the recordings are made at midnight. This allows freedom from external influence parameters such as the sun's rays.
On the other hand, in the short-term dataset the recordings are made with a much faster period and will therefore be sensitive to these external parameters. It then becomes much more difficult to evaluate a leakage rate by a calculation equivalent to the one proposed for the long-term dataset.

Should the volumes of the 3 phases be watched independently, reliable detection of relatively fast leaks is performed by comparing the measured densities for the three phases taken two by two. Assuming that the leak occurs in a single one of the three phases, a leakage rate can then be calculated without the need to allow for the external parameters.

This calculated leakage rate is used to predict the density value in the future (length parametrable from 20 minutes to 20 hours). This predicted value is then compared with the second SF6 threshold and an alarm (T2) is transmitted in case of an over step.

9.2 « Supervision of operations » function

9.2.1 General description

The supervision of the dynamic parameters during circuit breaker operations (operation time, speed, ...) allows any drift in its mechanical performance to be diagnosed.
In the « basic » version, use is made of the position sensors: 1 « closed » position sensor, one « open » position sensor .
In the « extended » version, use can be made of a travel sensor, allowing a finer analysis.

9.2.2 Counting of the number of operations

For each phase, the number of closure operations and the number of tripping operations are cumulated.

2 thresholds are defined for the number of operations and an alarm is generated when each of these thresholds is crossed.

9.2.3 Detection of a pole discrepancy

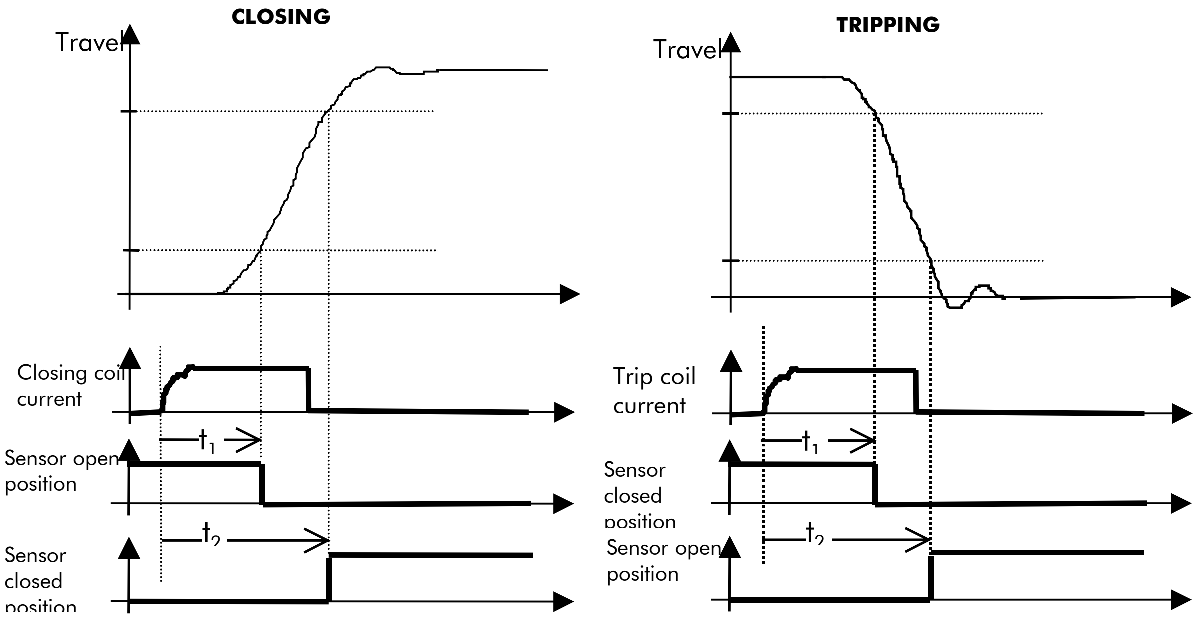
If there are sensors for each of the three poles, the positions are regularly compared. If there is a mismatch in positions during a period longer than a threshold, an alarm is declared.

9.2.4 Analysis of operating times

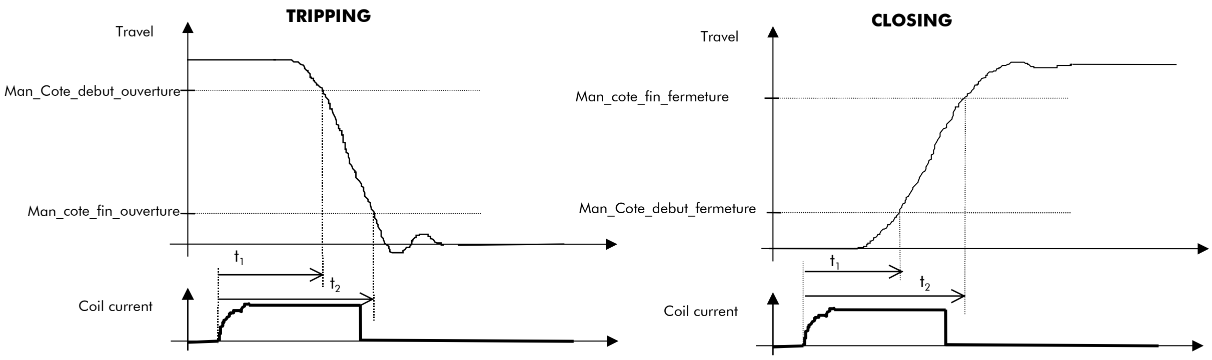
For each trip operation and for each of the phases, the following are recorded :
- the occurrence date of the trip impulse,
- the time t1 between the appearance of the impulse on the trip coil and the moment when the circuit breaker leaves the « closed » position,
- the time t2 between the appearance of the impulse on the trip coil and the moment when the circuit breaker reaches the « open » position.

In the same way, for each closure operation, the following are recorded for each of the phases :
- The occurrence date of the closure impulse,
- The time t1 between the appearance of the impulse on the closure coil and the moment when the circuit breaker leaves the « open » position,
- The time t2 between the appearance of the impulse on the closure coil and the moment when the circuit breaker reaches the « closed » position.

Measurement in basic version (with open and closed position sensors)



Measurement of operating times in extended version (with travel sensor)



For each operation, for each phase and between phases, the values of t1, t2 and t2-t1 are compared with maximum variation ranges.

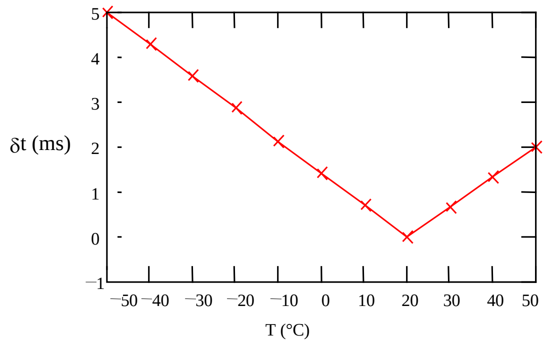
9.2.5 Elimination of some operations from the analysis

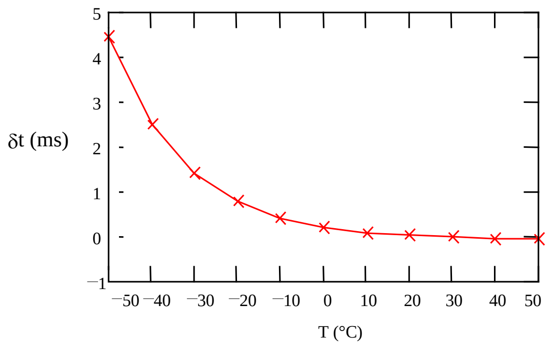
In case of several operations in the same operation sequence, the first operation only is analysed.

9.2.6 Offset of operation times versus temperature and versus coil voltage

The operation times of a circuit breaker vary with the coil control voltage and the room temperature. The operation time thresholds are offset versus these parameters according to piecewise linear compensation laws.

Example of laws offsetting closure times versus room temperature for two different circuit breakers :

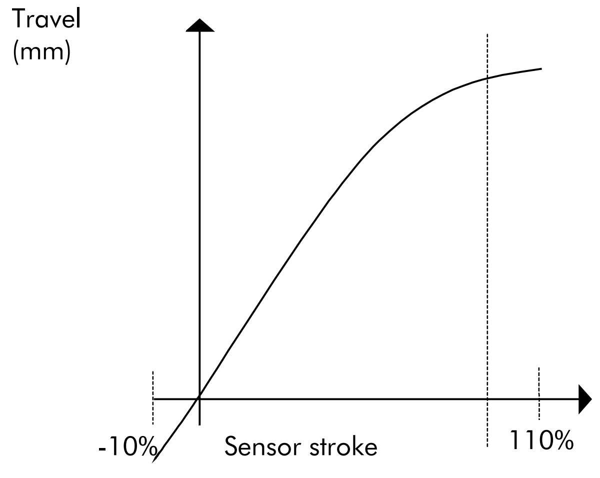




9.2.7 Travel sensor - Correction of kinematics

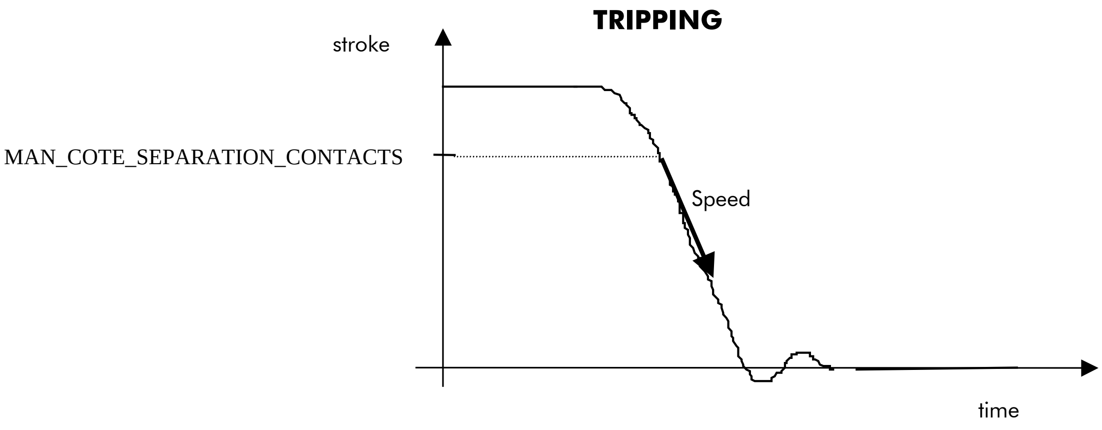
The travel measurement is not taken in the interrupting chamber but for example on the output shaft of the mechanical control mechanism. So a correction has to be applied to the measured travel to allow for the distortion due to the kinematics between the output shaft of the control mechanism and the travel of the contacts in the chamber.

This kinematics correction is described by a curve giving the travel of the contacts in the chamber versus the stroke at the sensor



9.2.8 Analysis of the separation speed of the contacts (requires the travel sensor)

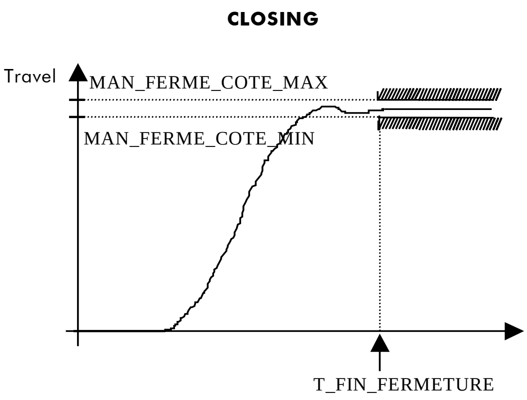
The speed is calculated at the time of separation of the contacts.
This speed is compared with a minimum threshold.

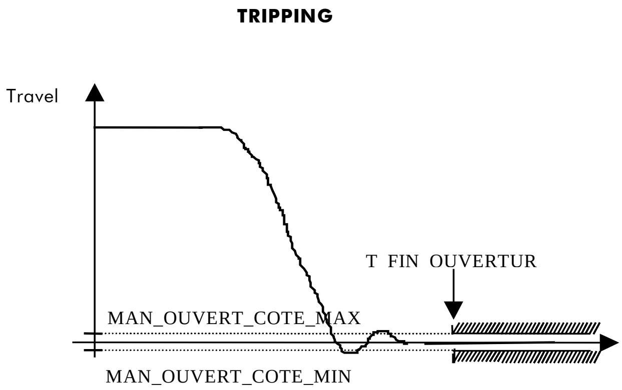


9.2.9 Supervision of rebounds and final position (requires the travel sensor)

Supervision of final position

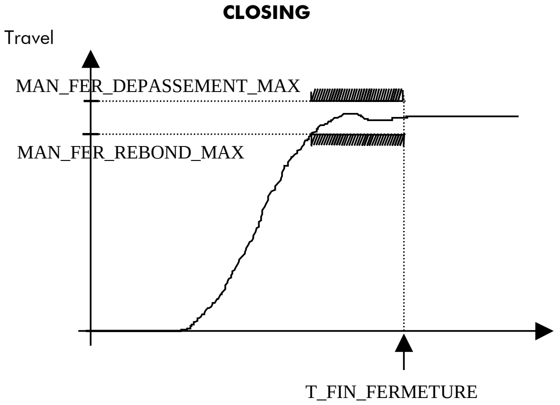
For each tripping or closing operation, the maximum positions which the position must reach at the end of the operation are defined.

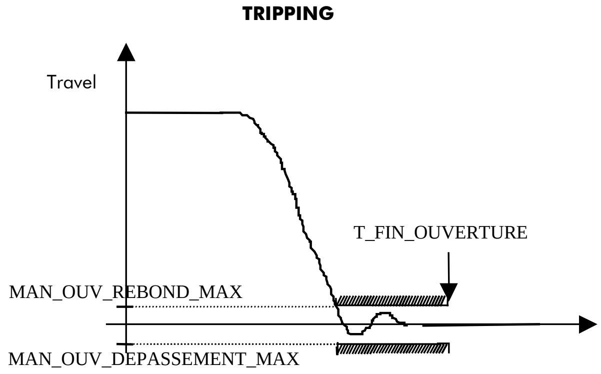




Supervision of rebounds

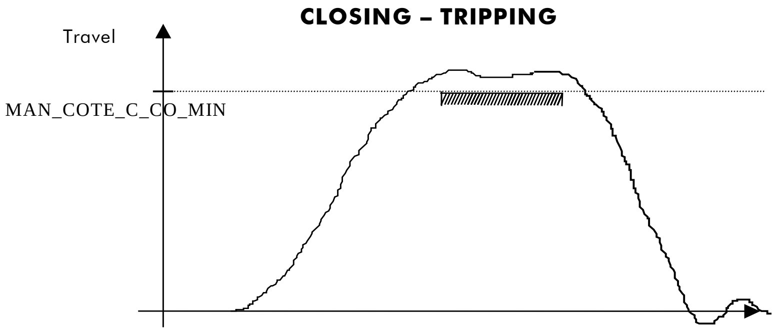
The rebounds and oversteps at end of stroke are also supervised :





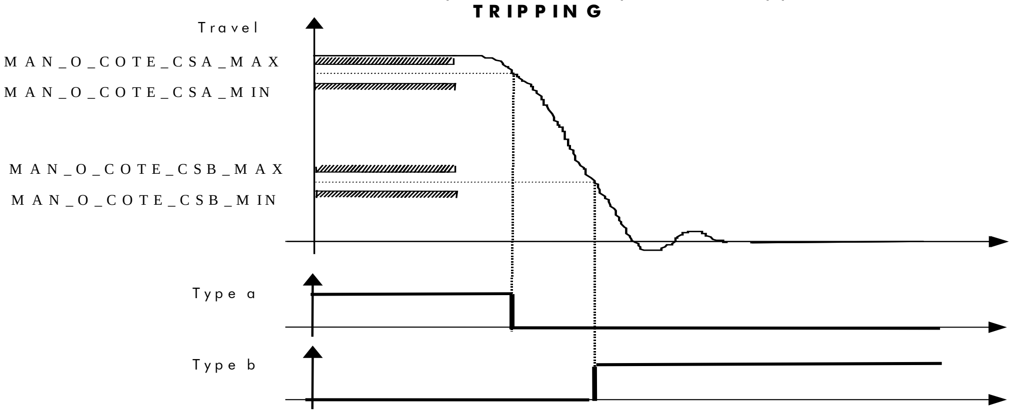
9.2.10 Supervision of the stroke during a CO cycle (requires the travel sensor)

During a CO cycle, it is supervised that the position reached at the end of operation C is sufficient.



9.2.11 Supervision of the aux.contacts and of the kinematics between aux.contacts and poles (requires the travel sensor)

If travel sensors are available, use can be made of the position sensor inputs to connect aux. contacts and a check can then be made on the actuation positions of the latter. For each operation, depending on the moment of actuation of the aux. contacts and on the travel curve, the actuation position of the contact is determined. This measured position is compared with upper and lower bounds.



9.3 « Supervision of closing spring reload » function (for circuit breakers with spring-loaded control mechanism)

9.3.1 General description

Following a closure operation, a contact starts up the reload motor of the closure spring in order to regenerate the operating energy.

9.3.2 Analysis of spring reload times

The spring reload phase time is measured (running time of the reload motor). This time is compared with a minimum time and a maximum time.

9.4 « Supervision of the hydraulic control mechanism » (For circuit breakers with hydraulic control mechanism).

9.4.1 General description

The inflation of the hydraulic control system is performed by a pump actuated by the reinflation motor. This motor starts below the « pump start » threshold and stops above the « pump stop » threshold.

In the basic version, the pump running time is supervised together with the number of start-ups in a given period. The lock pressure thresholds from the conventional pressure switches are also input.

In the extended version, the hydraulic pressure is continuously supervised.

9.4.2 Lock thresholds

The hydraulic thresholds (one for 3 phases) are input at the relays taking the signal from the conventional pressure switches :

- OCO lock threshold (one for 3 phases),
- C lock threshold (one for 3 phases),
- O lock threshold (one for 3 phases),
- nitrogen leak threshold (one for 3 phases).

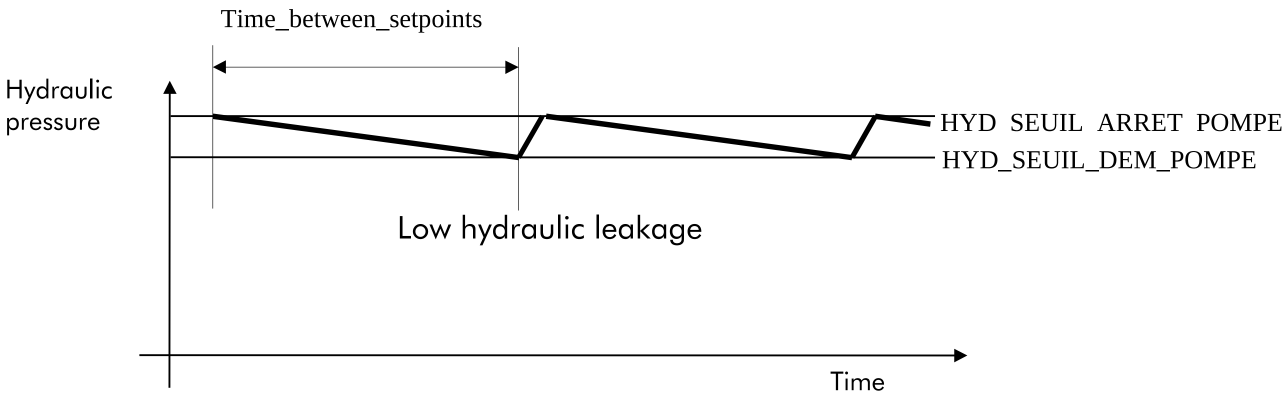
If one of these thresholds is crossed, an alarm is transmitted.

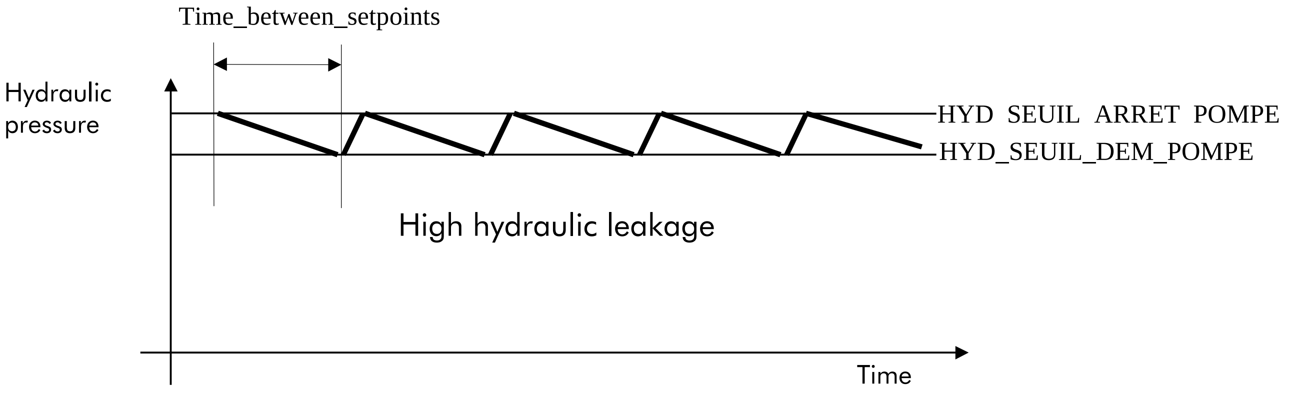
9.4.3 Analysis of the reinflation time after operation

Processing is activated by pump start following execution of an operation.
The pump running time is measured and, given the type of operation sequence validated by the operation supervision function, this time is compared with an upper bound.

9.4.4 Estimation of the hydraulic leakage rate

Measurement of the elapsed time between pump shutdown and start (<u>in the absence of a circuit breaker operation</u>) allows the hydraulic system leakage rate to be quantified (internal leaks + external leaks).





For each of the 3 phases, the quantity « Time_between_setpoints » is measured and the hydraulic leakage rate is calculated by the formula :

$$\text{Hydraulic\_leakage\_rate} = \frac{(\text{HYD\_SEUIL\_ARRET\_POMPE}) - (\text{HYD\_SEUIL\_DEM\_POMPE})}{\text{Time\_between\_setpoints}}$$

These values are averaged for a given number of measurements and the average is compared with a maximum hydraulic leakage rate ; an alarm is transmitted in case of overstep.

<u>Offset of the hydraulic leakage rate threshold versus temperature</u>:

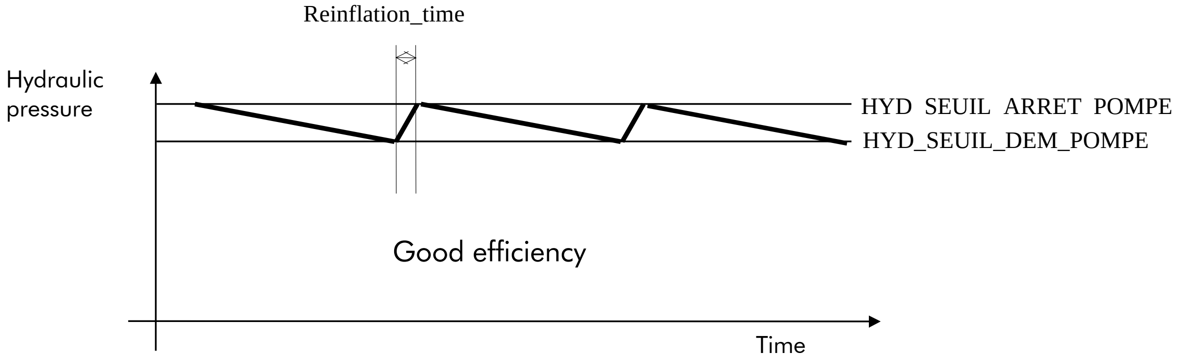
If t1 is the duration of the pressure decrease phase between the pump thresholds at temperature T1 and t2 is the same duration at temperature T2, this gives :

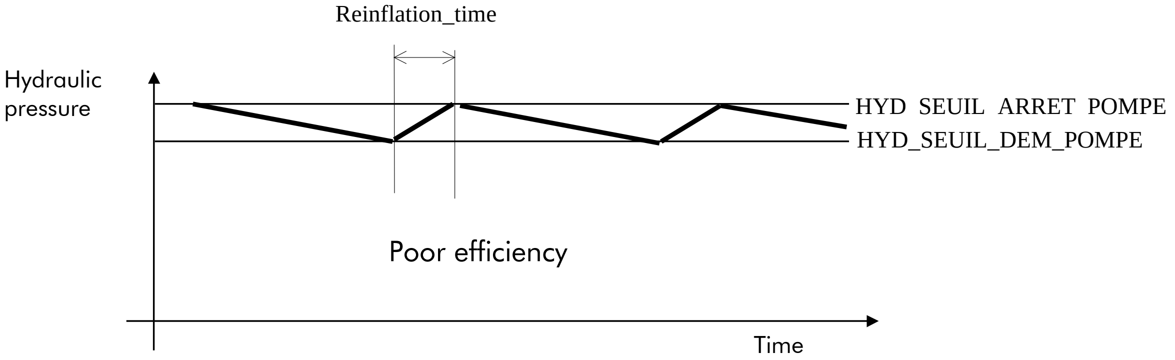
$$\frac{t_1}{t_2} = \frac{T_1}{T_2}$$

Remark :
The « depressurisation » time depends in the same way on the quantity of nitrogen in the accumulator (see appendix). A shortening of this time may therefore be due either to a larger hydraulic leakage or to a leak of nitrogen from the accumulator.

9.4.5 Estimation of re-inflation efficiency

Measurement of the reinflation time allows the efficiency of the motor/pump set to be quantified.





For each of the 3 phases, the reinflation period is measured and the hydraulic efficiency is calculated by :

$$\text{Pump\_efficiency} = \frac{(\text{HYD\_SEUIL\_ARRET\_POMPE}) - (\text{HYD\_SEUIL\_DEM\_POMPE})}{\text{Reinflation\_time}}$$

These values are averaged for a given number of measurements and the average is compared with a minimum value ; an alarm is transmitted in case of overstep.

9.4.6 Detection of a nitrogen leak from the accumulator under nitrogen

The reinflation period will decrease if the accumulator leaks nitrogen. This phenomenon cannot be confused with an hydraulic leakage.

By putting an upper bound on the measured reinflation efficiency, a nitrogen leak can thus be detected. The average reinflation efficiency is compared with a maximum value and an alarm is sent in case of an overstep.

9.4.7 Hydraulic pressure thresholds (requires the hydraulic pressure sensor)

Hydraulic pressure is continuously measured by a pressure sensor. This measured pressure is compared with the various lock thresholds (lock O, lock C, lock OCO) and an alarm is sent if there is an overstep.

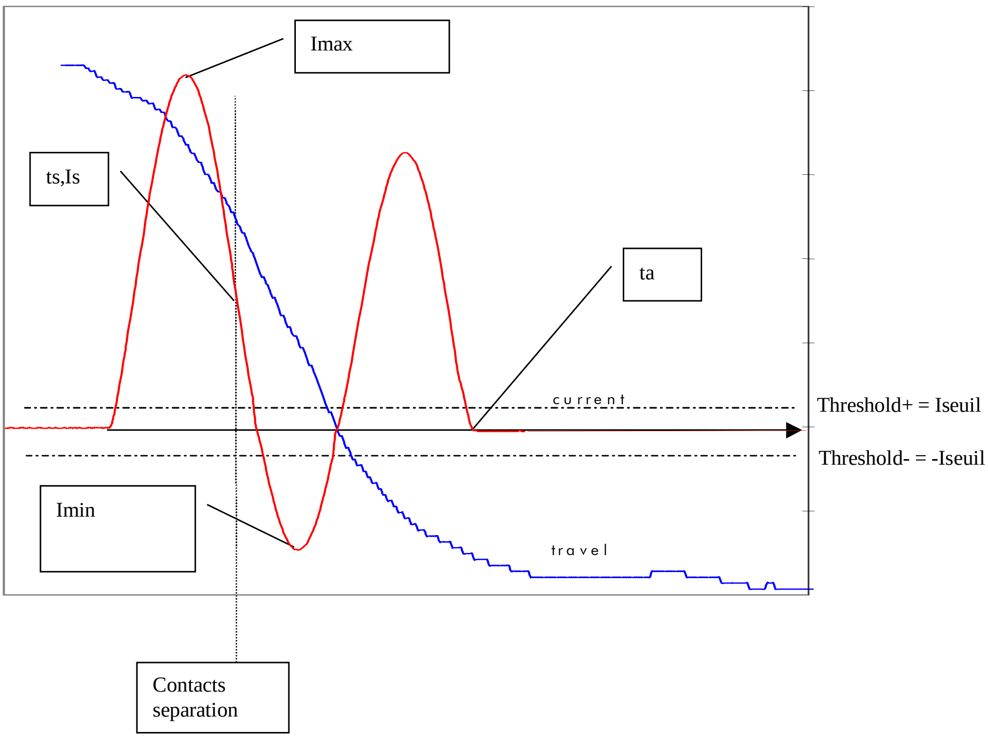
9.5 « Supervision of broken current » function

9.5.1 General description

Throughout circuit breaker lifetime, the square of the current broken by the arcing contacts is cumulated. These « cumulative square amperes » give an indication of the circuit breaker condition in terms of electrical wear.

Moreover, during each break, the arcing time is watched in order to detect any degradation of break performance and any « non-break ».

9.5.2 Current sampling before and during the break



During first 20 milliseconds following coil command, current peak minimum and maximum values are measured (Imin and Imax).

The RMS value of switched current is estimated by the formula: Irms=(Imax-Imin)/2√2
The threshold for detecting current zeroing is then calculated by the formula: Iseuil = Irms/Kseuil

Instant of contact separation is then calculated :
- If a travel sensor is installed, this correspond to the time when the contacts reach specific position on travel curve,
- If position sensors are installed, this correspond to a specific delay after switching of type a auxiliary switch.

A simplified current curve is recorded with the operation. (20 points consisting of 1 point every 2 ms starting from instant of contacts separation).

9.5.3 Calculation of electrical wear

After separation of the contacts (instant t_s) and up to final switching-off of the current (instant t_a), the square amperes broken by the circuit breaker are cumulated in order to estimate the electrical wear induced by the relevant operation :

$$One\_operation\_electrical\_wear = \int_{t_s}^{t_a} f(Irms) \cdot i(t)^2 \cdot dt$$

This quantity representing electrical wear for the relevant operation is then added to the previous total to obtain the total electrical wear.

$$Cumulated\_electrical\_wear = \sum_{manoeuvres} \int_{t_s}^{t_a} f(Irms) \cdot i(t)^2 \cdot dt$$

Default value for function f is f(Irms)=1 for all possible values of Irms.

Other functions are programmable in order to define different electrical wear depending on the level of broken current.

9.5.4 Electrical wear upper bounds

For each of the phases, the electrical wear rate is defined as the ratio between the cumulative electrical wear defined in the previous paragraph and a maximum electrical wear specified for the circuit breaker.

This electrical wear rate is compared with 2 upper bounds corresponding to 2 alarm thresholds.

9.5.5 Arcing time upper bounds

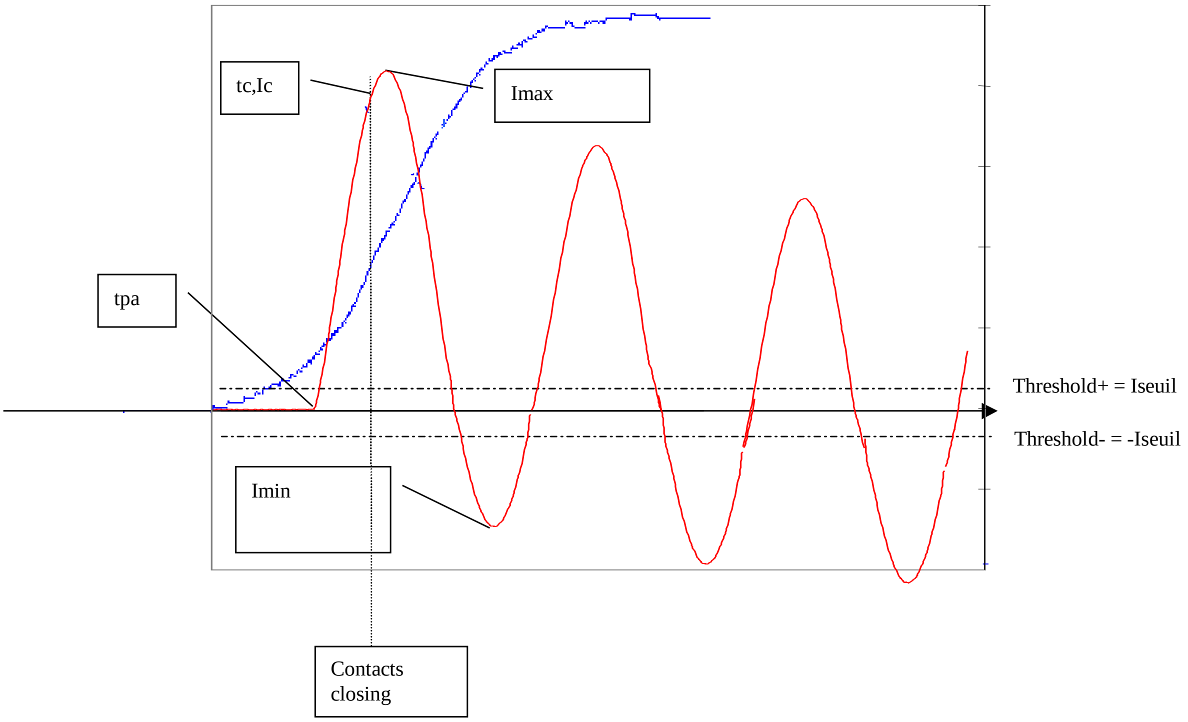
For each of the phases, the arcing time (t_a-t_s) is compared with a maximum arcing time and an alarm is sent if there is an overstep.

9.6 « Supervision of making current » function (OPTIONAL FUNCTION)

9.6.1 General description

Some breakers do not only suffer from electrical wear when breaking current , but also when making current , such as "by-pass" breakers .For such applications an optional function has been developed , which also measure electrical wear during closing operations .

9.6.2 Current sampling before and during the closing



During first 20 milliseconds following closing coil command, current peak minimum and maximum values are measured (Imin and Imax).

The RMS value of making current is estimated by the formula: Irms=(Imax-Imin)/2√2
The threshold for detecting pre-arcing current is then calculated by the formula: Iseuil = Irms/Kseuil

Instant of contact closing is then calculated :
- If a travel sensor is installed, this corresponds to the time when the contacts reach specific position on travel curve,
- If position sensors are installed, this corresponds to a specific delay after switching of type a auxiliary switch.

A simplified current curve is recorded with the operation. (20 points consisting of 1 point every 2 ms starting from instant of contacts closing).

9.6.3 Calculation of electrical wear

From the instant of pre-arcing time t_{pa} (detected by a current > Iseuil) to the closing of the contacts (instant t_c), the square amperes flowing through the contacts are cumulated in order to estimate the electrical wear induced by the relevant operation :

$$One\_operation\_electrical\_wear = \int_{t_{pa}}^{t_c} f(Irms) \cdot i(t)^2 \cdot dt$$

This quantity representing electrical wear for the relevant operation is then added to the previous total to obtain the total electrical wear.

$$Cumulated\_electrical\_wear = \sum_{manoeuvres} \int_{t_s}^{t_a} f(Irms) \cdot i(t)^2 \cdot dt$$

Default value for function f is f(Irms)=1 for all possible values of Irms.

Other functions are programmable in order to define different electrical wear depending on the level of making current.

9.6.4 Electrical wear upper bounds

See 9.5.4

9.6.5 Arcing time upper bounds

For each of the phases, the pre-arcing time (t_c-t_{pa}) is compared with a maximum pre-arcing time and an alarm is sent if there is an overstep.

9.7 « Supervision of the auxiliary and control circuits » function

9.7.1 Continuity of the coils and battery voltage presence

The sensor consists of an external coil supervision relay. This relay sticks as long as the coil is in good condition.
If there are several coils to be watched, the supervision relay outputs will be connected in series then connected to CBWatch-2.

If at least one coil supervision relay separates during a period longer than one upper bound, an alarm is transmitted.

This sensor also detects the presence of the battery voltage.

9.7.2 AC voltage presence

A sensor is connected either between 1 phase and neutral, or between 3 phases and neutral (star), or between 3 phases (delta). This sensor watches the AC voltage presence and separates a contact if voltage is absent.

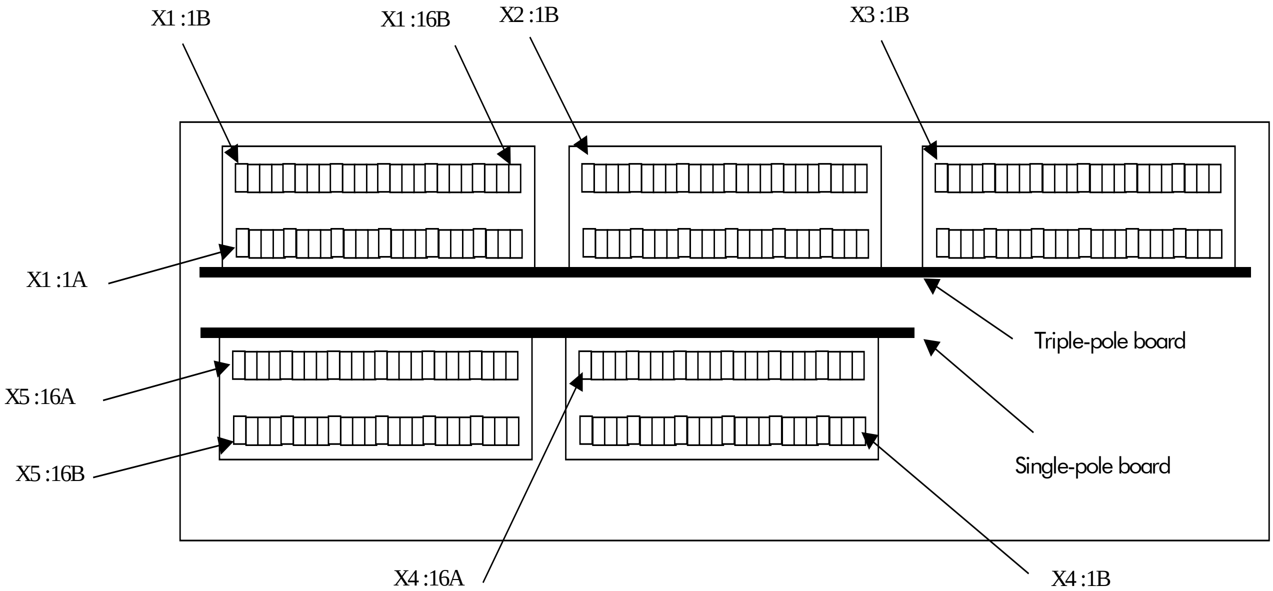
If the voltage is absent during a period exceeding an upper bound, an alarm is transmitted.

9.7.3 Heating supervision

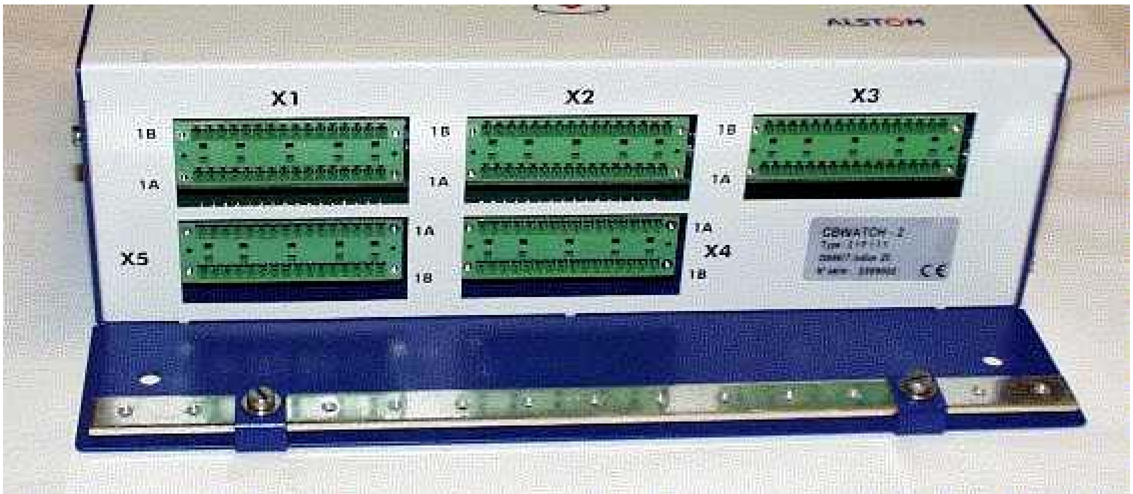
Between 1 and 4 measurement points can be equipped with a temperature sensor. The temperature of each of these points is compared with a min and a max temperature in order to diagnose any heating breakdown.

10 TERMINALS

10.1 Presentation



Bottom view



10.2 Terminal block X1 (see chapter 11 for mode of sensors connection)

Terminal N°		
1A	SF6 pressure/A (+24V)	
2A	SF6 pressure /A (SIG)	
3A	Hydraulic pressure /A (+24V)	
4A	Hydraulic pressure /A (SIG)	
5A	GND (don't connect)	
6A	Travel sensor /A (+24V)	
7A	Travel sensor /A (SIG)	
8A	Travel sensor /A (0V)	
9A	GND (don't connect)	
10A	Main current/A (S1)	
11A	Main current /A (S2)	
12A	Main current /B (S1)	
13A	Main current /B (S2)	
14A	Main current /C (S1)	
15A	Main current /C (S2)	
16A	GND (don't connect)	
1B	Outer temperature (red)	
2B	Outer temperature (white)	
3B	Outer temperature (red)	
4B	Temperature cubicle 1 (red)	See Note
5B	Temperature cubicle 1 (white)	
6B	Temperature cubicle 1 (red)	
7B	Temperature cubicle 2 (red)	
8B	Temperature cubicle 2 (white)	
9B	Temperature cubicle 2 (red)	
10B	Temperature cubicle 3 (red)	
11B	Temperature cubicle 3 (white)	
12B	Temperature cubicle 3 (red)	
13B	Temperature cubicle 4 (red)	
14B	Temperature cubicle 4 (white)	
15B	Temperature cubicle 4 (red)	
16B	GND (don't connect)	

Note : when all temperature input are not used, connect the temperature sensors beginning by temperature cubicle 1...

10.3 Terminal block X2 (see chapter 11 for mode of sensors connection)

Terminal N°	
1A	Hydraulic stage Tripping lock (SIG)
2A	Hydraulic stage Tripping lock (+48V)
3A	Hydraulic stage Closing lock (SIG)
4A	Hydraulic stage Closing lock (+48V)
5A	Hydraulic stage OCO lock (SIG)
6A	Hydraulic stage OCO lock (+48V)
7A	N2 leakage (SIG)
8A	N2 leakage (+48V)
9A	AC voltage presence (SIG)
10A	AC voltage presence (+48V)
11A	Coils supervision (SIG)
12A	Coils supervision (+48V)
13A	Motor limit switch /A (SIG)
14A	Motor limit switch /A (+48V)
15A	Alarm reset (SIG)
16A	Alarm reset (+48V)
1B	Not connected
2B	Not connected
3B	Not connected
4B	Not connected
5B	Closing coil impulse /A (S2)
6B	Closing coil impulse /A (S1)
7B	Tripping coil O2 impulse /A (S2)
8B	Tripping coil O2 impulse /A (S1)
9B	Tripping coil O1 impulse /A (S2)
10B	Tripping coil O1 impulse /A (S1)
11B	Aux. Contact type a /A (0V)
12B	Aux. Contact type a /A (SIG)
13B	Aux. Contact type a /A (+48V)
14B	Aux. Contact type b /A (0V)
15B	Aux. Contact type b /A (SIG)
16B	Aux. Contact type b /A (+48V)

10.4 Terminal block X3 (see chapter 11 for mode of sensors connection)

Terminal N°	
1A	MODBUS RS485 SIGNAL -
2A	MODBUS RS485 SIGNAL +
3A	Not connected
4A	CBWatch-2 failure (NO)
5A	Not connected
6A	Alarm 4 (NO)
7A	Not connected
8A	Alarm 3 (NO)
9A	Not connected
10A	Not connected
11A	Alarm 2 (NO)
12A	Not connected
13A	Alarm 1 (NO)
14A	Not connected
15A	Supply -
16A	Supply +
1B	Not connected
2B	CBWatch-2 failure (COM)
3B	CBWatch-2 failure (NC)
4B	Not connected
5B	Alarm 4 (COM)
6B	Alarm 4 (NC)
7B	Not connected
8B	Alarm 3 (COM)
9B	Alarm 3 (NC)
10B	Not connected
11B	Alarm 2 (COM)
12B	Alarm 2 (NC)
13B	Not connected
14B	Alarm 1 (COM)
15B	Alarm 1 (NC)
16B	Not connected

Note : earth is connected to earth bar at the bottom of the CBWatch2 frame

10.5 Terminal block X4 (see chapter 11 for mode of sensors connection)

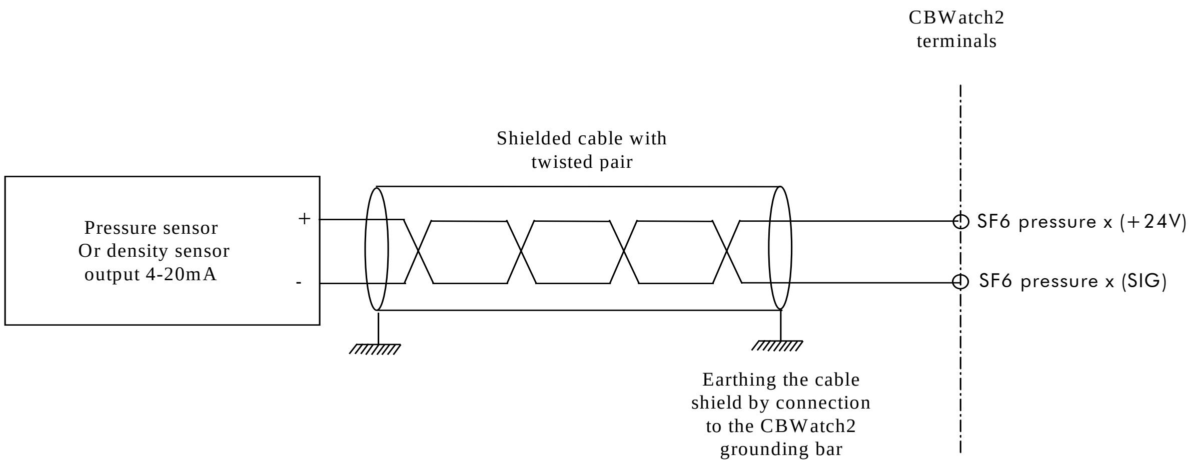
Terminal N°	
1A	Motor limit switch /B (+48V)
2A	Not connected
3A	Motor limit switch /C (+48V)
4A	Not connected
5A	Aux. Contact type b /B (0V)
6A	Aux. Contact type b /B (+48V)
7A	Not connected
8A	Aux. Contact type a /B (+48V)
9A	Aux. Contact type a /B (0V)
10A	Not connected
11A	Not connected
12A	Aux. Contact type b /C (0V)
13A	Aux. Contact type b /C (+48V)
14A	Not connected
15A	Aux. Contact type a /C (0V)
16A	Aux. Contact type a /C (+48V)
1B	Motor limit switch /B (SIG)
2B	Not connected
3B	Motor limit switch /C (SIG)
4B	Not connected
5B	Not connected
6B	Aux. Contact type b /B (SIG)
7B	Not connected
8B	Not connected
9B	Aux. Contact type a /B (SIG)
10B	Not connected
11B	Not connected
12B	Aux. Contact type b /C (SIG)
13B	Not connected
14B	Not connected
15B	Aux. Contact type a /C (SIG)
16B	Not connected

10.6 Terminal block X5 (see chapter 11 for mode of sensors connection)

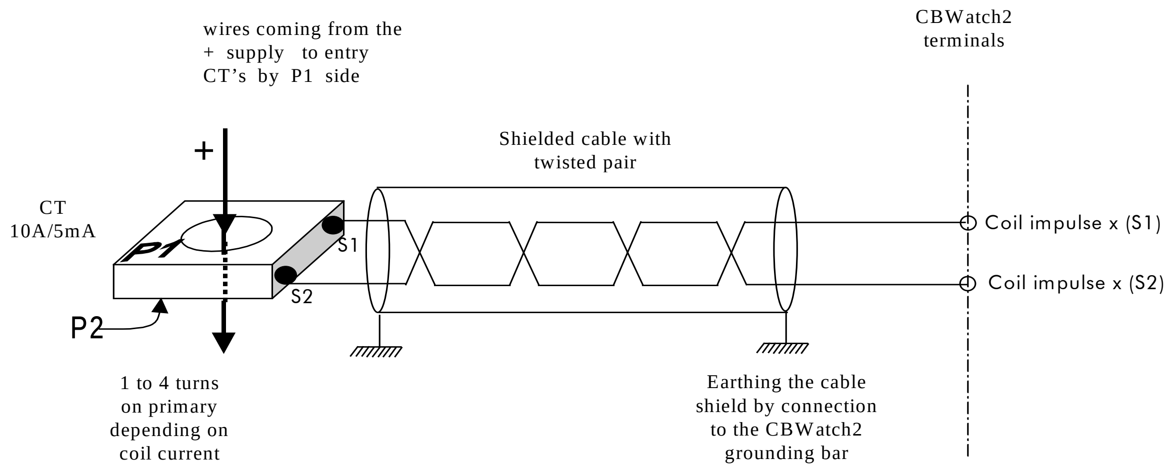
Terminal N°	
1A	Tripping coil O1 impulse /B (S2)
2A	Tripping coil O2 impulse /B (S2)
3A	Closing coil impulse /B (S2)
4A	Tripping coil O1 impulse /C (S2)
5A	Tripping coil O2 impulse /C (S2)
6A	Closing coil impulse /C (S2)
7A	Not connected
8A	SF6 pressure /B (+24V)
9A	SF6 pressure /C (+24V)
10A	Hydraulic pressure /B (+24V)
11A	Hydraulic pressure /C (+24V)
12A	Not connected
13A	Travel sensor /B (0V)
14A	Travel sensor /B (+24V)
15A	Travel sensor /C (0V)
16A	Travel sensor /C (+24V)
1B	Tripping coil O1 impulse /B (S1)
2B	Tripping coil O2 impulse /B (S1)
3B	Closing coil impulse /B (S1)
4B	Tripping coil O1 impulse /C (S1)
5B	Tripping coil O2 impulse /C (S1)
6B	Closing coil impulse /C (S1)
7B	Not connected
8B	SF6 pressure /B (SIG)
9B	SF6 pressure /C (SIG)
10B	Hydraulic pressure /B (SIG)
11B	Hydraulic pressure /C (SIG)
12B	Not connected
13B	Not connected
14B	Travel sensor /B (SIG)
15B	Not connected
16B	Travel sensor /C (SIG)

11 CONNECTION OF SENSORS

11.1 Pressure sensor or SF6 density sensor



11.2 Coil impulse sensor

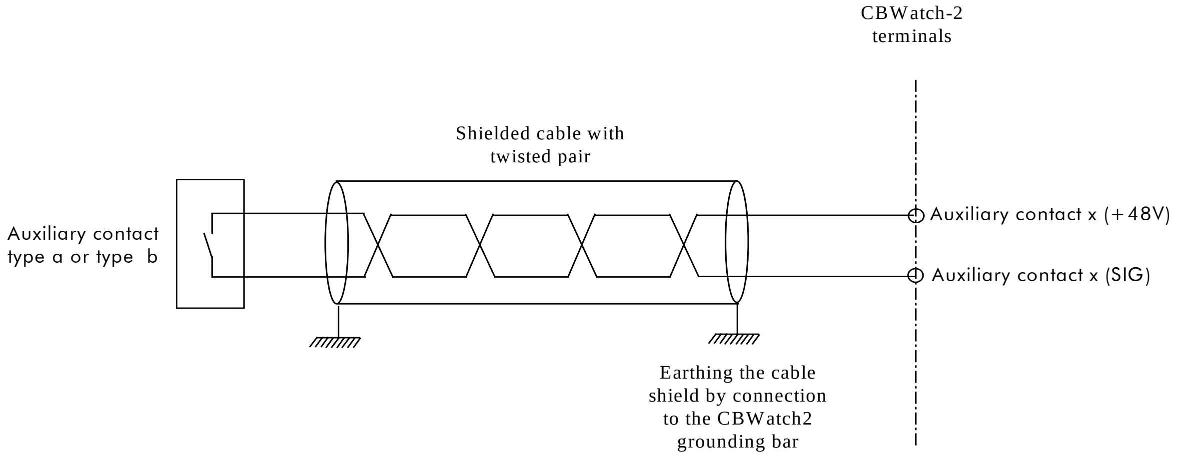


The coil current through the sensor must be more than 8 Amp x turns. If the current is lower, make several turns around the sensor.

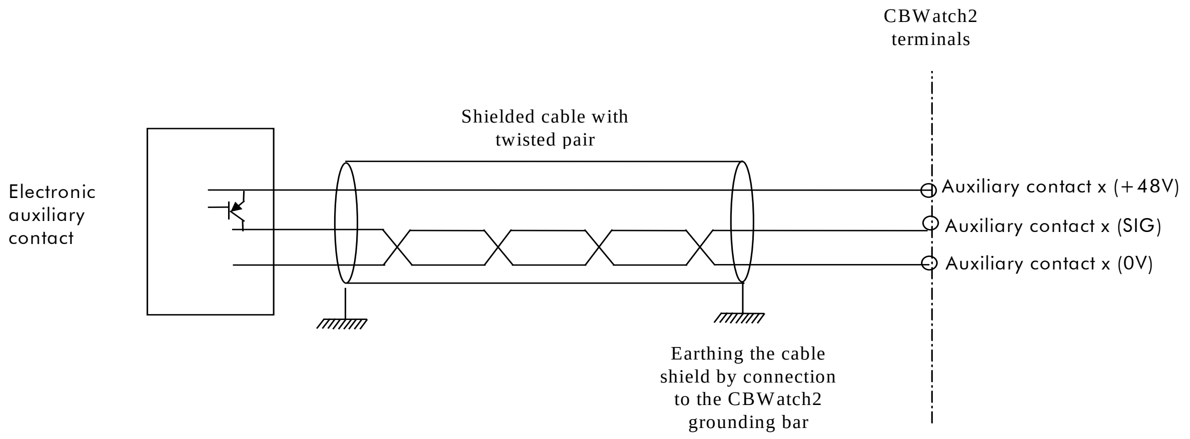
11.3 Position sensor and/or auxiliary contact

The same input circuit is used to connect a conventional auxiliary contact or an electronic sensor with output "open collector" type PNP.

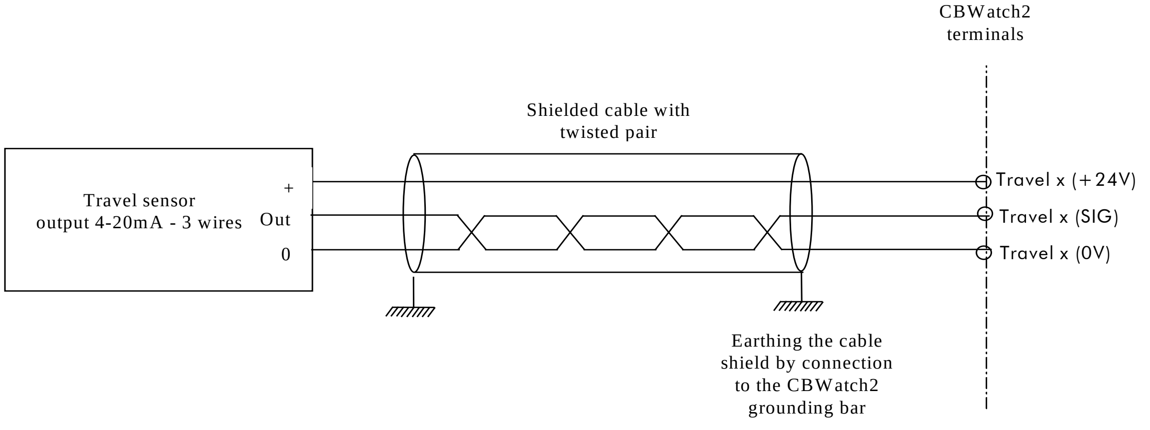
When conventional auxiliary contact is used



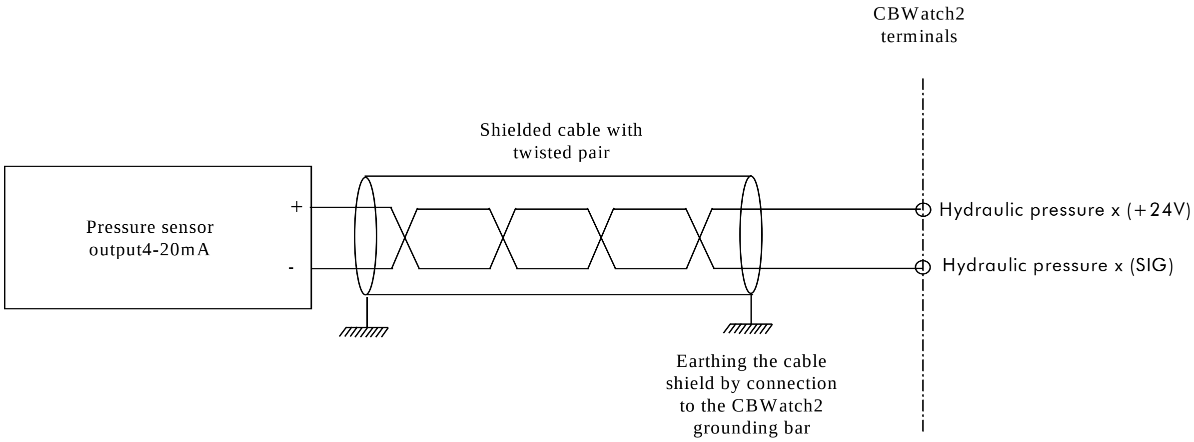
When electronic position contact is used



11.4 Travel sensor

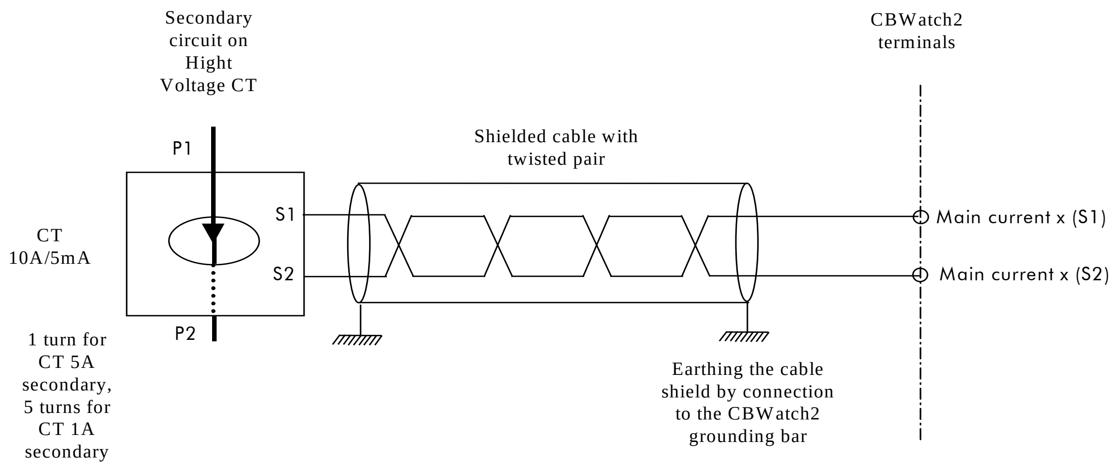


11.5 Hydraulic pressure sensor



11.6 Main current sensor

An auxiliary CT is used in the secondary circuit of High Voltage CT.
The nominal current is 5 A. When the secondary current is 1 A, make 5 turns.



11.7 Temperature sensor