Medium Voltage Products

eVM1
Installation and service instructions
12...17.5 kV - 630...1250 A - 16...31.5 kA

Index

Power and productivity
for a better world™

For your safety!

- Make sure that the installation room (spaces, divisions and ambient) is suitable for the electrical apparatus.
- Check that all the installation, putting into service and maintenance operations are carried out by qualified personnel with suitable knowledge of the apparatus.
- Make sure that the standard and legal prescriptions are complied with during installation, putting into service and maintenance, so that installations according to the rules of good working practice and safety in the workplace are constructed.
- Strictly follow the information given in this instruction manual.
- Check that the rated performance of the apparatus is not exceeded during service.
- Check that the personnel operating the apparatus have this instruction manual to hand as well as the necessary information for correct intervention.
- Pay special attention to the notes indicated in the manual. A note contains additional information worth noting in the specific context, and looks like the following:

⚠ Note

- Safety warning. The safety warnings should always be observed. Non-observance can result in death, personal injury or substantial damages to property. Guarantee claims might not be accepted when safety warnings are not respected. They look like the following:

STOP Warning!

Responsible behaviour
safeguards your own and others' safety!

For any requests, please contact the
ABB Assistance Service.

Index

I. Introduction

This publication contains the information needed to install medium voltage eVM1 (withdrawable version for UniGear ZS1 type switchgear and PowerCube modules) and put them into service.
For correct use of the product, please read it carefully.
Like all the apparatus we manufacture, the eVM1 circuit-breakers are designed for different installation configurations.
However, they do allow further technical and construction modifications (at the customer's request) to adapt to special installation requirements.
For this reason, the information given below may sometimes not contain instructions concerning special configurations.
Apart from this manual, it is therefore always necessary to consult the latest technical documentation (circuit and wiring diagrams, assembly and installation drawings, any protection coordination studies, etc.), especially regarding any variants requested in relation to the standardised configurations.
Only use original spare parts for maintenance operations.
For further information, please also see the technical catalogue of the circuit-breaker.

STOP **Warning!**

All the installation, putting into service, running and maintenance operations must be carried out by skilled personnel with in-depth knowledge of the apparatus.

II. Environmental protection programme

The eVM1 circuit-breakers are manufactured in accordance with the ISO 14000 Standards (Guidelines for environmental management).
The production processes are carried out in compliance with the Standards for environmental protection in terms of reduction in energy consumption as well as in raw materials and production of waste materials. All this is thanks to the medium voltage apparatus manufacturing facility environmental management system.

1. Packing and transport

The circuit-breaker is shipped in special packing, in the open position.
Each piece of apparatus is protected by a plastic cover to prevent any infiltration of water during the loading and unloading stages and to keep the dust off during storage.

2. Checking on receipt

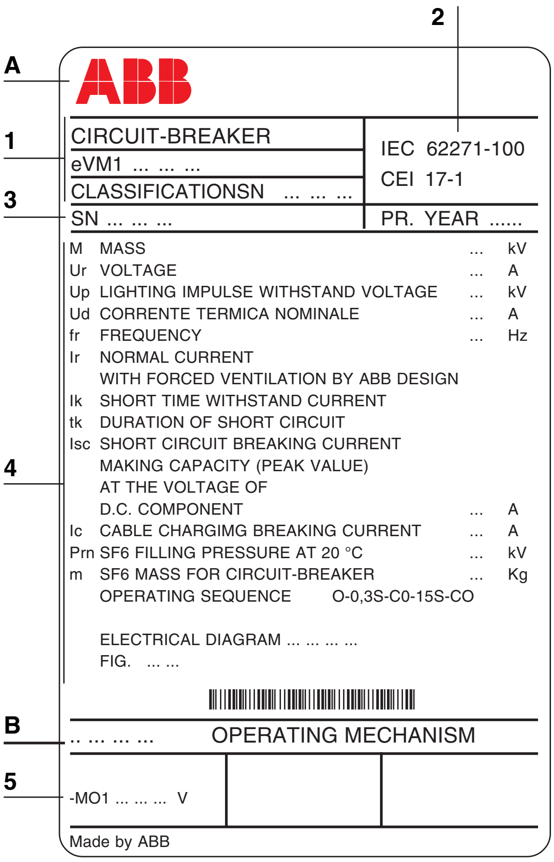
Before carrying out any operation, always make sure that the capacitors are discharged and that the apparatus is in the open position.

Warning!

On receipt, check the state of the apparatus, integrity of the packing and correspondence with the nameplate data (see fig. 1) with what is specified in the order confirmation and in the accompanying shipping notes.
Also make sure that all the materials described in the shipping notes are included in the supply.

Should any damage or irregularity be noted in the supply on unpacking, notify ABB (directly or through the agent or supplier) as soon as possible and in any case within five days of receipt.
The apparatus is only supplied with the accessories specified at the time of ordering and validated in the order confirmation sent by ABB.

The accompanying documents inserted in the shipping packing are:
– instruction manual (this document)
– test certification
– identification label
– copy of the shipping documents
– electric wiring diagram.
Other documents which are sent prior to shipment of the apparatus are:
– order confirmation
– original shipping advice notes
– any drawings or documents referring to special configurations/conditions.



Caption

A Circuit-breaker rating plate.
B Drive rating plate.
1 Type of apparatus.
2 Symbols of compliance with Standards.
3 Serial number.
4 Circuit-breaker characteristics.
5 Characteristics of the drive auxiliaries.

Fig. 1

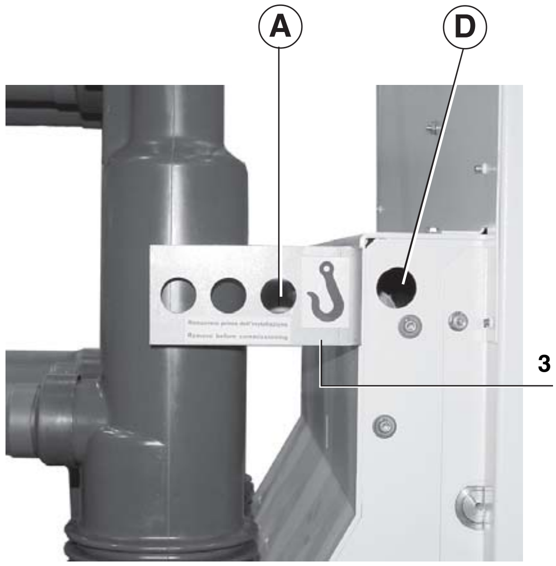
3. Storage

When a period of storage is foreseen, our workshops can (on request) provide suitable packing for the specified storage conditions.
On receipt the apparatus must be carefully unpacked and checked as described in Checking on receipt (chap. 2).
If immediate installation is not possible, the packing must be replaced, using the original material supplied.
Insert special hygroscopic substances inside the packing, using at least one standard packet per piece of apparatus.
Should the original packing not be available and immediate installation is not possible, store in a covered, well-ventilated, dry, dust-free, non-corrosive ambient, away from any flammable materials and at a temperature between –5 °C and +45 °C.
In any case, avoid any accidental impacts or positioning which stresses the structure of the apparatus.

4. Handling

Before carrying out any operations, always make sure that the capacitors are discharged.
To lift and handle the circuit-breaker, proceed as follows (fig. 2):
– use a special lifting tool (1) (not supplied) fitted with ropes with safety hooks (2);
– insert the hooks (2) in the supports (3) fixed to the frame of the circuit-breaker and lift. Latch the hooks (2) into the support holes (3) according to the type of apparatus (see table);
– on completion of the operation (and in any case before putting into service) unhook the lifting tool (1) and dismantle the supports (3) from the frame.

During handling, take great care not to stress the insulating parts and the terminals of the circuit-breaker.



Version	Pole centre distance	Rated current	Hole
Fixed	150 mm	up to 1250 A	**A**
Fixed	210 mm	up to 1250 A	**A**
Fixed	275 mm	up to 1250 A	**A**
Withdrawable	150 mm	up to 1250 A	**A**

Fig. 2

The apparatus must not be handled by putting lifting devices directly under the apparatus itself. Should it be necessary to use this technique, put the circuit-breaker onto a pallet or a sturdy supporting surface (see fig. 3).
In any case, it is always advisable to carry out lifting using the supports (3). Hole "D" must never be used.

Warning!

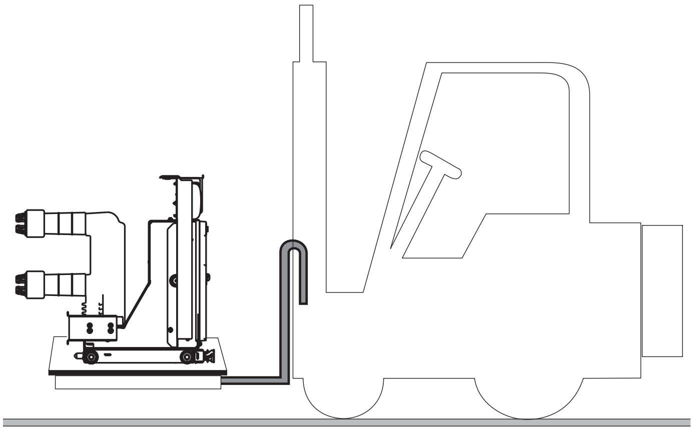


Fig. 3

5. Description

The eVM1/P type vacuum circuit-breakers are designed for indoor installation in air-insulated switchgear.
In respect of the technical characteristics, eVM1/P circuit-breakers are suitable for operation of electric circuits under normal and fault service conditions.
The vacuum circuit-breakers have particular advantages when used in systems with a high frequency of operations and/or which lead to a certain number of short-circuit trips.
The eVM1/P type vacuum circuit-breakers stand out for their particularly high operating reliability, extremely long useful life expectancy and for being completely maintenance-free.
The eVM1/P type vacuum circuit-breakers are available in the withdrawable version. Their basic structure is shown in the "Technical data" section.

5.1. Standards and regulations

5.1.1. Fabrication

The eVM1 circuit-breakers conform to the following Standards:
• VDE 0670, part 1000, and IEC 60694
• DIN VDE 0670, part 104, and IEC 62271-100
• DIN VDE 0847, part 4, and IEC 61000-4.

5.1.2. Installation and operation

For assembly and operation, please refer to the relative regulations, and in particular to:

- DIN VDE 0101, AC electrical plants with voltage higher than 1 kV
- DIN VDE 0100-410, Installation of electrical plants up to 1000 V, protective measures
- VDE 0105, Operation of electrical plants
- DIN VDE 0141, Earthing systems for special electrical plants with rated voltages higher than 1 kV
- Accident prevention regulations of insurance institutes against accidents at the workplace or of comparable organisations
- Safety directives for auxiliary and operating materials.

5.2. Service conditions

5.2.1. Normal service conditions

Follow the recommendations in the IEC 60694 and 62271-100 Standards. In more detail:

Ambient temperature

Maximum	+ 40 °C
Average maximum over 24 hours	+ 35 °C
Minimum (according to class – 5), apparatus for indoor installation	– 5°

Humidity

The average value of the relative humidity, measured for a period longer than 24 hours, must not exceed 95 %.
The average value of the pressure of the water vapour without condensation, measured for a period longer than 24 hours, must not exceed 2.2 kPa.
The average value of the relative humidity, measured for a period longer than 1 month, must not exceed 90 %.
The average value of the pressure of the water vapour, measured for a period longer than 1 month, must not exceed 1.8 kPa.

Altitude

< 1000 m above sea level.

5.2.2. Special service conditions

Installations over 1000 m a.s.l.

Possible within the limits permitted by reduction of the dielectric resistance of the air.

Increase in the ambient temperature

Reduction in the rated current.
Encourage heat dissipation with appropriate additional ventilation.

Climate

To avoid the risk of corrosion or other damage in areas with a high level of humidity, and/or rapid and large temperature variations, take appropriate steps (for example, by using suitable electric heaters) to prevent condensation phenomena.

For special installation requirements or other operating conditions, please contact ABB.

6. Structure

6.1. Drive structure

The drive is of the magnetic type and basically consists of the magnetic actuator (8) (fig. 4), the control module (10), the current sensors (3), the capacitor/s (2) and the kinematics which transmit the movement to the circuit-breaker poles.

The actuator (8) acts on the circuit-breaker poles by means of special kinematics. The capacitor/s (2) provides/provide the energy required for the operation.

The mechanical operating positions of the circuit-breaker are detected by two due sensors (14).

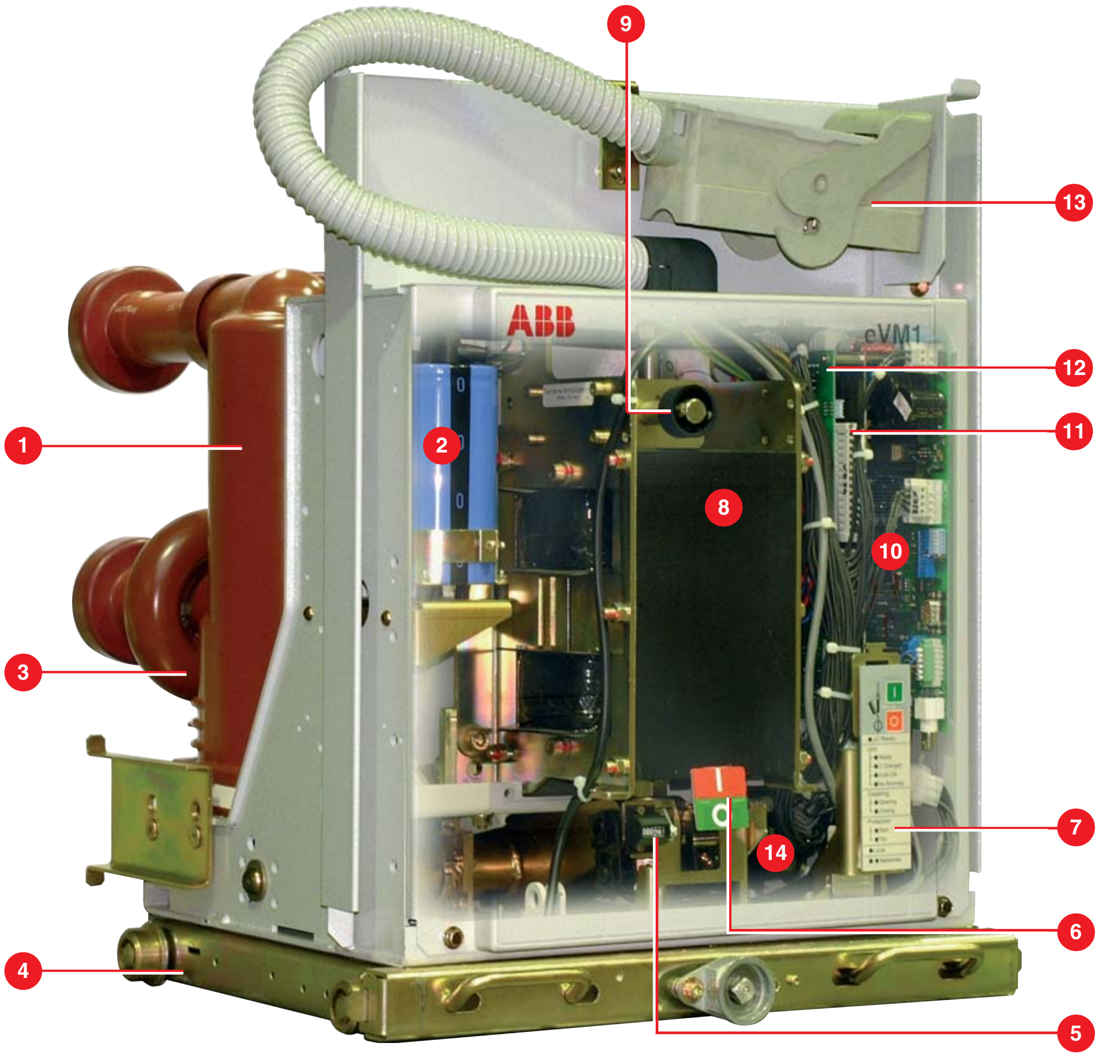
The basic version of the circuit-breaker is fitted with the following controls and instruments:

- coupling for manual emergency operation (9)
- mechanical state indicator (6)
- mechanical operation counter (5)
- control panel (7) with opening and closing pushbuttons.

6.1.1. Structure of the control module

The control module (10) of the circuit-breaker consists of:

- a microprocessor
- opto-electrical input couplers
- output relay
- electronic power system for controlling the actuator coils.



1 Pole: vacuum interrupter embedded in epoxy resin
2 Capacitor
3 Current sensor (Rogowski coil)
4 Truck of withdrawable circuit-breaker
5 Operation counter
6 Mechanical Open/Closed signalling device
7 Control panel
8 Magnetic drive
9 Coupling for emergency manual operating lever
10 Protection and control unit
11 Binary inputs/outputs
12 Communication
13 Socket for auxiliary circuits
14 Position Open/Closed sensors

Fig. 4

6.1.2. Capacitor

The energy for operating the circuit-breaker is stored in one or two capacitors according to the circuit-breaker model (fig. 5).

The capacitors are designed so that the energy for an O-C-O operating cycle is supplied without the need for recharging.

The energy stored by the capacitor is constantly monitored by means of measuring the relevant voltage.

The “UNIT READY” indication signals application of the power supply voltage and the “ready” state of the circuit-breaker for the next operation.

The energy stored in the capacitors determines the position of the READY/NOT READY contacts and lighting up of the luminous “UNIT READY” signal according to the following criteria:

- Case 1: circuit-breaker in the open position.
  - The energy available is sufficient for one closing and opening operation.
- Case 2: circuit-breaker in the closed position.
  - The energy available is sufficient for one opening operation.
  - The energy available is sufficient for one opening operation within about 30 seconds from interruption of the auxiliary power supply.

If the energy stored is not sufficient, the luminous “UNIT READY” signal is off, the “READY” contact is open and the “NOT READY” contact is closed to indicate that the circuit-breaker is not ready for the operation.

6.1.3. Position sensors

The use of two inductive position sensors (fig. 6) allows the state of the circuit-breaker (open - closed - anomalous intermediate position) to be determined without the use of auxiliary contacts, allowing continual monitoring of the system.

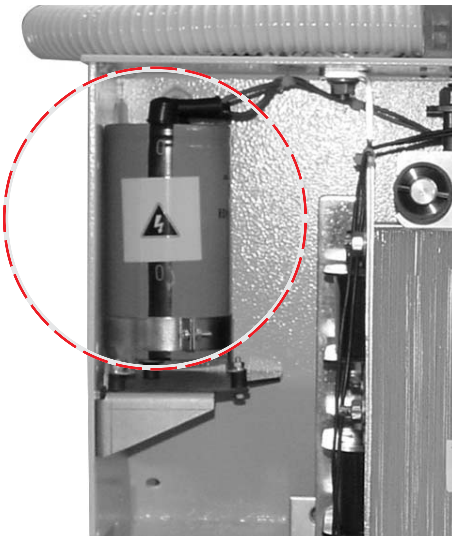


Fig. 5

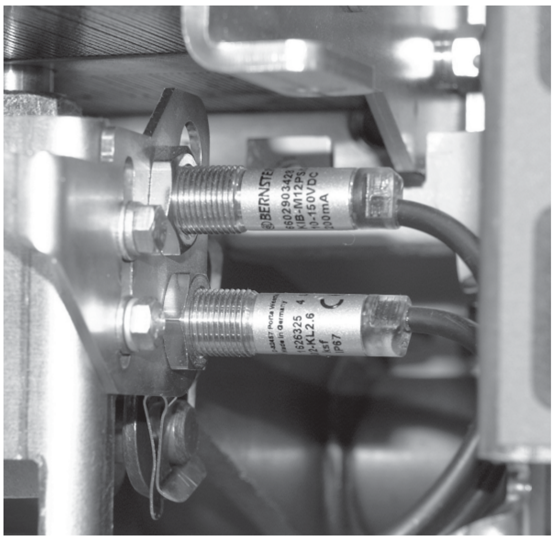


Fig. 6

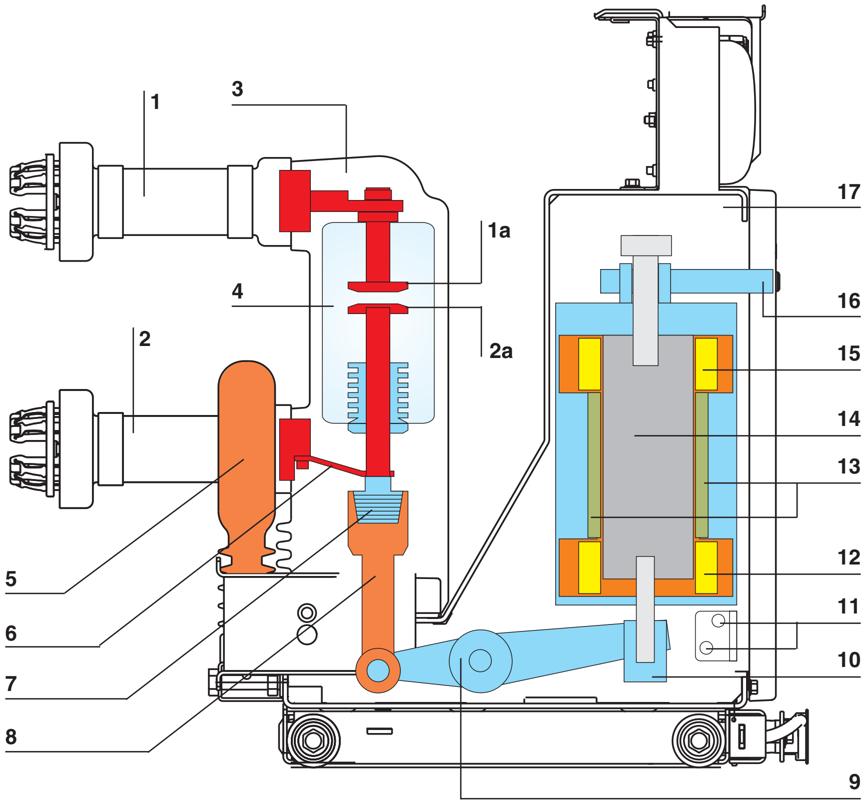
6.2. Structure of the circuit-breaker poles

The poles are installed in the rear part of the circuit-breaker frame (fig. 7).

The active parts of the poles (vacuum interrupters) are embedded in epoxy resin and protected against shocks and other external agents.

With the circuit-breaker closed, the current flows from the top terminal (1) to the fixed contact (1a) in the vacuum interrupter (4), and then through the moving contact (2a) and the flexible connector (6) as far as the bottom terminal of the circuit-breaker (2).

The movement of the moving contact are ensured by the insulating tie-rod (8) and by the kinematics (9).



1 Top terminal
1a Fixed contact
2 Bottom terminal
2a Moving contact
3 Pole in resin
4 Vacuum interrupter
5 Current sensor
6 Flexible connector
7 Contact pressure spring
8 Insulating tie-rod
9 Drive shaft
10 Run regulator
11 Position sensors
12 Closing coil
13 Permanent magnets
14 Moving armature
15 Opening coil
16 Device for manual emergency opening
17 Supporting structure

Fig. 7

6.3. Basic structure of the withdrawable circuit-breaker

The withdrawable truck (4) (fig. 8), either manual or motorised, consists of a steel sheet structure with wheels (3), on which the circuit-breaker with the relative auxiliary components, the isolating contacts (2) for electrical connection with the switchgear and the multi-pole connector (1) for connection of the circuit-breaker auxiliary circuits are installed.
After having been racked into the switchgear and hooked up, the withdrawable circuit-breaker can take up the following positions: racked-out, isolated for test (with connector inserted) and racked-in. The racked-in circuit-breaker is automatically earthed by means of the truck wheels.
The magnetic actuator of the circuit-breaker and the relative controls and indicators, are accessible from the front.
Withdrawable circuit-breakers of the same type and characteristics are interchangeable. However, the code of the connector prevents incorrect combinations between the circuit-breaker and switchgear.

Fig. 8

7. Operation

7.1. Operation of the circuit-breaker drive

7.1.1. Magnetic actuator

The magnetic actuator used in the eVM1 circuit-breakers generates the run required to operate the moving contacts of the interrupters and integrates all the functions of a traditional operating mechanism.
The magnetic actuator is a bistable system where end-of-run positions of the moving armature are reached by means of magnetic fields generated by two coils (one for closing and one for opening).
The moving armature is kept in position by permanent magnets.
The circuit-breaker operations are obtained by means of energisation of the opening or closing coil respectively. The magnetic field generated by each coil attracts the moving armature and thereby moves it from one of the latching points of the permanent magnets to the other.

The capacitors which allow circuit-breaker operation, for a maximum time of about 30 seconds (with closed circuit-breaker), even in the case of a drop in the auxiliary voltage, are provided in the control circuit. In case of emergency, the circuit-breaker can in any case be opened by means of a special crank handle which acts directly on the moving armature of the drive.
Compared to a traditional operating mechanism, the magnetic actuator has few moving parts and greatly reduced wear even after a high number of closing and opening cycles.
These characteristics therefore make it practically maintenance-free.

7.1.2. Opening and closing operations

The opening and closing operations can either be remotely controlled by means of the special inputs provided in the control module, or locally by pressing the pushbuttons on the control panel (7) (fig. 4).
During the operations, the moving armature of the actuator acts directly on the moving contact by means of the kinematics (8-9-10) (fig. 7).

7.1.3. Reclosing function

Thanks to the short duration of capacitor recharging, the drive is suitable for multiple reclosing operations with O-0.3s-CO-15s-CO cycle.

7.1.4. Control module functions

All the conditions for controlling the opening and closing commands given to the magnetic actuator are managed by a microprocessor:
- The power supply voltage must be applied to the AC/DC converter.
- The capacitor must be sufficiently charged for the next operation:

Circuit-breaker position	Operations
Open	Closes and Opens
Closed	Opens

Magnetic latching in end-of-run position.
Magnetic latching and action of the magnetic field of a coil.
Moving armature in opposing position and magnetic end-of-run latching.

- The closing coil can only be activated when the circuit-breaker is open
- The opening coil can only be activated when the circuit-breaker is closed
- Closing is disabled when an opening command is active at the same time
- De-activation of the opening or closing coil takes place when the relative limit position has been reached.
- WRONG POSITION (auto trip) function: if the final CLOSED (or OPEN) position is not reached within 70 ms during a closing (or opening) operation, an opening operation is immediately started to guarantee reaching a defined safe position in any case.
- The anti-pumping function ensures that only one closing-opening cycle is carried out when a closing command followed by an opening command is active. The active closing command must be cancelled and reset for the next closing operation.
- Activation of the input for the closing command can be locked by means of an external locking signal.
- The input for the “lock on closing” command must be energised to be able to close the circuit-breaker (without power it inhibits closing).

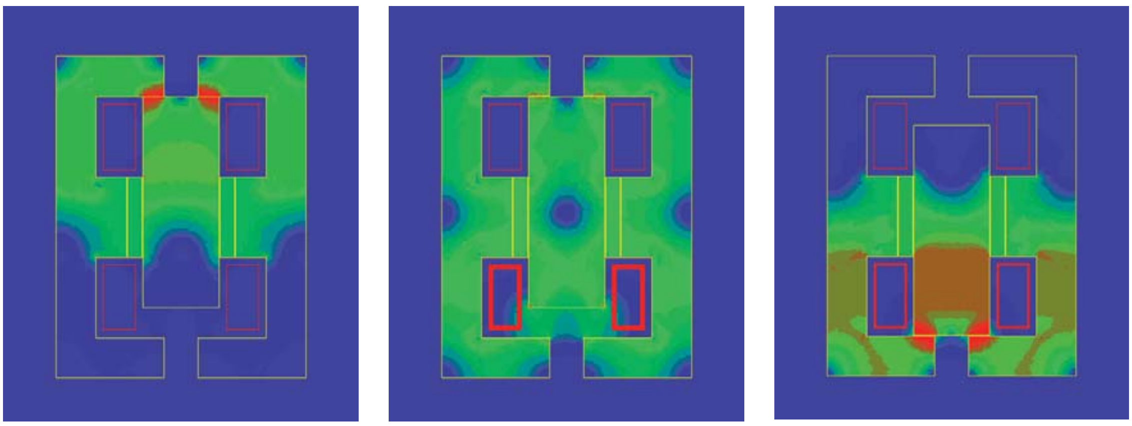
- Undervoltage function: controls circuit-breaker opening if the applied voltage drops below the tolerance limit (established by the Standards).
  To prevent the function intervening when the voltage drops below the specified level (e.g. in the case of motor starting), it is possible to set a trip time.
  The undervoltage function is normally disabled. In this case, it is possible to open and close the circuit-breaker without applying voltage to the input of the function.
- Monitoring function of the actuator closing and opening coil. This function serves to monitor the continuity of the closing and opening coils of the magnetic actuator to detect any faults.
  If a fault is detected, the luminous "COILS OK" signal on front of the circuit-breaker turns off and the "READY/NOT READY" signalling contacts are commutated.
- Additional safety opening command function. The second input of the control module for the opening function is designed so that an opening command is carried out directly even in the case of a fault in the microprocessor.

7.1.5. Truck locking magnet

The locking magnet is inserted in withdrawable circuit-breakers with manual movement and prevents traverse of the withdrawable truck when there is no power supply voltage. It is also linked to the interlock between circuit-breaker closed and truck: it guarantees that even in a situation with main welded contacts, the circuit-breaker cannot be isolated.

7.2. Principle of extinction of the vacuum interrupter

Given the relatively low static pressure of the interruption chamber (between 10^{-4} and 10^{-8} hPa), a relatively limited distance between the contacts is required to obtain high dielectric strength. The vacuum arc is extinguished on the first passage of the current through natural zero.
Considering the limited distance between the contacts, the high conductivity of the plasma of metallic vapours, the drop in voltage of the arc and, moreover, the short arcing time, the energy associated with the arc is extremely limited, therefore producing benefits for the useful life of the contacts obtained and, consequently, for the useful life of the vacuum interrupters.



Magnetic latching in end-of-run position.

Magnetic latching and action of the magnetic field of a coil.

Moving armature in opposing position and magnetic end-of-run latching.

Fig. 9

7.3. Interlocks

7.3.1. Interlocks / protection against malfunction (for withdrawable circuit-breakers for UniGear ZS1 type switchgear and PowerCube modules)

A series of interlocks is provided to prevent incorrect operations and/or malfunctions. The interlocks are the following:

- the withdrawable truck can only be moved from the test/isolated position to the service position (and vice versa) if the circuit-breaker is open (this means that first of all the circuit-breaker must be opened).
- the circuit-breaker can be closed if the withdrawable truck is exactly in the defined test position or in the service position (electric interlock).
- the circuit-breaker can be opened manually in the service or test position when it is not powered, but it cannot be closed.
- the switchgear is provided with devices which only allow connection and disconnection of the plug connector (1) (fig. 10) in the test/isolation position.

Any detailed information regarding additional interlocks, e.g. with the earthing switch operating mechanism, is given in the specific order documentation.

7.3.2. Interlocks in the case where withdrawable trucks are used UniGear ZS1 type switchgear and PowerCube modules

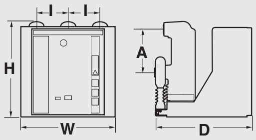
1) There is the possibility of configuring a binary input and relative function to allow the lock on circuit-breaker closing when a voltage of 24 V - 240 V a.c./d.c. is applied to the input (electric closing lock).
2) The eVM1/P circuit-breaker can only be closed when the withdrawable truck is in the test or service position. In intermediate positions the closing lock voltage is cut off by the auxiliary contacts of the truck.
3) A mechanical interlock positioned on the withdrawable truck prevents a closed circuit-breaker being moved from the test position to the service position.

Fig. 10

8. Circuit-breaker characteristics

8.1. General characteristics of fixed circuit-breakers

Fig. 11a

Circuit-breaker		eVM1 12			eVM1 17		
Standards	**IEC 60694 - 62271-100**	■			■		
	CEI 17-1 (File 1375)	■			■		
Rated voltage	**Ur** [kV]	12			17		
Rated insulation voltage	**Us** [kV]	12			17		
Withstand voltage at 50 Hz	**Ud (1 min)** [kV]	28			38		
Impulse withstand voltage	**Up** [kV]	75			95		
Rated frequency	**fr** [Hz]	50-60			50-60		
Rated normal current (40 °C)	(1) **Ir** [A]	630	1250		630	1250	
Rated breaking capacity	**Isc** [kA]	16	16		16	16	
(rated symmetrical short-circuit current)		20	20		20	20	
		25	25		25	25	
		31,5	31,5		31,5	31,5	
Rated short-time withstand current (3 s)	**Ik** [kA]	16	16		16	16	
		20	20		20	20	
		25	25		25	25	
		31,5	31,5		31,5	31,5	
Making capacity	**Ip** [kA]	40	40		40	40	
		50	50		50	50	
		63	63		63	63	
		80	80		80	80	
Operation sequence	[O-0,3s-CO-15s-CO]	■			■		
Opening time	[ms]	33			33		
Arcing time	[ms]	10...15			10...15		
Total interruption time	[ms]	43...48			43...48		
Closing time	[ms]	50			50		
Mechanical operations (cycles)	Actuator [No.]	... 100.000			... 100.000		
	Interrupters [No.]	... 30.000			... 30.000		
Electrical operations (cycles)	At rated current [No.]	... 30.000			... 30.000		
	Under short-circuit [No.]	... 100			... 100		
Maximum overall dimensions 	**H** [mm]	461	461	461	461	461	461
	W [mm]	450	570	700	450	570	700
	D [mm]	464	464	464	464	464	464
Pole centre distance	**I** [mm]	150	210	275	150	210	275
Bottom/top terminal distance	**A** [mm]	205	205	205	205	205	205
Weight	[kg]	106 ... 117			106 ... 117		
Consumption on stand-by	[W]	≤ 15			≤ 15		
Consumption after a self-closing cycle	[W]	≤ 110			≤ 110		
Standardised table of dimensions	[°C]	– 5 ... + 40			– 5 ... + 40		
Operating temperature	**IEC 61000**	■			■		
Electromagnetic compatibility	**IEC 60255**	■			■		

8.1.1. Types of circuit-breakers

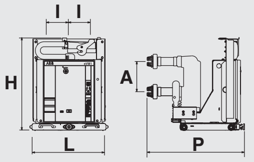
Ur [kV]	Ir (40°C) [A]	Isc [kA]	Dimensions L [mm]	I [mm]	A [mm]	Type of circuit-breaker
12	630	16	450	150	205	eVM1 12.06.16 p150
	630	20	450	150	205	eVM1 12.06.20 p150
	630	25	450	150	205	eVM1 12.06.25 p150
	630	31,5	450	150	205	eVM1 12.06.32 p150
	1250	16	450	150	205	eVM1 12.12.16 p150
	1250	20	450	150	205	eVM1 12.12.20 p150
	1250	25	450	150	205	eVM1 12.12.25 p150
	1250	31,5	450	150	205	eVM1 12.12.32 p150
12	630	16	570	210	205	eVM1 12.06.16 p210
	630	20	570	210	205	eVM1 12.06.20 p210
	630	25	570	210	205	eVM1 12.06.25 p210
	630	31,5	570	210	205	eVM1 12.06.32 p210
	1250	16	570	210	205	eVM1 12.12.16 p210
	1250	20	570	210	205	eVM1 12.12.20 p210
	1250	25	570	210	205	eVM1 12.12.25 p210
	1250	31,5	570	210	205	eVM1 12.12.32 p210
12	630	16	700	275	205	eVM1 12.06.16 p275
	630	20	700	275	205	eVM1 12.06.20 p275
	630	25	700	275	205	eVM1 12.06.25 p275
	630	31,5	700	275	205	eVM1 12.06.32 p275
	1250	16	700	275	205	eVM1 12.12.16 p275
	1250	20	700	275	205	eVM1 12.12.20 p275
	1250	25	700	275	205	eVM1 12.12.25 p275
	1250	31,5	700	275	205	eVM1 12.12.32 p275
17,5	630	16	450	150	205	eVM1 17.06.16 p150
	630	20	450	150	205	eVM1 17.06.20 p150
	630	25	450	150	205	eVM1 17.06.25 p150
	630	31,5	450	150	205	eVM1 17.06.32 p150
	1250	16	450	150	205	eVM1 17.12.16 p150
	1250	20	450	150	205	eVM1 17.12.20 p150
	1250	25	450	150	205	eVM1 17.12.25 p150
	1250	31,5	450	150	205	eVM1 17.12.32 p150
17,5	630	16	570	210	205	eVM1 17.06.16 p210
	630	20	570	210	205	eVM1 17.06.20 p210
	630	25	570	210	205	eVM1 17.06.25 p210
	630	31,5	570	210	205	eVM1 17.06.32 p210
	1250	16	570	210	205	eVM1 17.12.16 p210
	1250	20	570	210	205	eVM1 17.12.20 p210
	1250	25	570	210	205	eVM1 17.12.25 p210
	1250	31,5	570	210	205	eVM1 17.12.32 p210
17,5	630	16	700	275	205	eVM1 17.06.16 p275
	630	20	700	275	205	eVM1 17.06.20 p275
	630	25	700	275	205	eVM1 17.06.25 p275
	630	31,5	700	275	205	eVM1 17.06.32 p275
	1250	16	700	275	205	eVM1 17.12.16 p275
	1250	20	700	275	205	eVM1 17.12.20 p275
	1250	25	700	275	205	eVM1 17.12.25 p275
	1250	31,5	700	275	205	eVM1 17.12.32 p275

Note

L = Width of circuit-breaker.
I = Horizontal poles center lines.
A = Upper and lower distance.

8.2. General characteristics of circuit-breakers for UniGear type ZS1 switchgear and PowerCube modules

Fig. 11b

Circuit-breaker		eVM1/P 12		eVM1/P 17	
Standards	**IEC 60694 - 62271-100**	■		■	
	CEI 17-1 (Fasc. 1375)	■		■	
Rated voltage	**Ur** [kV]	12		17	
Rated insulation voltage	**Us** [kV]	12		17	
Withstand voltage at 50 Hz	**Ud (1 min)** [kV]	28		38	
Impulse withstand voltage	**Up** [kV]	75		95	
Rated frequency	**fr** [Hz]	50-60		50-60	
Rated normal current (40 °C)	(1) **Ir** [A]	630	1250	630	1250
Rated breaking capacity	**Isc** [kA]	16	16	16	16
(rated symmetrical short-circuit current)		20	20	20	20
		25	25	25	25
		31,5	31,5	31,5	31,5
Rated short-time withstand current (3 s)	**Ik** [kA]	16	16	16	16
		20	20	20	20
		25	25	25	25
		31,5	31,5	31,5	31,5
Making capacity	**Ip** [kA]	40	40	40	40
		50	50	50	50
		63	63	63	63
		80	80	80	80
Operation sequence	[O-0,3s-CO-15s-CO]	■		■	
Opening time	[ms]	33		33	
Arcing time	[ms]	10...15		10...15	
Total interruption time	[ms]	43...48		43...48	
Closing time	[ms]	50		50	
Mechanical operations (cycles)	Actuator [No.]	... 100.000		... 100.000	
	Interrupters [No.]	... 30.000		... 30.000	
Electrical operations (cycles)	At rated current [No.]	... 30.000		... 30.000	
	Under short-circuit [No.]	... 100		... 100	
Maximum overall dimensions 	**H** [mm]	628	628	628	628
	L [mm]	503	503	503	503
	P [mm]	662	662	662	662
Pole centre distance	**I** [mm]	150	150	150	150
Bottom/top terminal distance	**A** [mm]	205	205	205	205
Weight	[kg]	126 ... 137		126 ... 137	
Consumption on stand-by	[W]	≤ 15		≤ 15	
Consumption after a self-closing cycle	[W]	≤ 110		≤ 110	
Standardised table of dimensions	[°C]	– 5 ... + 40		– 5 ... + 40	
Operating temperature	**IEC 61000**	■		■	
Electromagnetic compatibility	**IEC 60255**	■		■	

(1) Rated uninterrupted currents guaranteed with withdrawable circuit-breaker installed in UniGear ZS1 type switchgear with air temperature of 40 °C.

8.2.1. Withdrawable circuit-breakers for UniGear type ZS1 switchgear and PowerCube modules

Complete the circuit-breaker selected with the accessories indicated in para. 8.4.

Ur [kV]	Ir (40°C) [A]	Isc [kA]	Dimensions L [mm]	I [mm]	A [mm]	ø [mm]	Type of circuit-breaker
12	630	16	650	150	205	35	eVM1/P 12.06.16 p150
	630	20	450	150	205	35	eVM1/P 12.06.20 p150
	630	25	450	150	205	35	eVM1/P 12.06.25 p150
	630	31,5	450	150	205	35	eVM1/P 12.06.32 p150
	1250	16	450	150	205	35	eVM1/P 12.12.16 p150
	1250	20	450	150	205	35	eVM1/P 12.12.20 p150
	1250	25	450	150	205	35	eVM1/P 12.12.25 p150
	1250	31,5	450	150	205	35	eVM1/P 12.12.32 p150
17,5	630	16	450	150	205	35	eVM1/P 17.06.16 p150
	630	20	450	150	205	35	eVM1/P 17.06.20 p150
	630	25	450	150	205	35	eVM1/P 17.06.25 p150
	630	31,5	450	150	205	35	eVM1/P 17.06.32 p150
	1250	16	450	150	205	35	eVM1/P 17.12.16 p150
	1250	20	450	150	205	35	eVM1/P 17.12.20 p150
	1250	25	450	150	205	35	eVM1/P 17.12.25 p150
	1250	31,5	450	150	205	35	eVM1/P 17.12.32 p150

Notes
L = Width of circuit-breaker.
I = Horizontal poles center lines.
A = Upper and lower distance.
ø = Diameter of the isolating contact.

8.3. Control circuit power supply

The energy for circuit-breaker operation is supplied by one or more capacitors which are kept charged by a feeder which also sees to supplying the electronic circuit with power.
This guarantees correct operation even if the auxiliary power supply does not reach the rated value.
Thanks to the use of low consumption components, the feeder consumption is about 15 watt with the circuit-breaker either closed or open.
After each operation, the feeder consumes about 110 watt for a few seconds to restore the optimal charging level of the capacitors.
The charging condition of the capacitors is monitored constantly by the electronic module which also sees to the opening, closing, signalling, etc. functions.
Two feeders are available:
type 1: 24...48 V a.c. / 24...60 V d.c.
type 2: 100...240 V a.c. / 110...250 V d.c.

8.4. Standard fittings

The basic versions of the withdrawable circuit-breakers are three-pole and fitted with:

– closing pushbutton (integrated in the control panel -PI1)
– opening pushbutton (integrated in the control panel -PI1)
– mechanical operation counter
– mechanical signalling device for circuit-breaker open/closed
– manual emergency opening device
– lever for manual emergency opening (the quantity must be defined according to the number of pieces of apparatus ordered)
– “READY” for operation signal, together with a further 11 luminous diagnostic signals on the local interface of the circuit-breaker
– one or more capacitors for energy storage for the operation
– mobile connector for direct connection to the sockets of the electronic module, for cabling the auxiliary circuits
– basic version control module with protections I> - I>> - I0> - I0>> (51-50-51N-50N)
– software for configuration of the protections, control, communication (if provided) and display of the states
– Transmitted contacts in the truck (-BT1; -BT2).

Basic version control module

The control module has 16 digital inputs and 16 digital outputs which can mostly be programmed freely, in accordance with the plant requirements by means of the configuration software.
To assign all the application meanings of the circuit-breaker, please refer to the 1VCD400060 schematic drawings.
Among the fixed inputs which cannot be programmed are:

– input for the undervoltage function
– remote opening and closing commands
– disabling the opening operation
– circuit-breaker in service
– circuit-breaker under test.
– hardware only second opening of the circuit-breaker for maximum reliability.

Among the fixed outputs which cannot be programmed are:

– circuit-breaker closed and open
– unit ready signal for –RL2 (locking magnetic on the truck)
– monitoring signal.

All the remaining inputs and outputs are mapped according to established meanings if one of the four default application diagrams is selected (withdrawable circuit-breaker, withdrawable with earthing switch, fixed, fixed with earthing switch) by means of the software configurator, whereas by ticking the ‘free’ diagram, it is possible to assign all the meanings available to the digitial inputs/outputs (see Input / Output Mapping chapter).
For example:

– earthing switch position, open and closed
– functional interlocks
– local – remote control enabling keys
– resetting trip of protections
– local circuit-breaker closing and opening command

And for the outputs:

– circuit-breaker in service or under test
– protection tripped
– functional interlocks
– protections under timing (start)
– circuit-breaker opened by opening protection commands (transient contact closed for 100 ms)

– opening and closing operations disabled.
The meanings of the inputs and outputs can be programmed several times with the same function, for example, three outputs to indicate the open position of the circuit-breaker.
The binary inputs can be supplied as follows:
- 24 ... 240 V AC (tolerance – 15% ... + 10%)
- 24 ... 250 V DC (tolerance – 30% ... + 10%).

The minimum impulse time for it to be considered valid is about 10 ms.
The functions carried out by the control module are:
– self-opening following detection of incorrect circuit-breaker state
– self-locking following capacitor charge threshold below the minimum value required for the opening and closing operation, self-opening if the conditions persists (Energy Failure Autotrip)
– anti-pumping relay function
– trip-free function control of the capacitor charging voltage with auto shut-down of the feeder if the maximum charging level is exceeded
– opening for undervoltage with selection of the rated reference voltage and with possibility of delaying opening from 0 to 5 s (-SO4).
– self-protection of the electronic power circuit with auto shut-down of the feeder in the case of overtemperature and/or overcurrent
– control of opening and closing coil continuity
– watchdog (DO16).

8.5. Optional accessories

The accessories identified with the same number are alternative to each other.

1 - Interface for panel (HMI)

The interface allows the control and protection device incorporated in the eVM1 circuit-breaker to be managed from the low voltage compartment door of the unit.

2 - Extended set of protections

Apart from the following basic protections (ref. IEC 60255-3 and IEC 60255-8):
– 51 Overcurrent IDMT (NI, VI, EI, LI)
– 50 Overcurrent DT1
– 50 Overcurrent DT2
– 51N Earth fault IDMT
– 50N Earth fault DT1
– 50N Earth fault DT2
the extended set of protections also makes the following available:
– 51MS Motor starting protection
– 66 Number of start-ups
– 51LR Locked rotor
– 49 Thermal overload
– 46 Unbalanced load.
The protections can be enabled/disabled locally by means of an RS485 port (local) or by the panel interface with IRDA connector by means of the configuration software.

3 - Fast capacitor discharging device (see para. 14.15).

Device which allows the circuit-breaker capacities to be discharged rapidly and safely.

4 - Cable for configuring eVM1 by means of HMI with RS232 – IRDA connection (see para. 14.10)**.**

Cable which allows the personal computer to be connected to the interface for the HMI panel to configure the eVM1.

5 - Connection cable Kit for configuring the eVM1 when there is no HMI (see para. 14.10).

Kit which makes it possible to have an RS485 port in the low voltage compartment of the panel to connect the personal computer to in those cases where there is no HMI.

6 - eVM1 RS232/USB – RS485 configuration cable (see para. 14.10).

Cable which allows the personal computer to be connected to the RS485 port prepared in the low voltage compartment of the panel to configure the eVM1.

9. Installation

9.1. General

Correct installation is of prime importance. The manufacturer's instructions must be carefully studied and followed. It is good practice to use gloves to handle the pieces during installation.
The areas involved by the passage of power conductors or conductors of auxiliary circuits must be protected against access of any animals which might cause damage or disservices.

9.2. Trip curves

The following graphs show the number of closing-opening cycles (No.) allowed, of the vacuum interrupters, according to the breaking capacity (Ia).

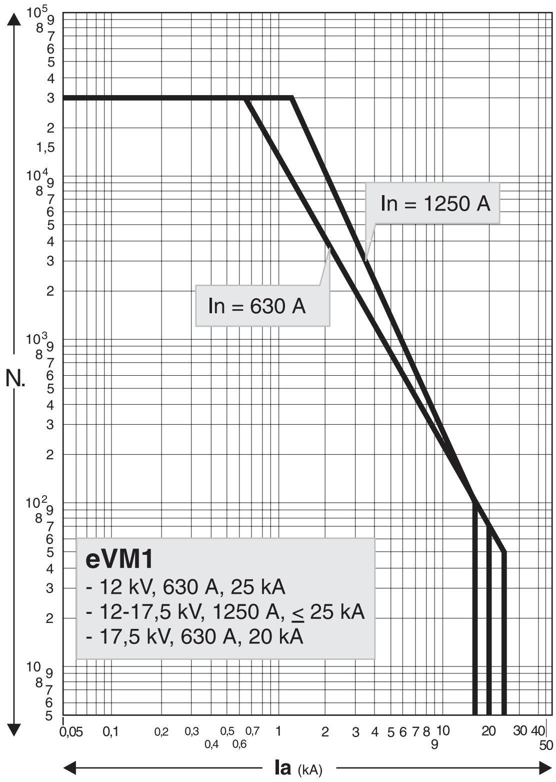


Fig. 12b

Warning!

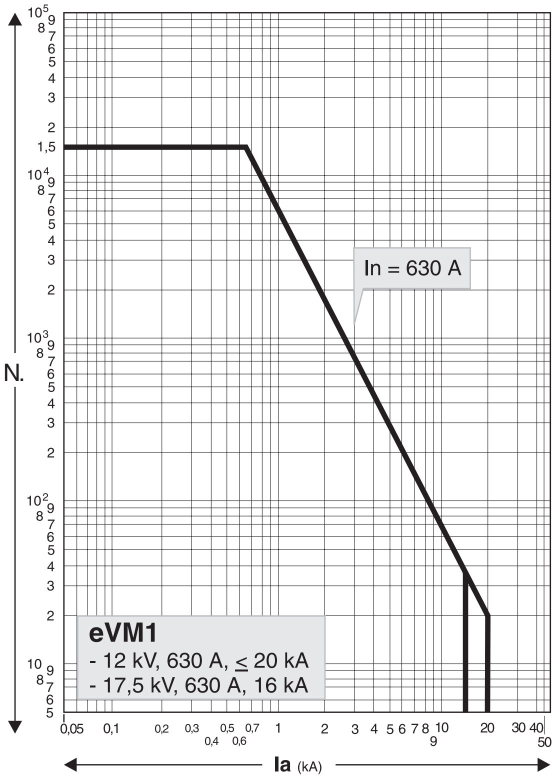


Fig. 12a

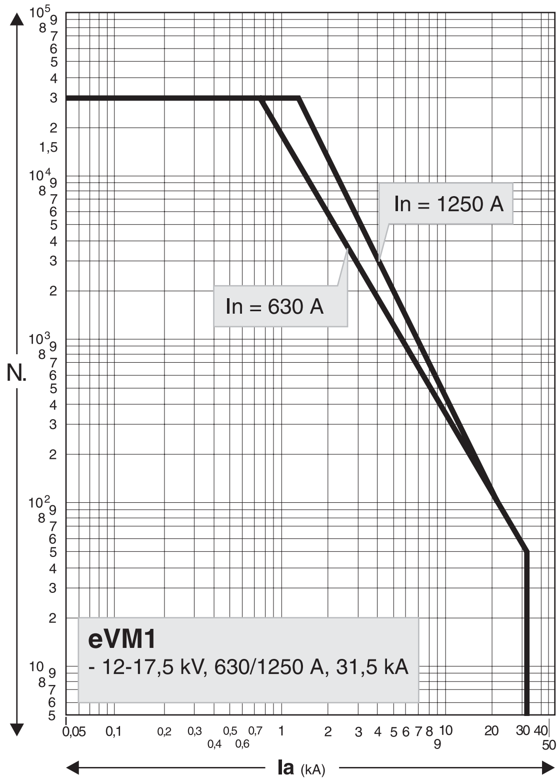


Fig. 12c

Caption

No. Number of closing-opening cycles allowed for the vacuum interrupters.

Ia Breaking capacity of the vacuum interrupters.

9.3. Preliminary operations

– Clean the insulating parts with clean dry cloths.
– Check that the top and bottom terminals are clean and free of any deformation caused by shocks received during transport or storage.

9.4. Installation of fixed circuit-breakers

The circuit-breaker can be mounted directly onsupporting frames to be provided by the cus-tomer, or on a special supporting truck (avail-able on request).The circuit-breaker, with supporting truck, mustbe suitably fixed to the floor of its own compart-ment by the customer. The floor surface in corre-spondence with the truck wheels must be care-fully levelled.A minimum degree of protection (IP2X) must beguaranteed from the front towards live parts.

9.5. Installation of withdrawable circuit-breakers

The withdrawable circuit-breakers are preset for use in UniGear ZS1 type switchgear and PowerCube modules.
For racking-in/racking-out of the switchgear: connect the auxiliary circuits thereby supplying the locking electromagnet in the truck, fully insert the crank handle (1) (fig. 13) in the appropriate seat (2) and work it clockwise for racking-in, and anti-clockwise for racking-out, until the end-of-run positions are reached.
Circuit-breaker racking-in/-out must be carried out gradually to avoid shocks which may deform the mechanical interlocks and the end-of-runs.
The torque normally required to carry out racking-in and racking-out is <25 Nm.
This value must not be exceeded. If operations are prevented or difficult, do not force them and check that the operating sequence is correct.

Note

To complete the racking-in/out operation, about 20 turns of the crank handle are required for circuit-breakers up to 17.5 kV. When the circuit-breaker has reached the isolated for test/isolated position it can be considered as racked into the switchgear and, at the same time, earthed by means of the truck wheels. Withdrawable circuit-breakers of the same version, and therefore with the same dimensions, are interchangeable.

For the circuit-breaker installation operations, also refer to the technical documentation of the above-mentioned switchgear.

Warning!

The racking-in/-out operations must always be carried out with the circuit-breaker open.

9.6. Auxiliary circuits

The auxiliary circuits of withdrawable circuit-breakers are fully cabled in the factory as far as the multi-pole connector (fig. 14). For the external connections, refer to the electric wiring diagram of the switchgear.

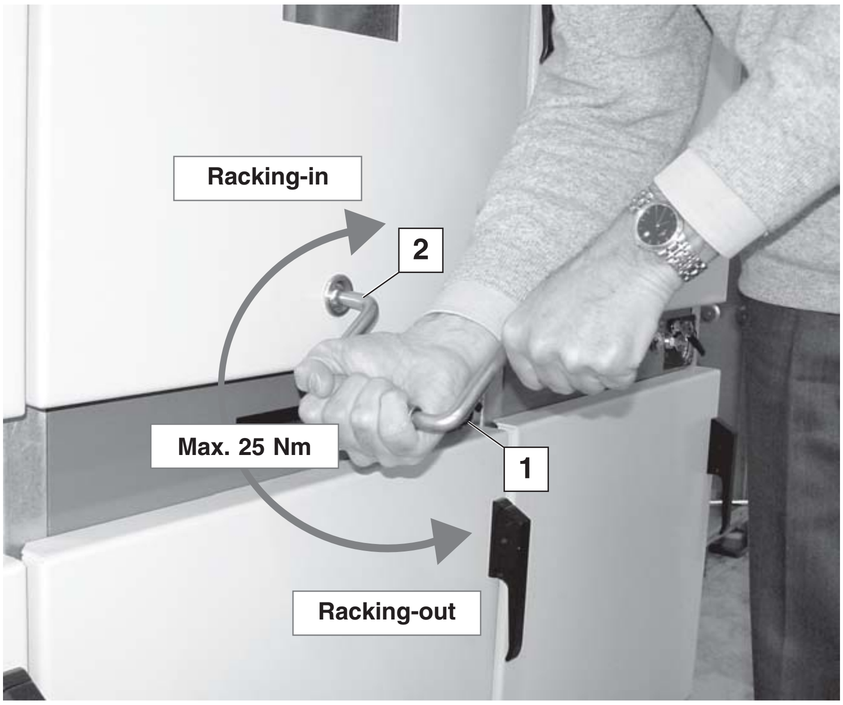
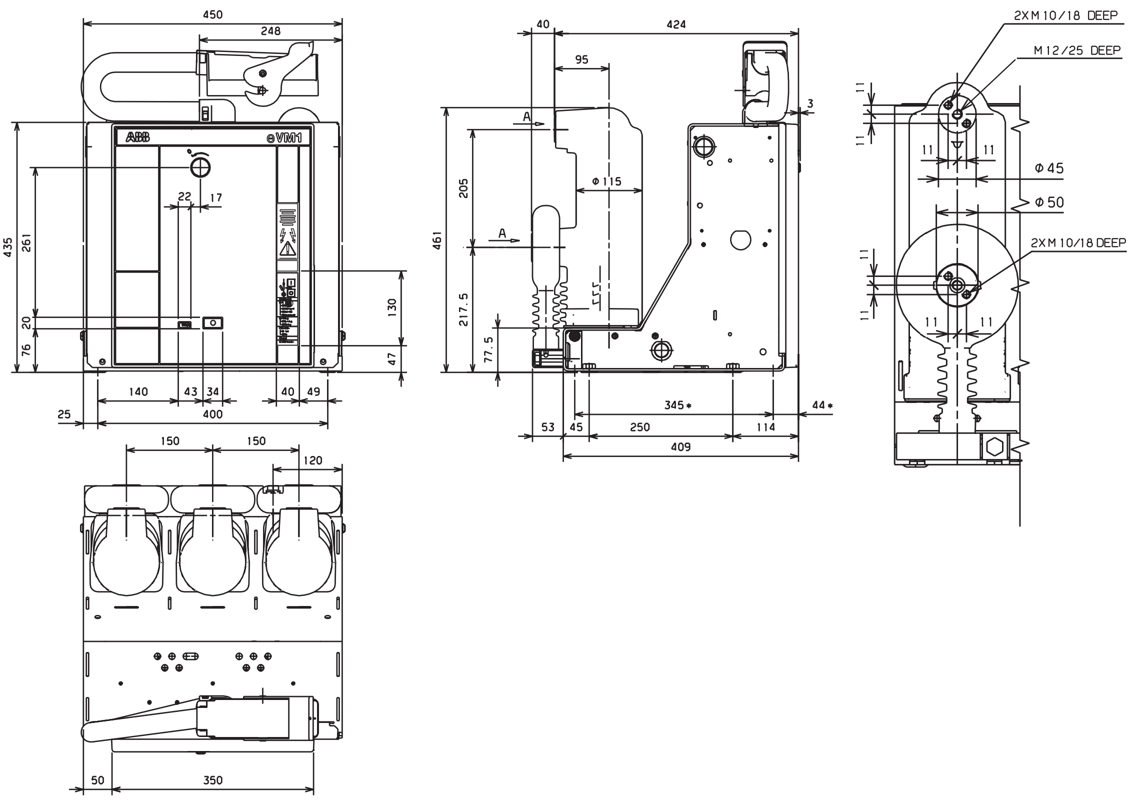


Fig. 13

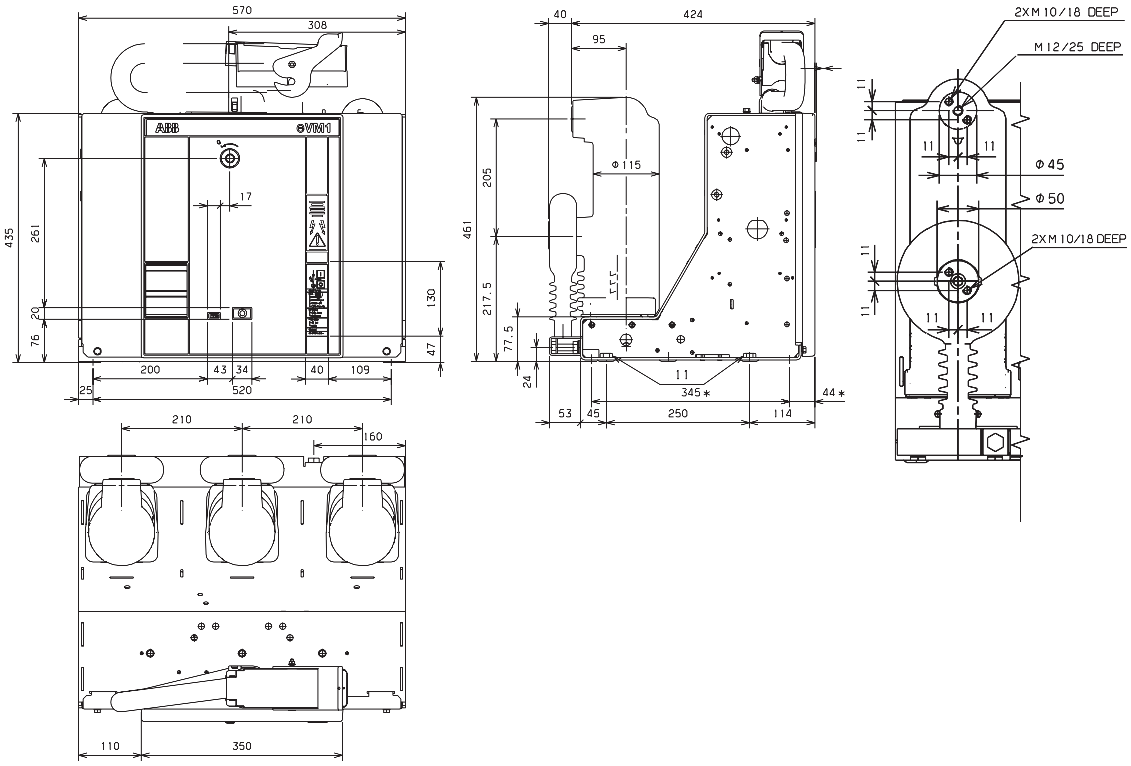
Fig. 14

9.7. Overall dimensions

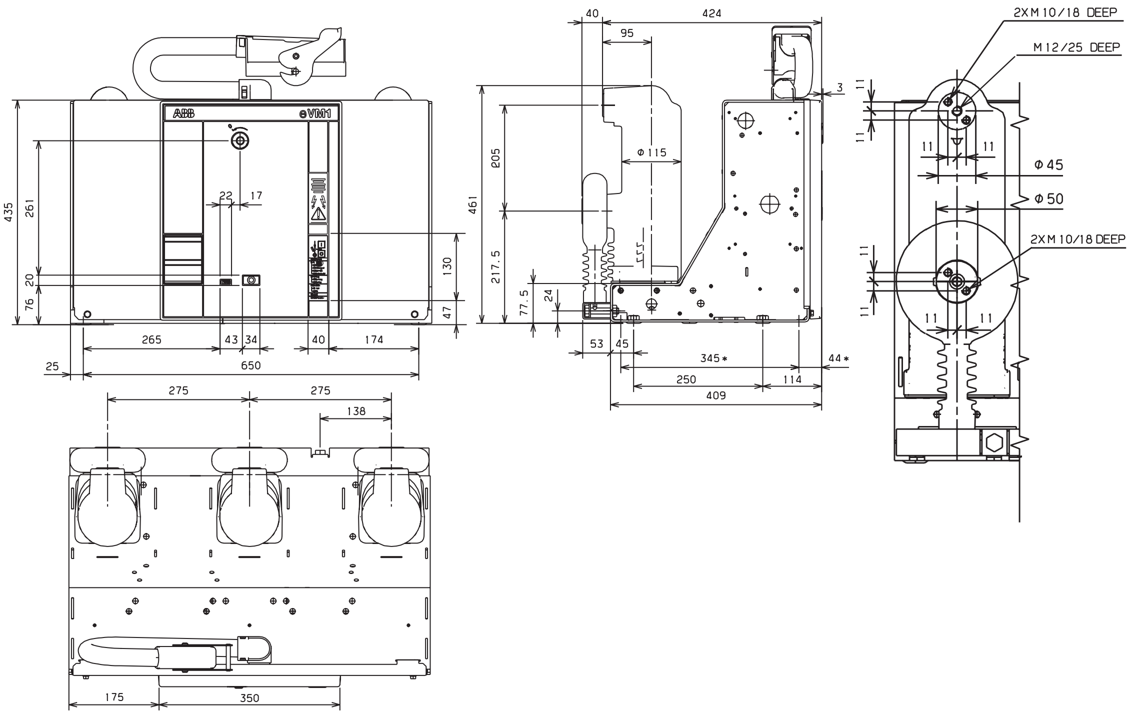
Fixed circuit-breaker	
eVM1 p150	
Ur	12 kV
	17.5 kV
Ir	630 A
	1250 A
Isc	16 kA
	20 kA
	25 kA
	31.5 kA



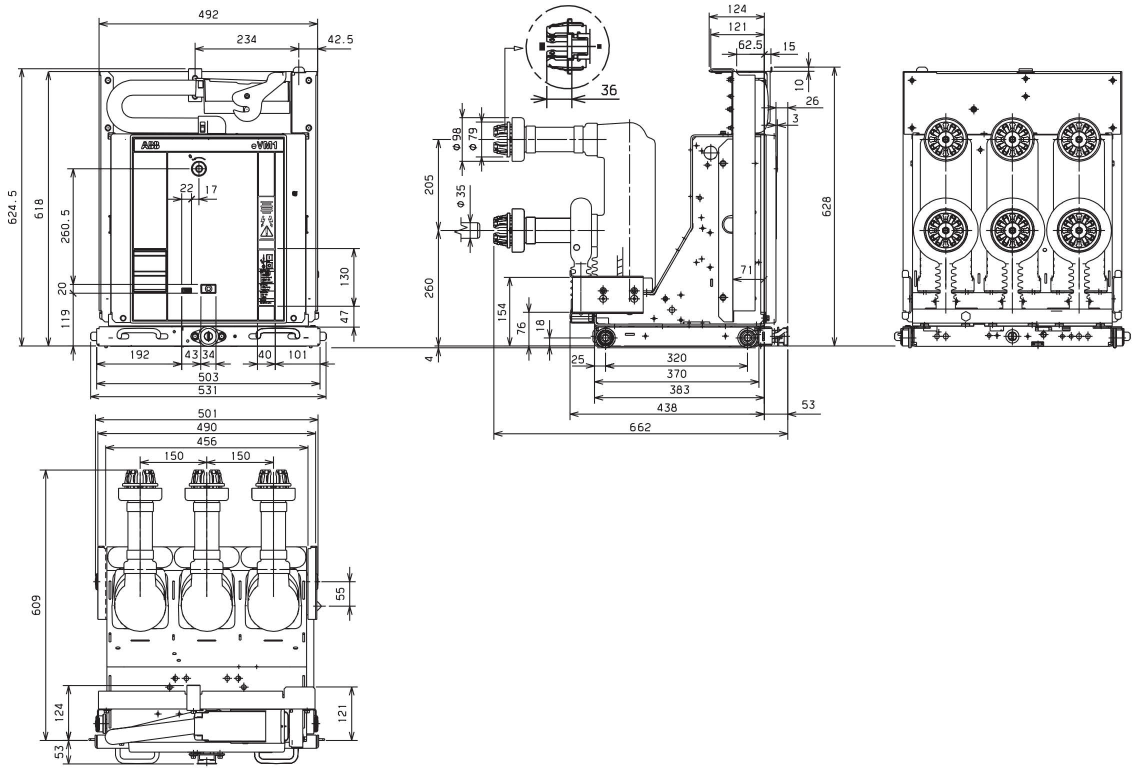
Fixed circuit-breaker	
eVM1 p210	
Ur	**12 kV**
	17.5 kV
Ir	**630 A**
	1250 A
Isc	**16 kA**
	20 kA
	25 kA
	31.5 kA



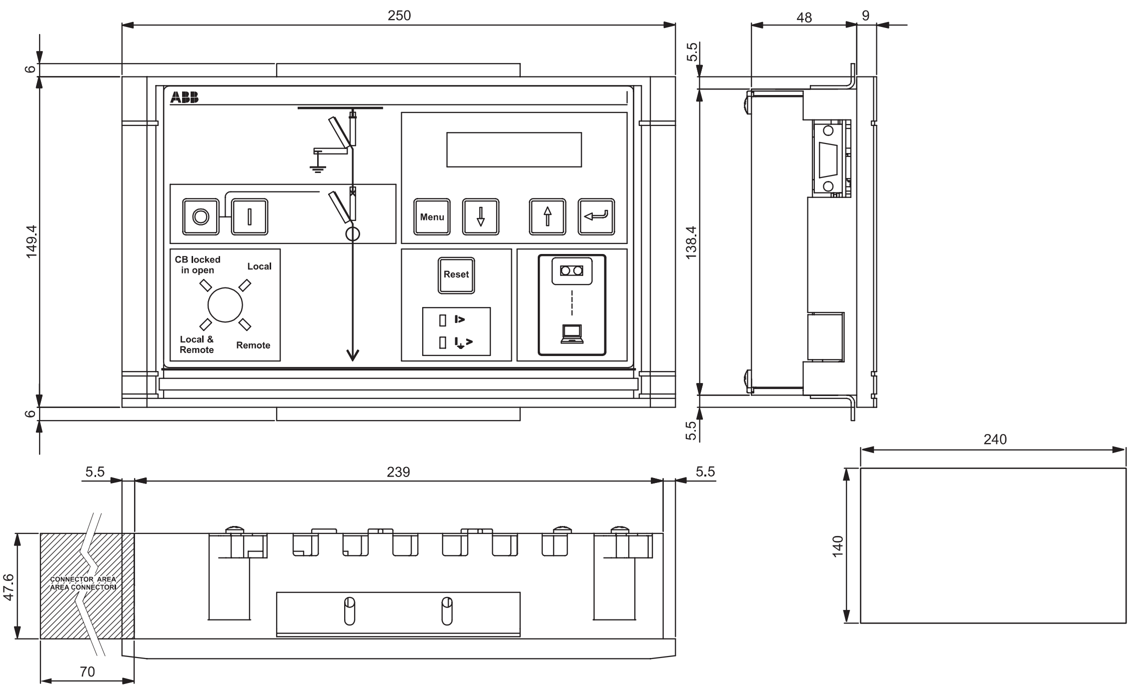
Fixed circuit-breaker	
eVM1 p275	
Ur	**12 kV**
	17.5 kV
Ir	**630 A**
	1250 A
Isc	**16 kA**
	20 kA
	25 kA
	31.5 kA



Withdrawable circuit-breaker	
eVM1/P p150	
Ur	**12 kV**
	17.5 kV
Ir	**630 A**
	1250 A
Isc	**16 kA**
	20 kA
	25 kA
	31.5 kA



HMI: Panel interface for eVM1



Door drilling

10. Putting into service

10.1. General procedures

Warning!

All the operations regarding putting into service must be carried out by ABB personnel or by suitably qualified customer personnel with in-depth knowledge of the apparatus and of the installation.
Should the operations be prevented, do not force the mechanical interlocks and check that the operating sequence is correct.
The operating forces which can be applied for racking-in withdrawable circuit-breakers are indicated in paragraph 9.5.

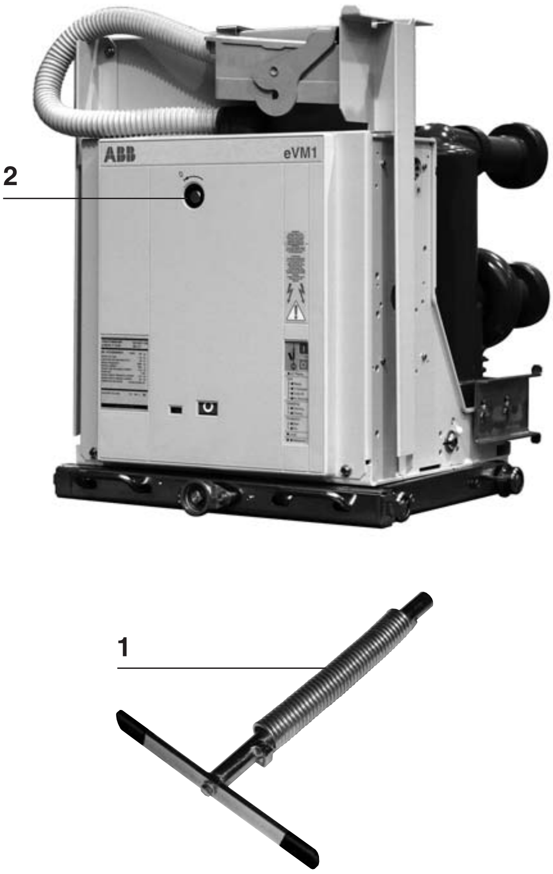


Fig. 15

Proceed as follows:
– disconnect the power supply voltage and take the circuit-breaker to the isolated position.
– couple the crank handle (1) in the seat (2)
– turn the crank handle (1) clockwise as far as the end-of-run position

10.2. Operation of the circuit-breaker

10.2.1 Closing

This can be carried out remotely by applying voltage to the relative input or locally by pressing the “I” pushbutton on the front of the circuit-breaker or on the panel HMI.

10.2.2 Closing in the case of a power failure

Closing is not advisable and is not possible.

10.2.3 Opening

This can be carried out remotely by applying voltage to the relative input or locally by pressing the “O” pushbutton on the front of the circuit-breaker or on the panel HMI (fig. 16).

10.2.4 Opening in case of a power failure

Opening can be carried out remotely by means of the control system, or locally by pressing the “O” pushbutton on the front of the circuit-breaker within 30 seconds from the auxiliary power failure (circuit-breaker in closed position).

10.2.5 Manual emergency opening

Use the crank handle 1 (fig. 15) for manual emergency operation.

Notes
– Manual emergency opening is possible even after the 30 s time limit.
– In the case of a power failure and after the 30 s time limit, the circuit-breaker remains in its present position. If automatic opening is required after the 30 s time limit, the relative function must be activated.

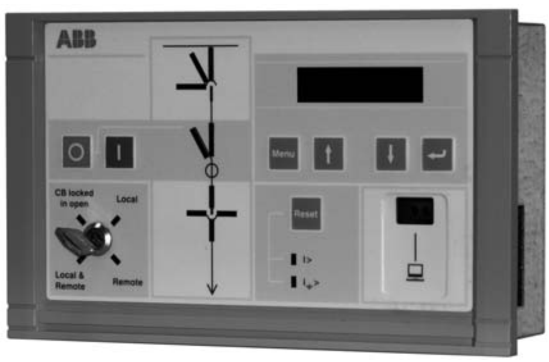


Fig. 16

10.3. Operations before putting into service

Before putting the circuit-breaker into service, carry out the following operations:

- remove the lifting hooks;
- check tightness of the power connections at the circuit-breaker terminals;
- establish the setting of the primary electronic overcurrent release (if provided);
- check that the value of the power supply voltage of the auxiliary circuits is between 85% and 110% of the rated voltage of the electrical accessories;
- remove any remains of packing materials;
- check that no foreign bodies, such as bits of packing, have got into the moving parts;
- remount any covers removed during the testing operations;
- check that there is a sufficient exchange of air in the installation place to avoid overtemperatures;
- supply the auxiliary circuits with power;
- check the functionality and efficiency of the mechanical and electrical locks;
- carry out a few circuit-breaker opening and closing operations by means of the pushbuttons on the front of the circuit-breaker;
- also carry out the checks indicated in table T3.

T3

ITEM INSPECTED	PROCEDURE	POSITIVE CHECK
1 Insulation resistance.	**Medium voltage circuit** With a 2500 V megger, measure the insulation resistance between the phases and the exposed conductive part of the circuit.	The insulation resistance should be at least 50 Mohm and in any case constant over time.
	Auxiliary circuits With a 500 V megger (if the apparatus installed allows this), measure the insulation resistance between the auxiliary circuits and the exposed conductive part. N.B. Before carrying out the test, disconnect the earthing of the electronic card from the circuit-breaker frame and reconnect it after the test. In particular, the communication connection must be disconnected to the protection and control unit, connector -XB24, and to the power supply connection (protected by a 275V common mode varistor), connector -XB24, both on the mother card of the protection and control unit.If the communication connection to the control and protection unit is made using connector D-Sub 9-pin for DIN rail in a secondary compartment, disconnect this connection.	The insulation resistance should be a few Mohm and in any case constant over time.
2 Auxiliary circuits.	Check that the connections to the control circuit are correct: proceed with the relative power supply.	Operations and signals are normal.
3 Auxiliary contacts in the drive.	Insert the auxiliary contacts in suitable signalling circuits. Carry out a few closing and opening operations	The signals take place normally.
4 Locking electromagnet on the circuit-breaker truck (-RL2).	With the circuit-breaker open, in the isolated for test position and the locking electromagnet not supplied, attempt to rack in the circuit-breaker. Supply the locking electromagnet and carry out the racking-in operation.	Racking-in is not possible. Racking-in takes place correctly.
5 Auxiliary transmitted contacts signalling circuit-breaker racked-in, isolated (UniGear switchgear or PowerCube modules).	Insert the auxiliary contacts in suitable signalling circuits.With the circuit-breaker racked into the enclosure, carry out a few traversing operations from the isolated for test position to the racked-in position. Take the circuit-breaker to the racked-out position.	The signals due to the relative operations take place regularly.

11. Maintenance

Maintenance operations are aimed at keeping the apparatus working properly for the longest possible time.

In accordance with what is specified in the IEC 61208 / DIN 31 051 Standards, the following operations must be carried out.

Inspection: Determination of the actual conditions

Servicing: Measures to be taken to maintain the specific conditions

Repairs: Measures to be taken to restore the specific conditions.

11.1. General

Vacuum circuit-breakers are characterised by simple, sturdy construction and long life.

The drive is maintenance-free for its whole operating life and only requires functional inspections.

The vacuum interrupters are maintenance-free for their whole operating life.

Vacuum interruption does not produce harmful effects even when there are frequent trips at the rated and short-circuit current.

The servicing interventions and their aim depend on the environmental conditions, on the sequence of operations and on the trips under short-circuit.

Note

For maintenance work, respect the following Standards:

- **the relative specifications indicated in para. 5.1 “Standards and Provisions” chapter;**
- **regulations for safety in the workplace indicated in the “Putting into service” chapter 10 and para. 10.2 “Circuit-breaker operations”;**
- **regulations and specifications of the country where the apparatus is installed.**

The maintenance operations can only be carried out by trained personnel who respect all the safety regulations. Furthermore, is recommended that ABB service personnel should be called in, at least to check the service performances, and for any repair work.

During maintenance work, turn the power supply off and put the apparatus under safe conditions.

Warning!

Before carrying out any operations, make sure that the circuit-breaker is open, the capacitor discharged and that it is not supplied (medium voltage circuit and auxiliary circuits).

11.1.1. Operating life

All vacuum circuit-breakers are characterised by simple, sturdy construction and long useful life.

Frequent operation of the service and short-circuit currents does not negatively affect the degree of vacuum of the interrupters.

Typical useful life expectancy of a eVM1 vacuum circuit-breaker is determined by the following factors:

- embedded vacuum interrupter, maintenance-free up to 30,000 mechanical operating cycles.
- drive with magnetic actuator, maintenance-free under normal service conditions
  - up to 100,000 operating cycles for all the circuit-breakers with breaking capacity up to 25 kA and rated current up to 1250 A
  - up to 50,000 operating cycles for all the circuit-breakers with rated current d” 1600 A and/or breaking capacity e” 31.5 kA
- control module and sensors, maintenance-free (excluding the auxiliary contacts)
- indication of ON/OFF position of the auxiliary contacts (optional) up to 30,000 operating cycles
- withdrawable truck: up to 1000 handling operations can be carried out in the case of normal activation and with regular inspections.

Also see the IEC 62771.200 Standard.
The data on the useful life are in principle applied to all the components which are not directly affected by the operator.
The useful life of the manually activated components (movement of the withdrawable truck, etc.) can vary according to the type of handling.
The time intervals and amount of maintenance are determined by environmental agents, by the frequency of operation and by the number of trip operations under short-circuit.

11.1.2. Procedure for discharging the capacitor/s

Activate the circuit-breaker.
Disconnect the power supply voltage.
Operate the circuit-breaker by pressing the pushbuttons with the following cycle: O-C-O
The luminous "Unit Ready" signal turns off when the operation cycle has been completed, i.e. when the circuit-breaker is no longer ready for operations.
After 1 minute have passed, the capacitor voltage drops to a value of less than 15 V (circuit-breaker with A2 actuator and in closed position).
If required in specific cases, further information can be obtained from the technical documentation regarding the switching apparatus (e.g. any special service conditions agreed on), as well as from this instruction manual (see par. 14.15)..

11.1.3. Drive with magnetic actuator

The drive with magnetic actuator is maintenance-free up to the number of operation cycles indicated in paragraph 11.1.1.

11.2. Inspections and functional tests

11.2.1. Interruption devices in general

– Carry out regular inspections to check that the interruption devices are in good condition.
– Inspection at fixed intervals can be waived when the apparatus is permanently monitored by qualified personnel.
– Above all, the checks must include a visual inspection to check for any contamination, traces of corrosion and electrical discharge phenomena.
– Carry out more frequent inspections when there are unusual operating conditions (including adverse climatic conditions) and in the case of environmental pollution (e.g. heavy contamination or an atmosphere with aggressive agents).
– Visual examination of the isolating contacts. Turning the system of contacts alternately is recommended, in order to keep the internal surface of the contact areas clean. The contact areas must be cleaned if there are signs of overheating (discoloured surface) (also see paragraph 11.4 "Repairs").
– If any anomalous conditions are found, appropriate servicing measures must be taken (see paragraph 11.3 "Servicing").

11.2.2. Circuit-breaker pole

No check is required apart from what is already specified in par. 11.3.3.

11.3. Servicing

11.3.1. Interruption devices in general

If cleaning is found to be necessary during the inspections, as specified in par. 10.3., use the following procedure:

- insulate the working area and make it safe by following the safety regulations specified in the IEC/DIN VDE Standards.
- general cleaning of the surfaces:
  – dry and eliminate any light deposits of dirt using a soft dry cloth;
  – more resistant deposits of dirt can be removed using a slightly alkaline household cleanser or Rivolta BWR 210 type detergent.
- cleaning the insulating surfaces and conductive components:
  – light dirt: with Rivolta BWR 210 detergent;
  – resistant dirt: with cold 716 type detergent.

After cleaning, rinse thoroughly with clean water and dry carefully.

Note

Only use halogen-free detergents and never 1.1.1-trichloroethane, trichloroethylene or carbon tetrachloride!

11.3.2. Actuator and transmission system

A functional test of the drive must be carried out:

- when the number the number of operating cycles indicated has been exceeded, or
- during maintenance operations.

Before carrying out the functional test, open the circuit-breaker and

- take it to the test position (withdrawable circuit-breaker) or
- insulate and block the working area and make it safe in conformity with the safety rules and according to the regulations in force (fixed circuit-breakers)
- follow the procedure for discharging the capacitor
- carry out a visual inspection of the state, removing the front panel, e.g. of:
  – lubrication of the ball bearings
  – the operation counter
  – assembly of the sensors
  – the position indicator.

Functional test:

- Connect the power supply voltage.
- Carry out several no-load operations. This test particularly applies to circuit-breakers which are rarely activated under normal conditions.

To check the capacitor, carry out a rapid O-C-O cycle of operations of the circuit-breaker, by pressing the pushbuttons on the front of the circuit-breaker in rapid succession.

- The LEDs on the inductive sensors are activated as soon as the circuit-breaker has reached the closing and opening limit positions.

Note

These operations can only be carried out by ABB personnel or suitably qualified and specially trained personnel.

11.3.3. Circuit-breaker pole

The circuit-breaker pole and relative vacuum interrupter are maintenance-free up to the maximum number of electrical operations foreseen for the type of interrupter (see para. 9.2. Trip curves).
The operating life of the vacuum interrupter is defined by the sum of the ultimate currents corresponding to the specific type of interrupter in accordance with what is indicated in the graphs of par. 9.2. Trip curves: when the sum of the ultimate currents is reached, the complete pole must be replaced.

Dismantling and replacement of the pole can only be carried out by ABB personnel or suitably qualified and specially trained personnel, especially for the necessary adjustments.

Note

To carry out the interrupter test without dismantling the circuit-breaker pole, use:
– the VIDAR vacuum tester, made by the company Programma Electric GmbH, Bad Homberg v.d.H.

To check vacuum tightness of the interrupter, the following test values must be set on the VIDAR tester:

Rated voltage of the circuit-breaker	d.c. test voltage
12 kV	40 kV
17.5 kV	40 kV

The test must always be carried out with the circuit-breaker open with the contacts at the nominal distance (12 kV and 17.5 kV).
Procedure for testing the degree of vacuum of the interrupter of the circuit-breaker poles:
– turn the power supply off and make the working area safe by following the safety regulations specified in the IEC/DIN VDE Standards;
– open the circuit-breaker;
– earth a terminal of each circuit-breaker pole;
– connect the earth terminal of the VIDAR tester to the circuit-breaker structure;
– connect the high voltage terminal of the VIDAR tester to the terminal of the circuit-breaker pole not connected to earth (L1 phase) and carry out the test. Repeat the test for phases L2 and L3.

The tester connection cables can produce an indication due to the capacitive effect. In this case the cables must not be removed.

Note

11.4. Repairs

Replacement of spare parts and accessories must only be carried out by ABB personnel or suitably qualified and specially trained personnel.
Always work with the circuit-breaker open and locked so that it cannot be closed again, with the work area insulated and made safe.
The capacitors must be discharged.
All power supply sources must be disconnected and made safe against any reclosing during removal and installation work.

Should maintenance be carried out by the customer's , responsibility for the interventions remains with the customer. The replacement of parts not included in the "List of spare parts" (para. 13.1.) must only be carried out by ABB personnel. In particular:
– complete pole with bushings/connections
– actuator
– transmission system.

Warning!

12. Application of the X-ray emission Standards

One of the physical properties of vacuum insulation is the possibility of X-ray emission when the interrupter contacts are open.
The specific tests carried out at the PTB laboratories (Physikalisch-Technische Bundesanstalt, in Brunswick - Germany) show that local emission at a distance of 10 cm from the interrupter or pole surface does not exceed 1 μSv/h.

It follows that:

– at the rated service voltage the use of vacuum interrupters is absolutely safe;
– application of the withstand voltage at power frequency, according to the IEC 62271-100 and VDE 0670 Standards, is safe;
– application of a voltage higher than the withstand voltage at power frequency or of a direct current test voltage, specified in the IEC and VDE Standards, cannot be used;
– limitation of the above-mentioned local phenomena, with interrupters with open contacts, depends on keeping the specific distance between the contacts.

This condition is intrinsically guaranteed by correct operation of the drive and by adjustments of the transmission system.

13. Spare parts and accessories

STOP **Warning!**

All assembly operations of spare parts/accessories must be carried out following the instructions enclosed with the spare parts, by ABB personnel or by suitably qualified customer personnel with in-depth knowledge of the apparatus (IEC 60694) and all the Standards aimed at carrying out these interventions in safe conditions. Should the maintenance be carried out by the customer's personnel, responsibility for the interventions remains with the customer.
Before carrying out any operation, make sure that the circuit-breaker is open, not supplied (medium voltage circuit and auxiliary circuits) and with the capacitors discharged.

To order circuit-breaker spare parts/accessories, refer to the ordering sales codes indicated in the technical catalogue and always state the following:
– type of circuit-breaker
– rated voltage of the circuit-breaker
– rated normal current of the circuit-breaker
– breaking capacity of the circuit-breaker
– serial number of the circuit-breaker
– rated voltage of any electrical spare parts.

For availability and to order spare parts, please contact our Service office.

13.1. List of spare parts

– Position sensors
– Position contact of the withdrawable truck
– Contacts signalling racked-in/isolated
– Isolation interlock with the door
– HMI
– Local control panel (see chap. 14.10).

For availability and to order spare parts, please contact our Service office, specifying the serial number of the circuit-breaker.

14. Multifunction Protection and Switchgear Control Unit

14.1 About this section

This section describes how to use the protection functions available in the electronic controller of the eVM1.

This section is addressed to engineering personnel and to anyone who needs to configure the eVM1.

14.2 Safety Information

Do not make any changes to the eVM1 configuration unless you are familiar with the eVM1 and its Operating Tool. This might result in malfunction and loss of warranty.

Warning!

The selection of this control mode requires caution, because operations are allowed both from the HMI and remotely.

Note

14.3 Acronyms and definitions

14.3.1 Acronyms

CB	Circuit-breaker or Switch	IED	Integrated Electronic Device
CCT	Cable Current Transformer	MA	Magnetic Actuator
CP	Control Panel	MB	Main Board
CU	Control Unit	MV	Medium Voltage
CT	Current Transformer	PS	Power Supply
CoT	Configuration Tool	VT	Voltage Transformer
HMI	Human Machine Interface		

14.3.2 Definitions

Active signal	A signal is active when high, e.g. logic value “1” or over activation threshold for DI, (about 20 V)
Inactive signal	A signal is inactive when low, e.g. logic value “0” or below activation threshold for DI (about 10 V)

14.3.3 Document information

Revision History

Version	Date	Comment
1VTA0002	5.03.2004	1st release

Applicability

This manual is applicable to eVM1 Release 1.0, software version V1.0.

14.4 Menu, Toolbar and Tabs

The Menu, Toolbar and Tabs windows allow you to navigate Windows like all the Configuration Tool functions. Pop-up labels indicate the meaning of the icon buttons.

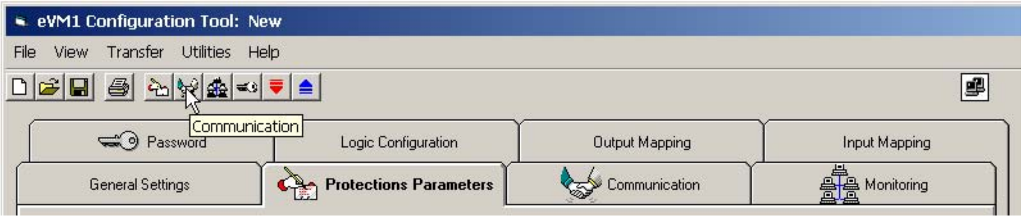


Fig. 17

14.4.1 Toolbar

The buttons on the Toolbar with the same Tab icon allow you to open the main pages of the Configuration Tool. A detailed chapter is dedicated to each one below.

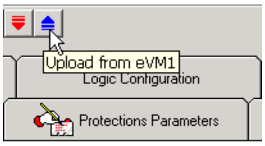


Fig. 18

Upload/Download functions are detailed in the Chapter: Transfer.

14.4.2 Menu

The Menu function lists are only fully accessible with service level rights (see chapter: Password). Otherwise some functions are disabled and coloured in light grey.

14.4.2.1 File

The File Menu provides utilities for file management:

New: opens a new unnamed project with all data as default configuration

Open: opens a previously saved project recalling all specific configurations

Save: saves current configuration data on existing project file in format .eVM1

Save as: saves current configuration data on project file in format .eVM1 requiring the project filename

Print: Prints all the Tabs on default printer enabling you to keep a paper copy of data settings

Exit: exits the Configuration Tool

14.4.2.2 View

View Menu makes it possible to enable/disable the **Toolbar** and to enable/disable the **Status Bar**, displaying whether a valid connection to the IED has been established.

14.4.2.3 Transfer

The Transfer Menu provides the utilities for Upload/Download of the CB configuration and to start Monitoring the CB status continuously.

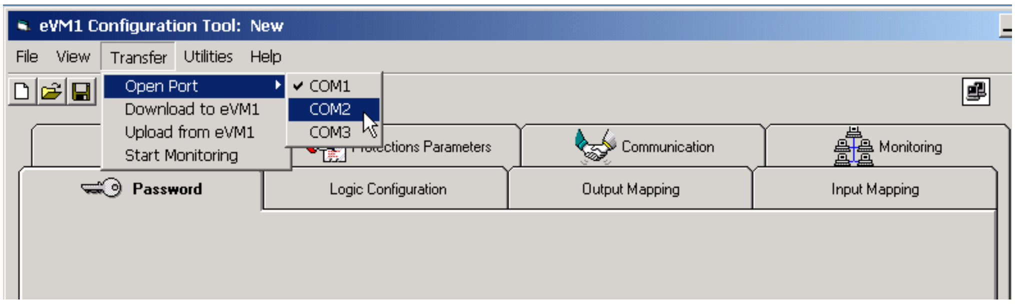


Fig. 19

All functions are available when an active communication link has been established with the electronic Device (IED) inside the CB, either directly through the D-Sub connector –XB24 (refer to schematic drawings 1VCD400060) or through the 58 pin connector, directly or via the Panel HMI.

Upload function: Transfers the configuration file from the electronic device (IED) to the PC if an active connection is available. The file can be renamed and stored on disk for download onto a new CB to be used as a replacement or spare. Information relevant to Product serial numbers and Product License are linked to the specific IED and will not be copied.

Download function: Transfers the configuration file from PC to the electronic device (IED) if an active connection is available.
Only configuration parameters are written-read with Download-Upload functions. HW parameters as serial numbers and calibration factors are introduced in production and can only be modified by accessing with service level rights (see chapter: Password).

14.4.2.4 Utilities

The Utilities Menu provides general use functions:

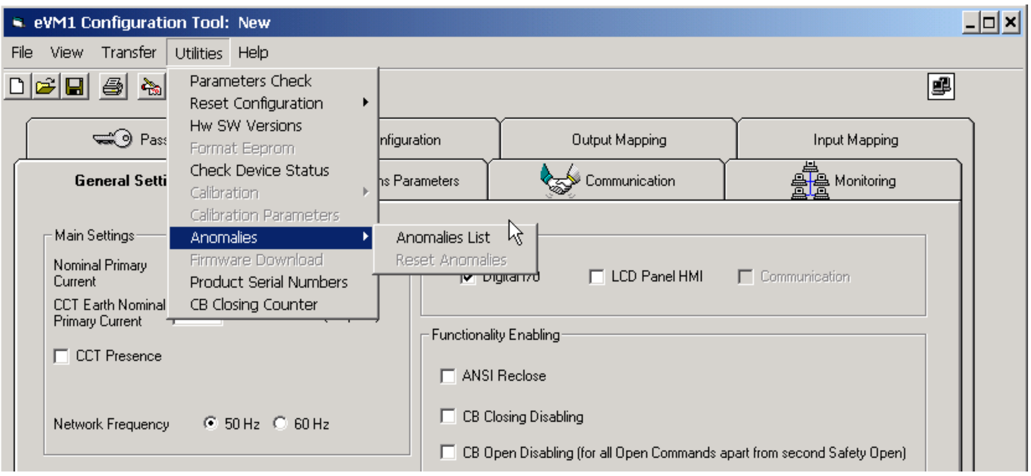


Fig. 20

Parameters Check: verifies that all Protection function parameters are within possible range. Function useful after a change in The Nominal Primary Current value, when all ranges are modified. It is automatically performed when downloading a configuration. A pop-up window signals the protection functions and parameters possibly found not to be in the admissible range.

Reset Configuration: set all configurable parameters to the default ones, available at Configuration Tool opening.This menu allows two choices.

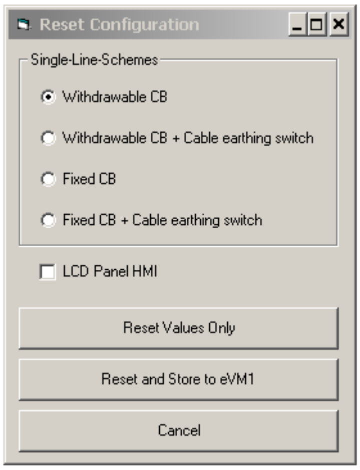


Fig. 21

Reset Values Only: set all the parameter of the selected default configuration

Reset Values and Store to eVM1: set all the parameter of the selected default configurationand transfers this configuration from PC to the electronic device (IED) if an active connectionis available

HW SW Versions: reads the HW and SW versions from the IED for compatibility check and information to ABB service. Available when an active communication link has been established with the IED.

Format Eprom: emergency function. This formats the Eprom memory for overwriting a new configuration set.

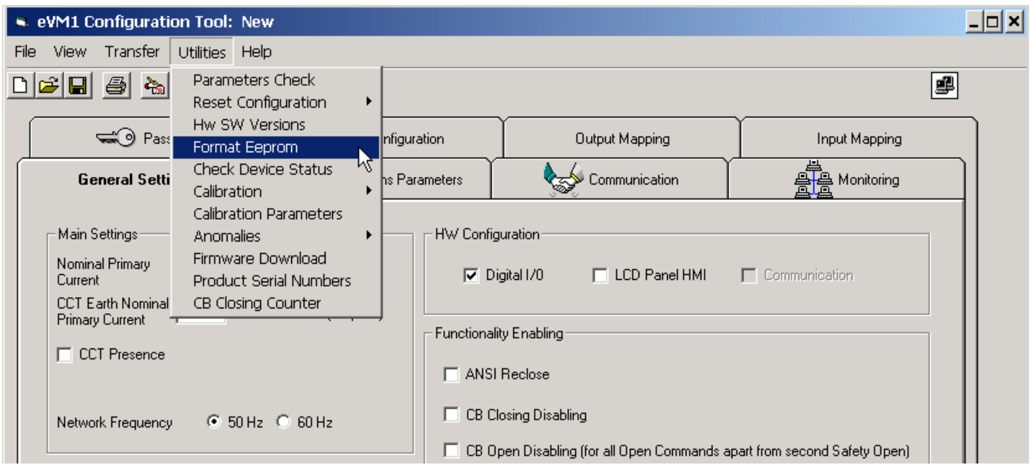


Fig. 21a

Check Device Status: Available when an active communication link has been established with the IED. Shows calibration status; gain and offset must be at 111 for valid calibration.

Calibration sub-Menu: calibration enables you to correct errors due to device tolerance within the accuracy class and to improve overall analog input acquisition precision.

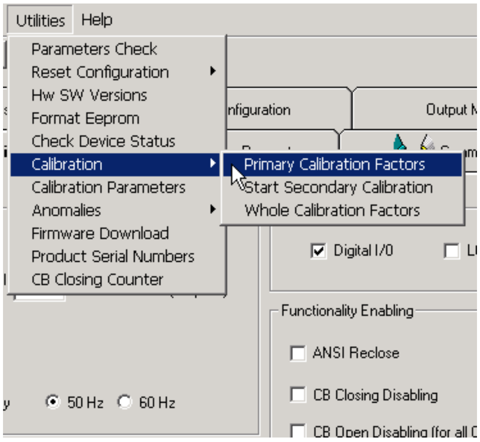


Fig. 22

Primary Calibration Factors: the calibration factors for Rogowski sensors L1, L2, L3 (available on R. sensor label) and for Earth CCT can be introduced and read.

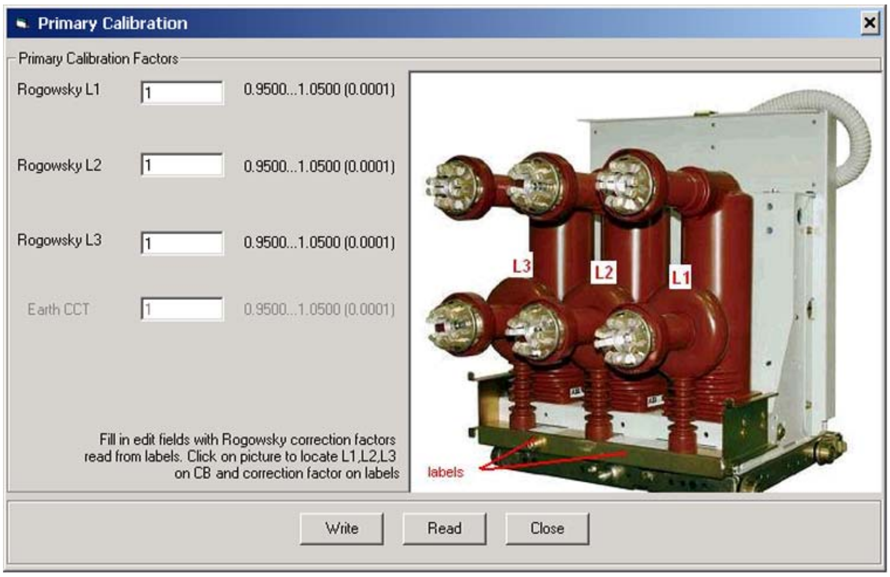


Fig. 23

Start Secondary Calibration: with a pop-up window, this function, executed at IED production and accessible only to service personnel, provides the possibility of calibrating the IED analog channels by injecting a reference signal. Refer to calibration and test procedure document 1VCD6000132.

Whole Calibration Factors: with a pop-up window, this function provides the possibility of calibrating all the analog channels (r. sensor + IED electronics) by introducing a numerical correction factor.

Calibration Parameters: reads all the calibration parameters from the IED, i.e. the correction factors for phase 1, 2, 3 and phase shift in respect of phase 1 stored during secondary calibration.

Anomalies sub-Menu: enables you to read (**Anomalies List**) all active anomalies from the IED for information to ABB service and to reset (**Reset Anomalies**) the Anomaly signalling, clearing the list and turning off the blinking LED "No Anomaly" on the CB HMI. Available when an active communication link has been established with the IED.

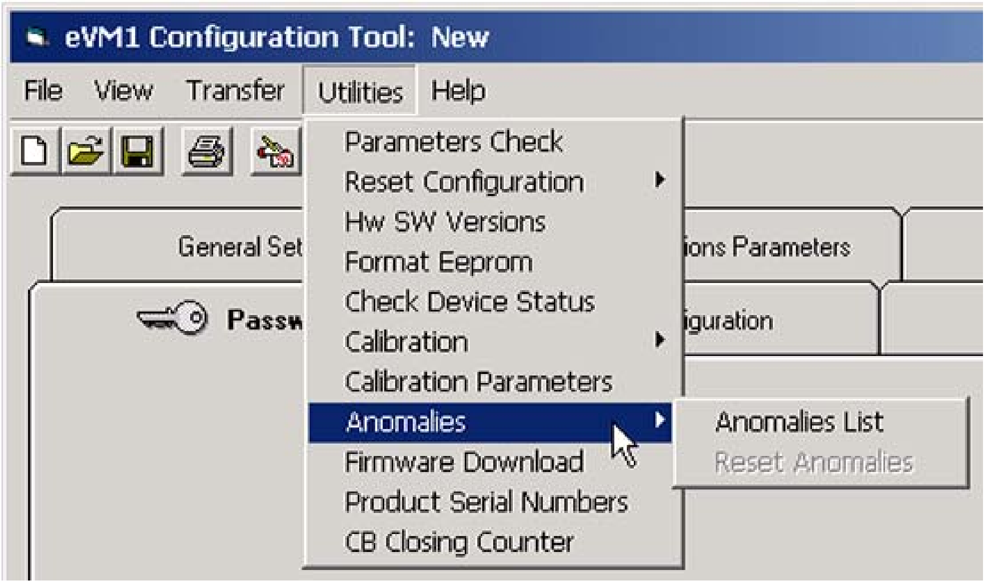


Fig. 24

Reset Anomalies: setting the digital input "Trip Signal and Reset Anomalies (default DI 11) on high the function is executed. Reset is available when an anomaly is present.
Reset Anomalies clear the anomaly indication only; if the anomaly condition persists will be indicated again.

Firmware Download: enables you to upgrade the firmware version on the IED, it opens a browse window to choose the file .out to download. Available when an active communication link has been established with the IED, and only in help mode.

Procedure

Shut down the IED power supply and wait until Ready indication and position sensor indication goes off.
Close (arrow to ON) all I1 dip switches (from I1-1 to I1-5) and set JP6 (insert jumper) to define full duplex communication mode, refer to 1VCD600132, figure 1, motherboard layout.
Power up the IED (please note that in this mode the CB HMI control panel will not light up)
Select Firmware Download from CoT, browse for file, launch with Open in browse window.
On completion of updating the firmware version, exit and re-launch the configuration tool, power down the IED and reconfigure it to half duplex, removing JP6 and put I1 dip switches in off position or according to required functionalities.

Product serial Numbers: opens the product Configuration window, in production it enables you to enter (**Write**) serial numbers of the CB, the Rogowski sensors and the IED. That information is stored in a non-volatile memory on the IED and is not modified by new configuration or firmware download. **Read** retrieves data from the IED for compatibility check and information to ABB service. Available when an active communication link has been established with the IED.

CB Closing Counter: opens a window that shows the number of closing operations performed by the CB and the percentage of contact wear due to load or short-circuit opening operations (0% means new circuit-breaker). Both values can be modified and saved to the IED when in service mode.

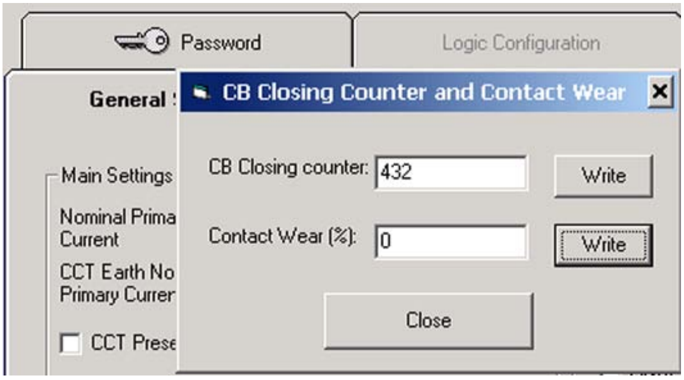


Fig. 25

The percentage of contact wear is calculated according to the following graphs showing the number of closing-opening cycles (No.) allowed according to the breaking capacity (Ia).

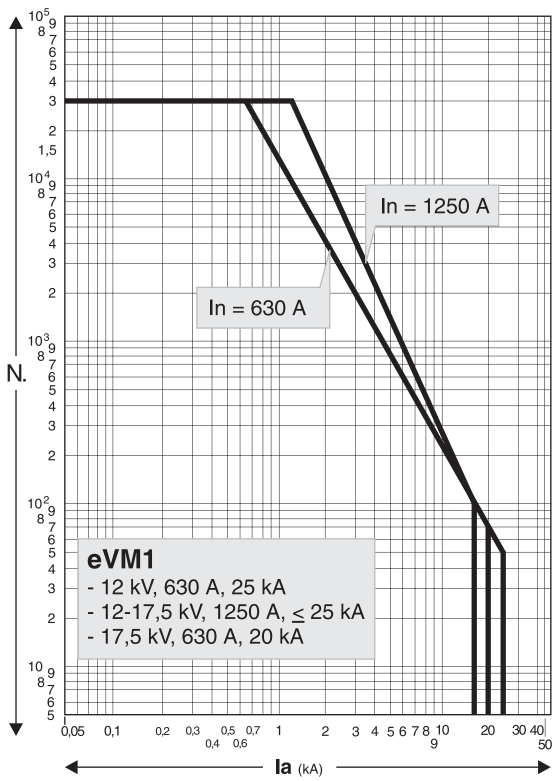


Fig. 26 (12b)

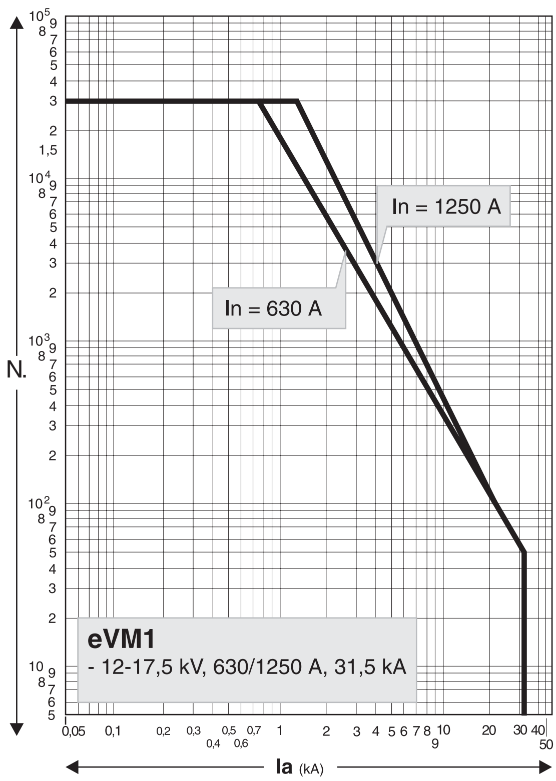


Fig. 27 (12c)

Caption

No. Number of closing-opening cycles allowed for the vacuum interrupters.

Ia Breaking capacity of the vacuum interrupters.

14.5 General Settings

The General Settings Tab enables you to configure the HW according to the Electronic Device (IED) integrated in the CB and to the application characteristics, such as the current ratings, network frequency and single-line diagram. It manages enabling of a number of automation functions.

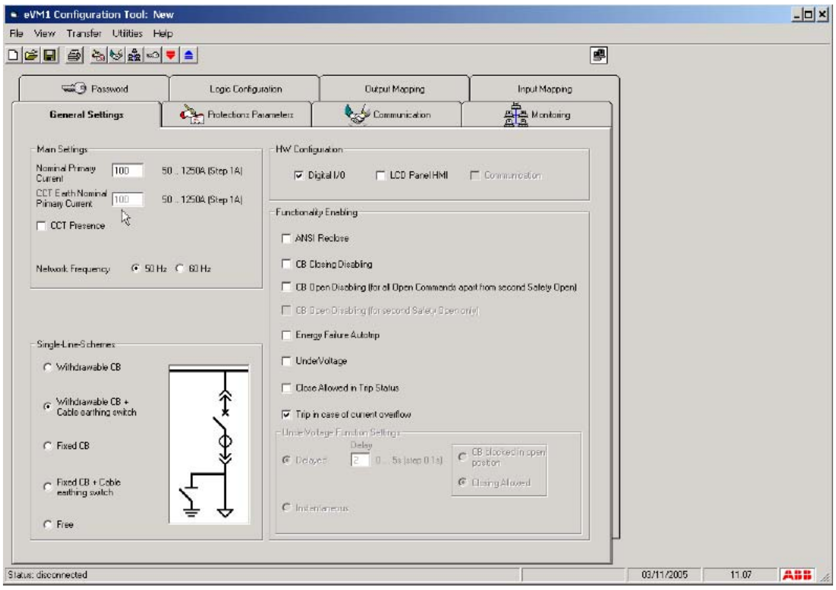


Fig. 28

14.5.1 Main Settings

The Main settings dialogue window allows the user to configure the nominal values of the analog input channels and to set default values for each sensor type.

The Main Settings for the Analog inputs are:

– Set the Nominal Primary Current, i.e. the rated Nominal current of the application
– Check the CCT Presence tick box
– Set the CCT earth Nominal Primary Current value
– Set the Rated Network Frequency value, by default 50 Hz.

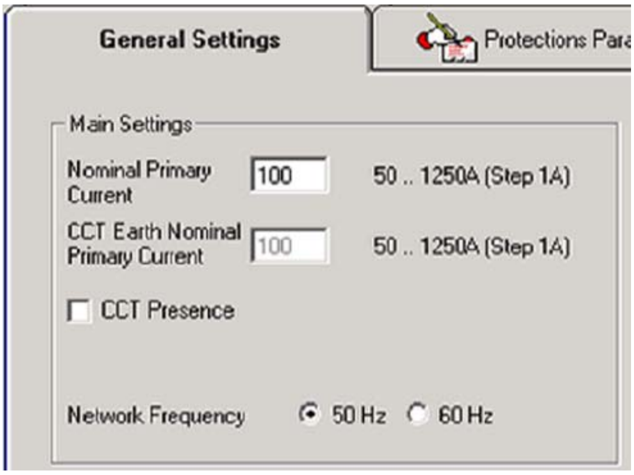


Fig. 29

Warning!

Do not make any changes to the eVM1 configuration unless you are familiar with the eVM1 and its Operating Tool. Changing the nominal currents and frequency values of the Main Settings might result in malfunction of protection functions.

14.5.1.1 Nominal Primary Current

Channels 1…3 are used for phase current measurement based on the Rogowski sensor input.
The Nominal Primary Current is the load rated current; the protection function setting range is adjusted automatically according to the Nominal Primary Current value entered.
The threshold setting range of each protection is expressed in primary current Ampere [A], typically from is 0.5 In to 20 In where In is the Nominal Primary Current value entered.

14.5.1.2 CCT Earth Nominal Primary Current and CCT Presence

Earth fault protection functions can operate on measured or calculated earth current.
When an earth fault protection is activated the earth current is calculated from the vectorial sum of the three phase currents if the CCT is not present (blank box). This can be done in networks with low-resistance neutral earthing in which large zero-sequence currents occur. When the CCT Presence box is ticked the earth current is directly measured on the channel 4. To provide the earth current signal a residual current transformer must be connected in the primary circuit.
This option should be used in networks with high-resistance, compensated or isolated neutral point, where low amplitude earth fault currents occur, to provide higher sensitivity.
The CCT Earth Nominal Primary Current is the residual current transformer rated current, Ine/1 [A/A]. The earth fault protection function setting range is adjusted automatically according to the CCT Earth Nominal Primary Current value entered.

14.5.1.3 Analog value measurement and processing

The four available high precision Analog Input channels allow acquisition and processing of three phase currents through the Rogowski current sensors fitted on the Circuit-breaker contact arms and an earth current (if an optional earth current sensor is present).
The four signals are sampled at a frequency of 600 Hz with 16 bits of resolution.
The Discrete Fourier Transform (DFT) is calculated for each signal in order to extract the RMS value of the fundamental component (i.e. 50 or 60 Hz).
All protection functions are based on the fundamental component RMS value at the rated network frequency.

14.5.1.4 General constraints

- Channels 1…3 are used for phase current measurement based on the Rogowski sensor input; Board Input Rated Value (IRV) is 0.150 V for 180 A primary current at 50 Hz.
- Channel 4 can be used for earth current measurement based on external residual current transformer input; Board Input Rated Value (IRV) is 1 A.

Note

Residual current transformers with rated secondary current different from 1A must not be used; their use may damage the earth current input and/or provide erroneous measurements.

14.5.1.5 Power Connection Diagram

As an example, the following figure shows the typical connection diagram of phase current Rogowski sensors and of optional CCT earth current transformer for a generic feeder; please refer to schematic drawings 1VCD400060 for the withdrawable version and 1VCD400089 for the fixed version.

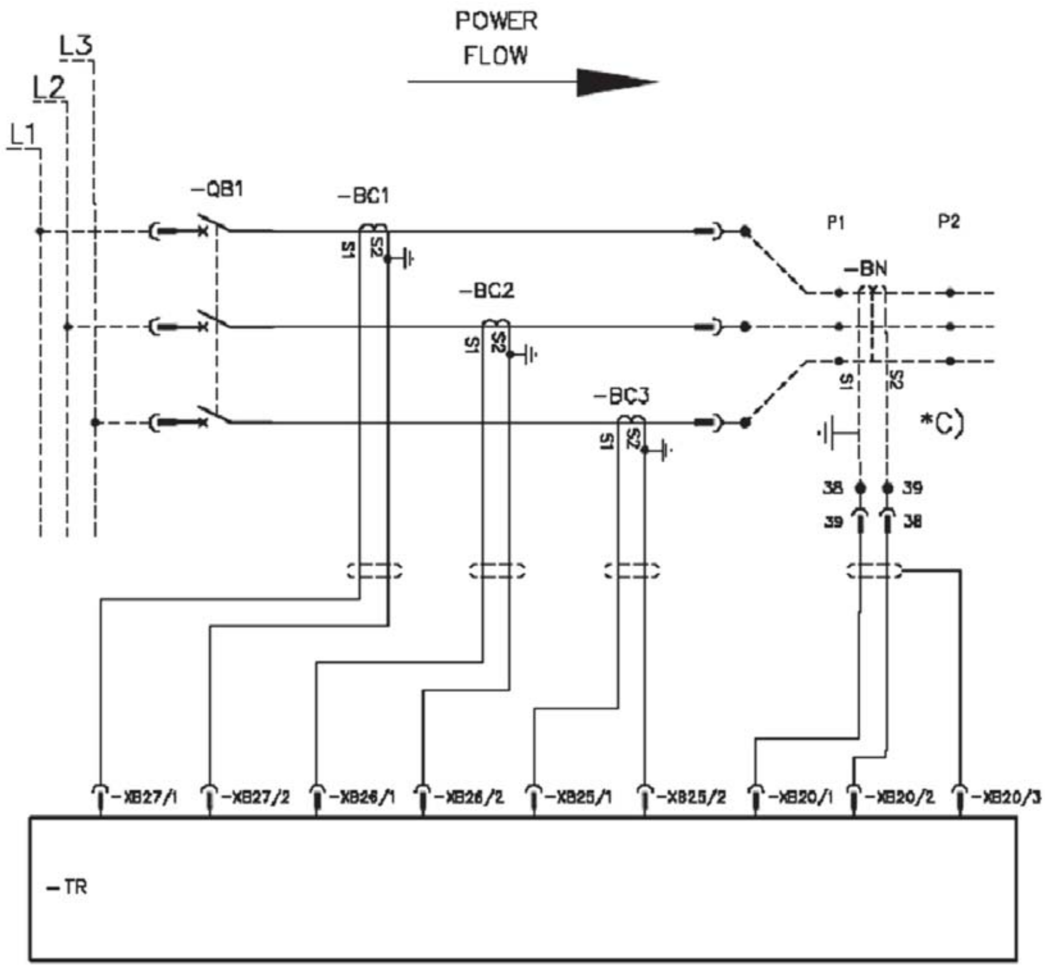


Fig. 30 Generic feeder connection, overcurrent protections can be activated, residual current can be directly measured

14.5.2 Single-Line diagrams

The Single-Line diagram selection enables you to define a typical application diagram between a fixed and withdrawable CB and with or without an earthing switch on the cable side.

When one of the four defined applications is selected by the tick box, the digital inputs and outputs (DI/O) are mapped according to selected predefined meanings (see chapter: Input / Output Mapping). Refer to schematic drawings 1VCD400060 for complete meaning assignment of withdrawable CB application. In this case all I/O are assigned and are not user configurable.

By ticking the “free” scheme, all available meanings can be assigned to the configurable I/O with no restrictions.

As default, the free DI/O mapping will show the meanings assigned in the predefined diagram selected before (e.g. by choosing “Free” after selecting “Withdrawable CB”. The DI 14, 15 will not be used in DI mapping, while selecting “Free” after “Withdrawable CB + earthing switch” the meanings “ES Open” and “ES Closed” will be assigned to DI 14,15).

When Free is selected the figure shows the single-line diagram of the last scheme selected in light grey, as this is the meaning base free configuration is starting from.

Note

The picture shown in light grey in Free configuration is not fully relative to the actual single-line scheme, since with free selection some components might not be applicable (e.g. the earth switch can be de-selected but the picture will not show it).

14.4.3 HW Configuration

By checking the HW modules available it is possible to configure the HW according to the Electronic Device (IED) integrated in the CB and to activate the relative Tabs.

Possible selections are:

Digital I/O: ticked by default, this activates the Output, Input Mapping Tabs.

LCD Panel HMI: optional HMI module, enables you to operate the CB and to access information displayed on the LCD by a menu navigation. It shows the panel single-line diagram according to the selection and available inputs.
When LCD Panel HMI is selected, the Local/Remote selection Key and Close/Open commands from local functions are provided by the HMI and the meanings are not configurable in the DI mapping Tab (see picture below).

Fig. 31

Trip Signal and Anomaly Reset function can still be performed both from HMI with the Reset pushbutton and by DI (by default DI 11).
In default configurations, without HMI, the #Local/Remote selection is not available - see figure below. This means that the IED will be in Global mode (both Local and Remote commands are accepted).

Fig. 32

To define a Local/Remote selection without HMI, it is necessary to use the Free configuration and to select on #Local/Remote selection Key meaning the available DI10.
When the input is supplied above the activation threshold the IED will go to Remote mode and local command will be not executed; otherwise it will be in Local mode.
Communication: not ticked by default, it activates the Communication Tabs.

14.5.4 Functionality Enabling

The Functionality Enabling checklist manages the enabling of a number of automation functions.

Note

The SW enabling of the automation function is only one of the possible conditions to be verified to operate the automation. Additional necessary conditions may be activation of a specific digital input (DI) and a specific HW setting on the IED. Tick the following for each function whose conditions apply.

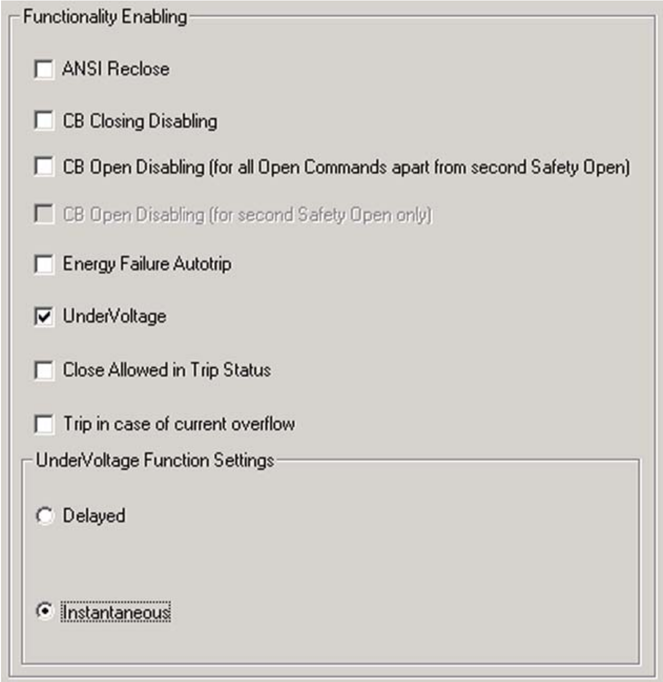


Fig. 33

All automation functions are not ticked (i.e. inactive) by default. In the example (figure above) the UnderVoltage function is enabled.

14.5.5.1 ANSI Re-close

This activates the Re-Close Function according to ANSI requirements, see figure.

This function is only activated when the CB is in the closed position and a Close Command is valid (positive edge event). Close and Open can be local or remote commands. If the close command is released (negative edge) before the open command (positive edge event), the function is a normal open command and the re-close function will not be performed. If the close command is released any time after the open command positive edge, the re-close function is correctly performed.

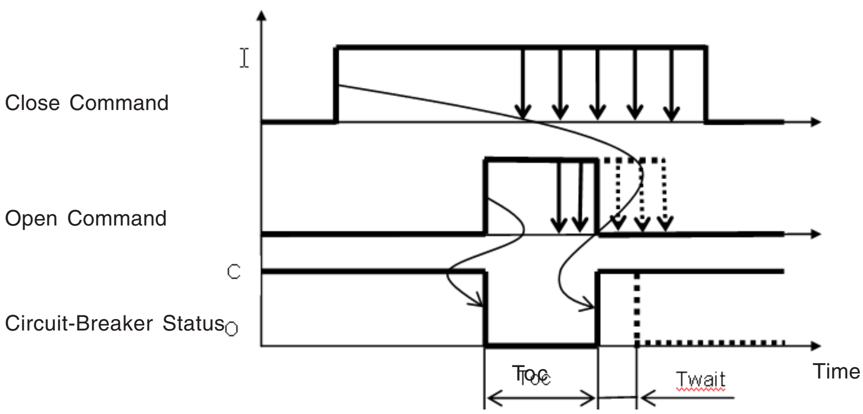


Fig. 34

Once the re-close sequence has been performed, the function is automatically reset (it is not repeated other times till new correct conditions reappear).
In accordance with ANSI, Toc must be less than 300ms independently of Open Command duration (for convention we can define Toc=200ms). If the open command persists over Toc, another opening operation will be performed after the OC operation (see dash-line). Twait is less than 1.5 cycles.
Remark: the Re-close is not activated if the Under Voltage function is timing i.e. all the conditions to operate an Undervoltage open are true.
If the Re-close function is activated but # CB Close Disabling input (default DI 5) is enabled and active (no voltage on input), the Re-close will not be performed.
In applications that foresee Local/Remote mode selection, the transition from Local to Remote mode resets the local stored closing positive edge. To perform a re-close it is necessary to activate the close remote close input. Vice versa, it takes place from Remote to Local mode transition (remote stored closing positive edge is reset).

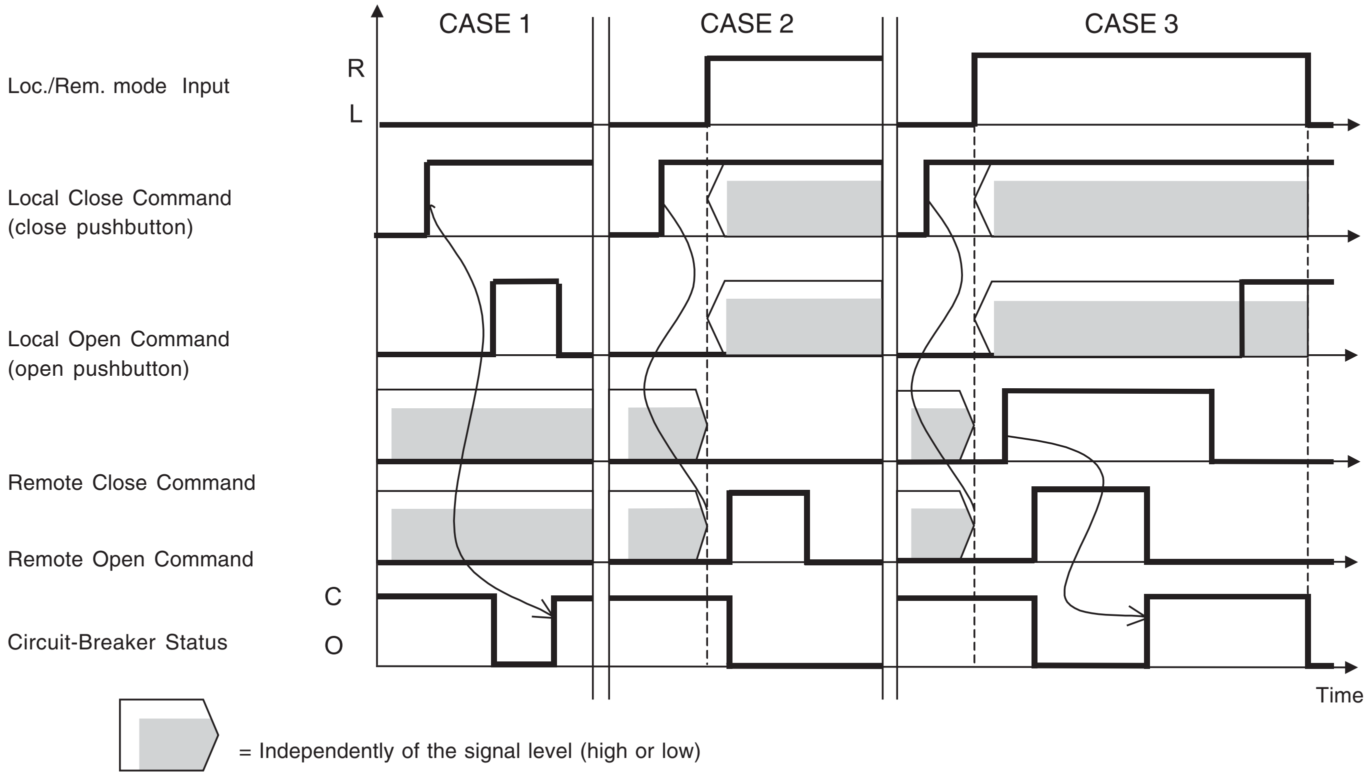


Fig. 35

CASE1: normal re-close sequence performed locally by pushbuttons

CASE2: when the close pushbutton is pressed the ED is ready for a re-closing operation (CB closed, local). When the Loc/Rem mode input is switched to remote mode the previous Local Closing positive edge is reset: in this case if an opening command is launched, the re-close is not performed.

CASE3: when the close pushbutton is pressed the ED is ready for a re-close operation (CB closed, local). When the Loc/Rem mode input is switched to remote mode the previous Local Closing positive edge is reset. To perform the re-close sequence, it is necessary to have a new Remote Close Command positive edge and the relative Remote Open command.

14.5.5.2 CB Closing Disabling

This is used to block the CB in the open position by external interlocking logics. When the function is enabled (ticked) and the # CB Close Disabling input (default DI 5) is at low level “0” (no voltage on input or lower than activation threshold, about 10V AC/DC), no closing command is executed. The function is Global, i.e. it blocks closing commands both from Local (CB HMI, Panel HMI or Close Command from local, default DI 12) and from Remote (Close Command from remote, default DI2 or from Communication).

14.5.5.3 CB Open Disabling (for all commands apart from Second Safety Open)

This is used to block the CB in the closed position by external interlocking logics. When the function is enabled (ticked) and the # CB Open Disabling input (DI e, non-configurable) is at low level “0” (no voltage on input or lower than activation threshold, about 10V AC/DC), no opening command is executed.
The function is Global, i.e. it blocks opening commands both from Local (CB HMI, Panel HMI or Open Command from local, default DI 13) and from Remote (Open Command from remote, default DI3 or from Communication).

Warning!

Use CB Open Disabling function with caution, as all Open Commands, apart from 2nd Safety Open, including those issued from protections, will be not executed. This condition might result in malfunction of protection functions.

Note

The Second Safety Open is not blocked by this function and will be executed.

14.5.5.2 CB Open Disabling for Second Safety Open only

It used to block the Second Safety Open Command. When the function is enabled (ticked), Second Safety Open (DI 16, non-configurable) is blocked by this function and will not be executed (see details).

Warning!

Use CB Open Disabling for Second Safety Open only function with caution, as 2nd Safety Open Command will be not executed. This condition might result in a severe malfunction.

CB Open Disabling (for second Safety Open only) is by default grey, not selectable, and can only be enabled (ticked) in the configuration when CB Open Disabling is enabled.

14.5.5.5 Second Safety Open Command

Second Safety Open Command is an emergency opening that can operate the HW opening of the CB even when the microprocessor (DSP) has failed, thus overriding all logic and SW states.

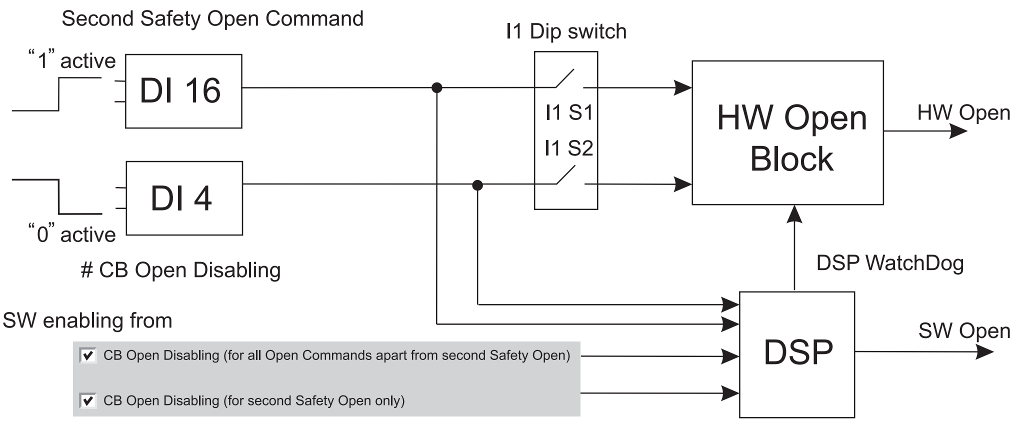


Fig. 36

The Second Safety Open is executed when DI 16, non-configurable, goes to high level "1" (voltage on input higher than activation threshold, about 16…20V AC/DC) in two modes:

a) DSP is working and the WD signal is ok

the Second Safety Open Command is executed by DSP as a SW opening if there is no SW blocking condition, i.e. when CB Open Disabling (for second Safety Open only) has not been enabled in the configuration

OR DI4, # CB Open Disabling is not active, i.e. it is at high level "1";

b) DSP fails and the WD signal enables the HW block

the Second Safety Command is executed as a HW opening if dip switch I1-S1 is closed (ON);

AND dip switch I1-S2 is open (OFF)
OR dip switch I1-S2 is closed (ON) and DI 4, # CB Open Disabling is not active, i.e. it is at high level "1";

14.5.5.5.1 HW configuration

The Second Safety Open operating mode is selected by setting Dip-Switch I1 (S1…S2) on the motherboard; by default I1-S1 is ON and I1-S2 is OFF, Second Safety Open HW block is enabled.

See figure below for I1 Dip switch location on the IED Motherboard

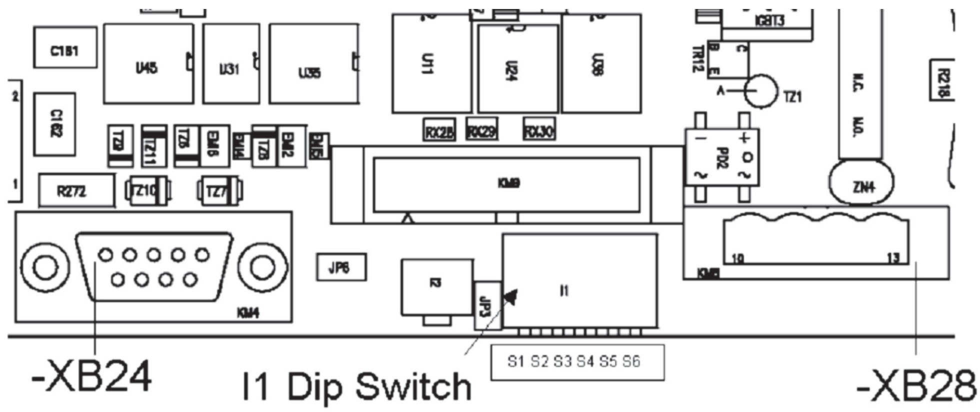


Fig. 37

14.5.5.6 Energy Failure Autotrip

The IED monitors the charge of the capacitors, continuously checking the voltage. When the CB is in the closed position there must be enough energy to carry out the opening operation (O), while if the CB is open there must be enough energy to close and then to open (CO) it. If there is not enough energy (level 'KO'), the CB must be locked in its position or opened if the Energy Failure Autotrip function is enabled

When Energy Failure Autotrip is enabled it will make the CB open when the external power supply is shut down or there is an internal energy failure. The Opening operation is typically performed within 1-2 minutes after auxiliary power failure depending on CB ratings, and the delay is due to discharging of energy stored in the internal capacitor by the IED.

An Anomaly alarm is issued and the No Anomaly LED on the CB HMI goes ON.

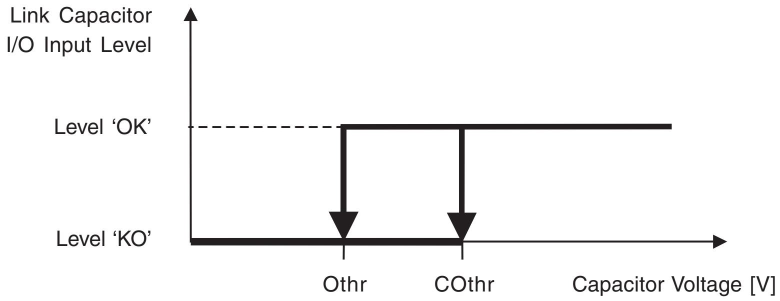


Fig. 38

The system is in 'Energy Failure status' when the capacitor charge is under the Othreshold ('KO' level).

The following behaviour is allowed:

CB position Capacitor Charge	Closed	Open
Energy sufficient for O-CO operations	**Opening allowed**	**Closing allowed**
Energy sufficient for CO operations	**Opening allowed**	**Closing allowed**
Energy sufficient for O operations	**Opening allowed**	**Blocked in open position**
Energy insufficient for any operation	**Blocked in closed position or CB immediately opened**	**Blocked in open position**

14.5.5.7 UnderVoltage

The IED monitors the voltage on UnderVoltage Binary input DI1 and the value is processed.

When the UnderVoltage function is enabled it will make the CB open when an undervoltage condition is detected; i.e. when the voltage drops below 70% of its nominal value. The UnderVoltage condition will only be reset when the voltage on DI1 becomes higher than 85% (ref. to IEC 60694.5.8.4).

The nominal voltage value is selected by setting the Dip-Switches S1 ... S4 on the I/O board.

14.5.5.7.1 SW configuration

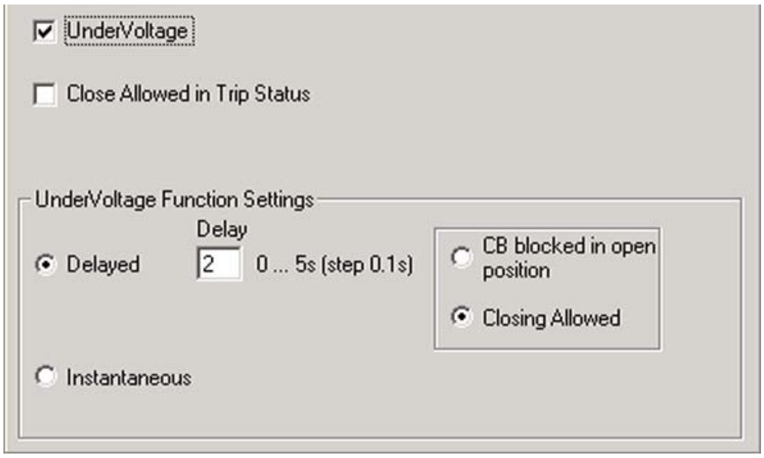


Fig. 39

When UnderVoltage function is enabled (ticked), UnderVoltage Function Settings is enabled and the function operation mode can be set:

Instantaneous: the function operates with no intentional delay when the UnderVoltage condition is detected;

Delayed: ticked by default. The function is started when the UnderVoltage condition is detected (voltage on DI1 falls below 0.70 of the dip-switch value setting). After the protection has entered the Detected status and the preset operating time (Delay) has elapsed, the opening signal is generated. An Anomaly alarm is issued and the No Anomaly LED on the CB HMI goes ON.

The UV function will come back in passive status and Reset if the voltage on DI1 exceeds 0.85 of the dip-switch value setting.

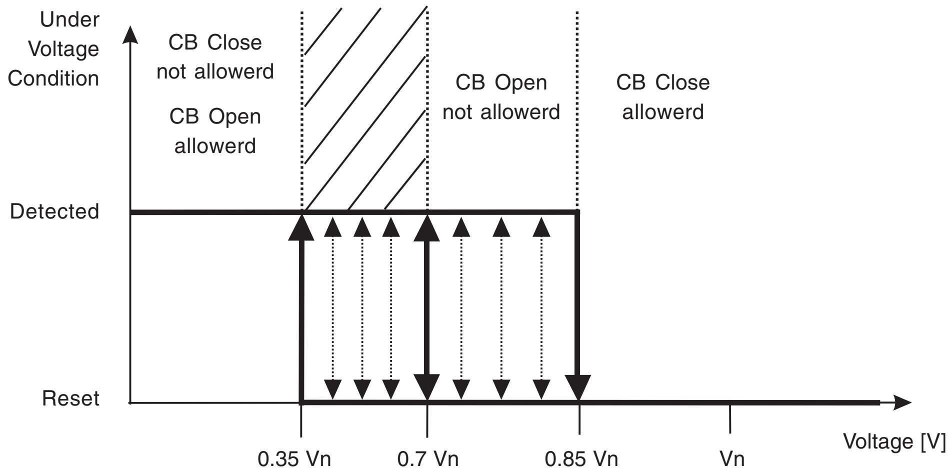


Fig. 40

The UnderVoltage Open and Close not allowed are in accordance with UnderVoltage according to IEC 60694.5.8.4.

CB blocked in open position: CB closing is not allowed after UV opening; the UV condition must be reset before closing is performed.

For ‘Instantaneous’ and ‘Delayed’ with 0s of operating time Closing Allowed option is not available.

Closing Allowed: ticked by default. CB closing is allowed after UV opening operation even if UV condition is detected. It is used for particular applications, like supervision of the Supply Voltage of a MV motor via a VT, where the CB powers the motor).

CB position UnderVoltage condition/Function select	Open	Closed
Reset/Enabled or Detected/Disabled	Closing allowed	Opening allowed
Detected/Enabled, Close block enabled (by CoT)	CB blocked in open position	Automatic opening performed
Detected/Enabled, Close block disabled (by CoT)	Closing allowed	Automatic opening performed

In both cases (Close block enabled or disabled) during UnderVoltage timing, opening commands via control panel pushbuttons or external inputs will be performed normally.
If the UnderVoltage Close block is disabled (Closing Allowed is enabled) and the voltage on the relative external UV input is absent, the CB can be closed; the function timing will start again when microprocessor reads the CB closed position.
If the ANSI Re-close function is activated during UnderVoltage timing, the CB will not be re-closed, but only opened.

Note

In general when a protection function (overcurrent, ...) is enabled, and the fault condition is detected, it is not possible to disable or change the function setting until the fault condition is cleared. The UV function also allows the disabling of the function by CoT when an UV condition is detected.

14.5.5.7.2 HW configuration

The UnderVoltage function nominal voltage value is selected by setting Dip-Switches I1 (S1…S4) on the I/O board.
The figure below shows the voltage range selectable, by default the 100Vac – 127Vdc range is selected.

Dip Switches I1 on I/O board				Threshold
S1-off	S2-off	S3-off	S4-off	220…240 Vac/dc
		S3-on	S4-on	100…127 Vac/dc
S1-off	S2-off			
	S2-on	S3-on	S4-on	48…60 Vac/dc
S1-off				
S1-on	S2-on	S3-on	S4-on	24…30 Vac/dc
S1-on	S2-on	S3-on	S4-on	all others configuration are not used
S1-off	S2-off	S3-off	S4-off	

See figure below for I1 Dip switch location on I/O board:

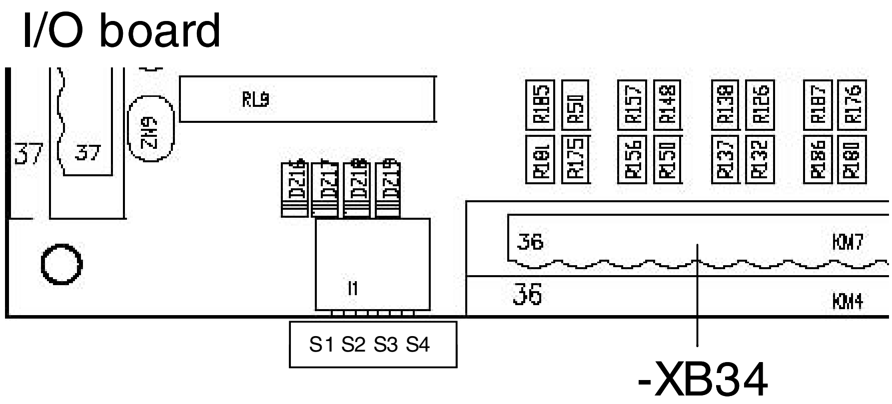


Fig. 41

14.5.5.8 Close allowed in trip status

After a protection TRIP, the general Trip signal is latched, i.e. the signal status remains high after all protections exit the TRIP status. It can be reset by means of the dedicated “Protection Trip Signal Reset” input or the Reset pushbutton on the HMI. Until the trip reset is executed no close command is accepted. This built-in logic requires an active operation (reset) before enabling re-closing on a possible fault condition, as the CB was opened by a protection trip.
The “Close allowed in trip status” tick box enables this logic block to be overridden. When the function is enabled (ticked) a close command can be executed before resetting the latched Trip signal. The aim is to enable performance of re-closure cycles controlled by an external logic. A typical example is a re-closure sequence (e.g. O-0.3s-CO- 3s CO - 15s – CO) on an overhead line where transient faults may occur and be cleared by sequence.

14.5.5.9 Trip in case of current overflow

The IED monitors the currents up to 25 times the Nominal Primary Current value entered in the General Settings, In. The protection setting range is limited to 20 times In.
Therefore under fault conditions the phase current signal will always “saturate” above the maximum protection threshold set and the phase protection will always operate correctly.
Protections based on the calculation of current values (i.e. Unbalanced load and calculated Earth fault) will be affected by the phase current signal saturation as it occurs separately on the three phases, in particular for low values of the Nominal Primary Current when 25 In is lower than the CB short-circuit rating (25 kA or 31 kA).
The “Trip in case of current overflow” tick box enables the function that will operate a Trip whenever phase current saturation occurs. This function is not ticked by default and can only be enabled in service access mode.

14.5.6 Additional built-in Functionality

14.5.6.1 Unit Ready Monitoring

The Ready LED on the CB HMI and relative "READY/NOT READY" contacts signal the CB is Ready to operate when the following conditions are true:

- capacitor is charged
- WatchDog OK (uP is operative)
- detection of correct "CLOSED" and "OPEN" CB status by the position sensors
- blocking anomalies status are active (see par. 14.14).

Note

In Unit Not Ready status all Close commands (both local and remote) are ignored. The Open command is always allowed if energy for opening is sufficient and opening coil continuity is Ok.

The Ready LED on the CB HMI will go off if position sensor indication or coil continuity is lost. It will flash when the capacitor voltage (i.e. the stored energy) is below the maximum charge level until there is enough energy for an opening or closing operation.

14.5.6.2 Actuator Coil Supervision

The IED monitors the actuator opening and closing coil continuity. It verifies that both coils are connected and not interrupted (they are both not in open circuit condition).
When this condition is true, the "Coil OK" LED on the CB HMI goes ON.
When the function becomes false an Anomaly alarm is issued, the No Anomaly LED on the CB HMI goes ON, the Coil Continuity LED goes OFF and the IED can enter Not Ready status, depending on the CB position and which coil fails, according to the following cases:

CB position Coil continuity condition	Closed	Open
Closing coil continuity incorrect	Unit Ready Unit in wait state for Open command only	Unit Not Ready Unit does not carry out any command
Opening coil continuity incorrect	Unit Not Ready Unit does not carry out any command	Unit Not Ready Unit does not carry out any command

14.5.6.3 Capacitor load voltage Supervision

The IED monitors the charge of the capacitors, continuously checking the voltage. During the capacitor charging phase, when the maximum charging level is exceeded, an automatic Power Supply shutdown is performed, to avoid damage to the capacitor.

The voltage on capacitor output (normally $80V_{dc}$) must not exceed $90V_{dc}$ .At this value the Power Supply is turned off according to the following diagram:

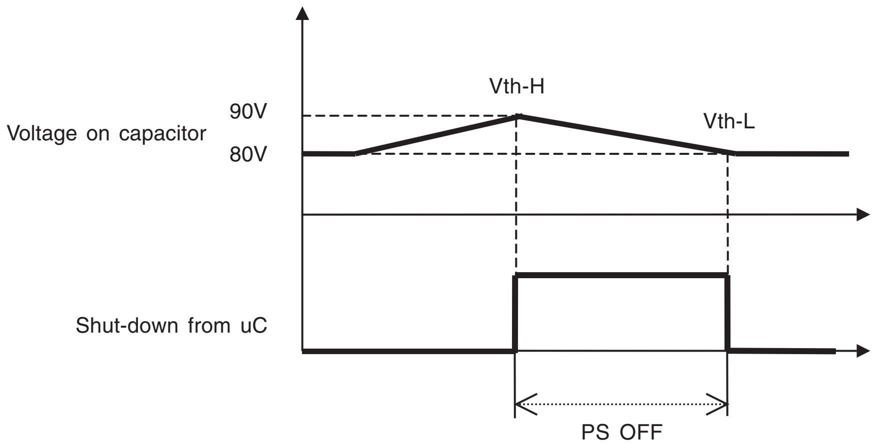


Fig. 42

14.5.6.4 Wrong Position Auto-Trip

Wrong Position Auto-Trip is performed to reach the open position following detection of wrong circuit-breaker state, inconsistent (both open and closed position signalled simultaneously) or absent position indication.

An automatic CB opening is performed when either Close or Open operation is not completed (the CB does not reach the desired position) at the maximum time Tmax of 70ms:

1 – CB remains in initial position (for Open operation only)
2 – CB reaches a wrong intermediate position
3 – CB touches the final position but bounces into a wrong intermediate position

If the Auto-trip opening command is carried out properly, the IED will be READY for another operation.

In case the Auto-trip opening command is not completed as well, the IED:

- will remain in READY in above case 1, until the Maximum unsuccessful attempts have been carried out.
- will become NOT READY in above cases 2 and 3, until the CB is put back into the correct position manually.

Wrong Position Auto-Trip is performed if - at power-on reset (IED start-up) - the CB is in a wrong intermediate position.

This function is always enabled, in case of Wrong Position Auto-Trip an Anomaly alarm is issued and the No Anomaly LED on the CB HMI goes ON.

14.5.6.5 Maximum unsuccessful attempts

This built-in function manages a maximum of 10 accumulated (1) unsuccessful attempts to operate (open or close) the CB, i.e. when either Close or Open operation is not completed (the CB does not reach the desired position) at the maximum time Tmax.
The Maximum unsuccessful attempt function limits the stress on the IED power drive components and signals the Anomaly condition to the operator.
An Auto-trip opening is carried out after each failed attempt.
In the case of a failed opening operation, other opening attempts will be launched until the opening input remains active.
In the case of a failed closing operation, an Auto-trip opening will be made. For another closing attempt it will be necessary to re-activate the closing signal.
When the number of Maximum unsuccessful attempts is reached an Anomaly alarm is issued and the No Anomaly LED on the CB HMI goes the "Not Ready" Status. The "Unit Ready" LED turn off.

(1) The maximum number of unsuccessful operation attempts is cumulative, i.e. the IED stores the unsuccessful attempts. Only 10 unsuccessful attempts (10 opening operations and 10 closing operations) are allowed. If the operation is not carried out for any reason, a further 9 attempts are possible. If the second attempt is completed successfully, there remain a further 9 "unsuccessful" attempts, whereas if it is not carried out correctly, a further 8 attempts are available, and so on. After 10 unsuccessful attempts, the unit passes into the "Not Ready" state and signals the anomaly. In that case, it is necessary to reset the unit (disconnect the auxiliary power supply and discharge the capacitors). Normal operations with positive outcome do not increase the counter. This function preserves the IED components and obliges the operator to check the circuit-breaker.

14.5.6.6 Trip Free Function

Trip Free[2] is the capability of the CB to have the moving contacts return to and remain in the open position when the opening operation is initiated after the closing operation is started, even if the closing force and command are maintained.

⚠ Note

To ensure proper breaking of the current that might be established, it may be necessary for the contacts to momentarily reach the closed position.

The opening operation prevails over the closing operation. The IED opens the CB when a tripping signal is received while a closing operation is being executed, even if the closing signal is maintained.

⚠ Note

The Open command (both local and remote) always has priority over the close command: the Open command must be processed on positive edge event but it is active with priority for the whole time its state is high. In any case and condition, when the ED intercepts a valid Open Command, this has to be performed as soon as possible (if necessary, it can be stored and performed later on). The Open command is always possible independently of the CB status.

14.5.6.7 Anti-Pumping (Pump-Free) Function

The anti-pumping function ensures that only one closing-opening cycle is carried out when a closing command followed by an opening command is active. The active closing command must be cancelled and reset to perform a new closing operation.
The IED prevents re-closing after an opening operation as long as the Close Command is maintained in the position for closing (active).
This function is only active when the CB is in the open position. If the close command is released before the open command (positive edge event), the function is not active and the closing-opening sequence is performed.

(2) According to ANSI IEEE Std. C37.100-1992 requirements.

When the close command is removed, the anti-pumping function is reset. This is a Global function, i.e. the function manages both Local and Remote O/C commands.

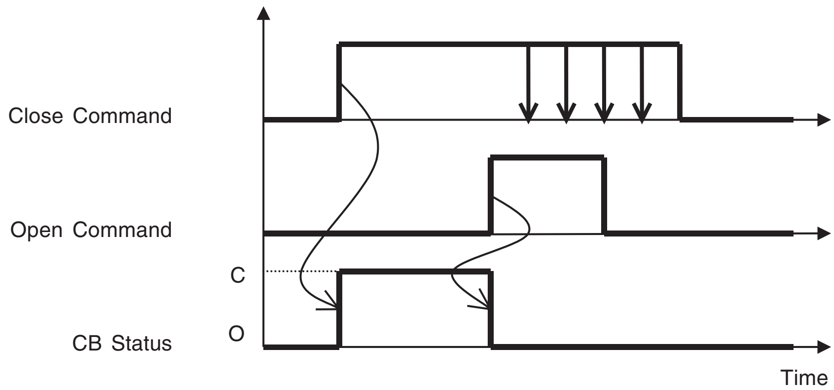


Fig. 43

14.5.6.8 Simultaneous O-C Commands

This function ensure that closing is disabled when an opening command is active at the same time In the case of simultaneous open and close commands (when closing and opening have different delays before being considered valid, e.g. 10ms for closing and 20ms for opening), opening has higher priority and closing will not be executed, independently of the CB position (e.g. with the Re-close function, too, opening has higher priority): the ED will not close the CB if – at the end of the closing signal delay – the delay time of the opening signal is already running. See figure below:

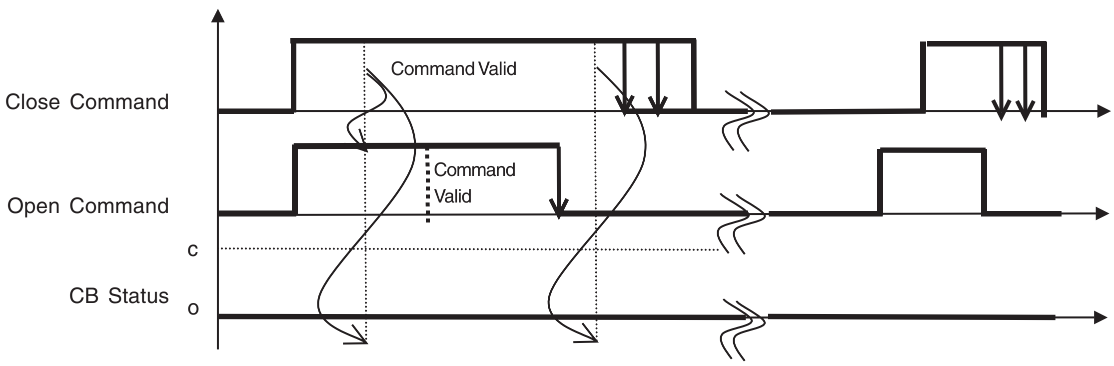


Fig. 44

In correspondence with release of the Open command, if the Close signal is still high the CB will not be closed because the Close command is only considered valid on positive edge front.
If the closing operation is initiated and in the meantime a valid Open Command has arrived, it has to be stored and performed as soon as possible (as soon as the close operation is ended).
In the case where the CB is already closed, the CB opens.

14.6 Logic Configuration

The Logic Configuration Tab enables management of the logical output Start and Trip signals of the protection function and use of external signals to block them.

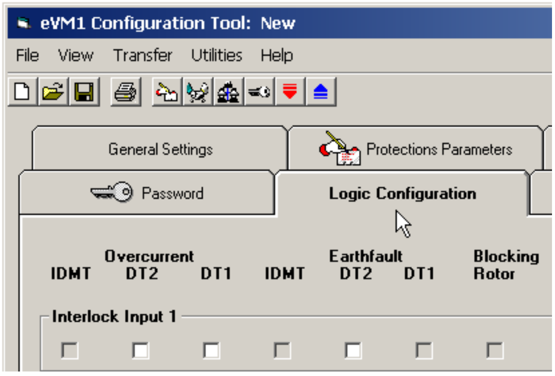


Fig. 45

14.6.1 Logical interface of protection functions

The input/output signals described below are logical quantities inside the Circuit-breaker controller. They are not generally available one by one at the breaker interface and can be made available as a digital input/output through the logic configuration and input/output mapping (see chapter: Input / Output Mapping).

In the next figure, the logical block of a generic protection function (n) is shown.

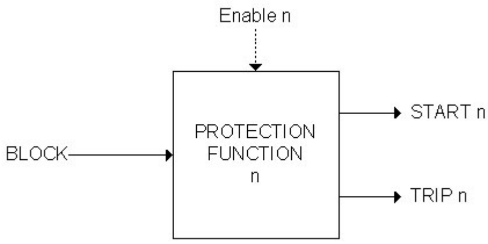


Fig. 46 Logical Block of a generic Protection Function (n)

14.6.1.1 Protection Logic, Input Signals

Enable:

Each protection function is independently activated (ENABLED) in the “Protection Parameters” dialogue window when the protection box is ticked. When a Protection Function is not enabled, the corresponding Start and Trip outputs are inactive and its status is forced to DISABLE.

BLOCK

The BLOCK signal can come from 2 dedicated digital inputs and from the Motor Start protection function.

Each protection function can be configured to be blocked by any of these sources.

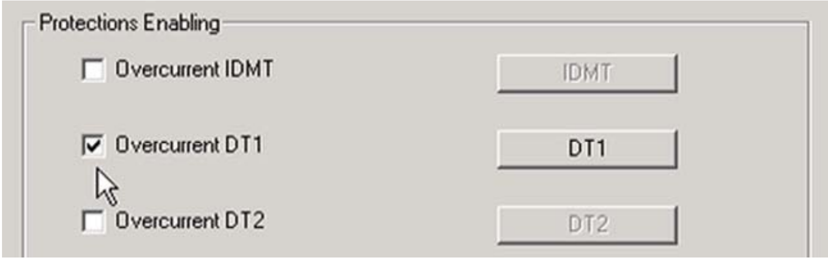


Fig. 47

When the Block signal is active the protections to be blocked are reset, put in PASSIVE status and are temporarily disabled; all internal registers and timers are cleared. The protection function will then remain in the idle state until the Block signal goes low.
When the Block signal disappears the blocked protections are re-enabled.

Note

Blocking a protection function always implies a delay in protection operation; only when the block signal is released does the protection become active and, if the start conditions are true, begins to count. After the block release, the set protection time delay has to expire before the protection trips.

BLOCK from Motor Start protection

Each active protection function can be blocked by the Motor Start protection in the Motor Start configuration pop-up window.
The active protections have a selectable box. When the Motor Start protection enters the START status all the ticked protection functions will be put into PASSIVE status and are temporarily disabled; all internal registers and timers are cleared.
In the example below, the Motor Start blocks overcurrent protection DT1.

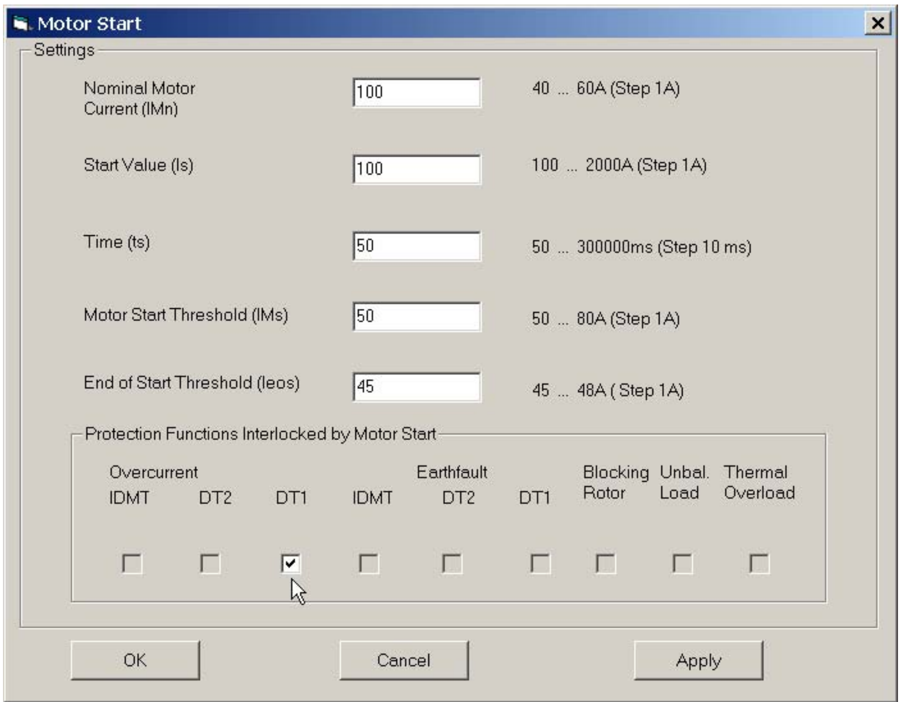


Fig. 48

BLOCK from Interlocking Inputs:

Each active protection function can be blocked by the Interlocking inputs in the Logic Configuration Tab Window.
The active protections have a selectable box. When the relative Interlocking Input is active (i.e. a voltage above the activation threshold is applied) all the ticked protection functions will be put into PASSIVE status and are temporarily disabled; all internal registers and timers are cleared.
In the example below, Interlocking Input 1 is used to block all overcurrrent protections while Interlocking Input 2 is used to block all earth fault protections.

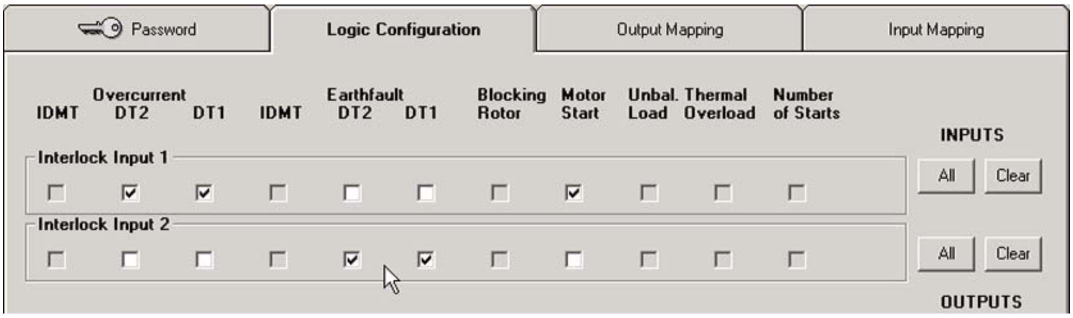


Fig. 49

14.6.1.2 Protection Logic, Output Signals

Each protection of the Start and Trip logical outputs are only active when the function is in Start or Trip status respectively.
By combining Start and Trip logical outputs from Protection Functions, the general Start and Trip signals are obtained and can be provided through available digital outputs (Protection Start 1 or Protection Start 2, Protection Trip 1 or Protection Trip 2).

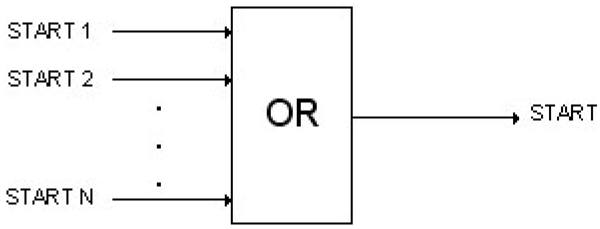


Fig. 50 Logical Network for START signal

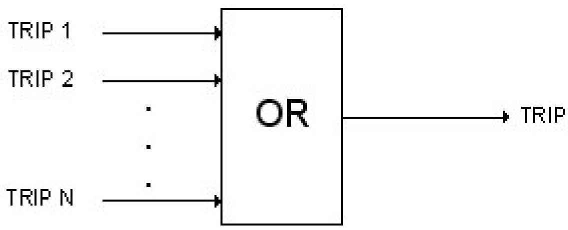


Fig. 51 Logical Network for TRIP signal

The General Start signal is active if at least one protection function is in START status; the General Trip signal is active if at least one protection function is in TRIP status.
It must be noted that general START and TRIP can become active when the unit is not in Ready status. The protection Trip will then operate the CB if the conditions for an Open operation are true. The General Trip signal is latched, i.e. the signal status remains high after all protections exit the TRIP status. It can be Reset through the dedicated "Trip Signal and Anomaly Reset" input, the Reset pushbutton on the Panel HMI or from Configuration Tool by the Reset pushbutton in the Monitoring Tab.

Warning!

General trip latched signal indicates the CB has been opened by a protection intervention because a fault condition has been detected. Re-closing of the CB is not allowed until Reset (see Close allowed in Trip status for exceptions).If no Reset means are available, pushing the local CB HMI opening pushbutton for 5s resets the trip signal. Remember that a re-close on network faulty condition is then possible.

Interlock Output 1 and 2: Interlock Output 1 and Interlock Output 2 are Start signals, and all enabled protection function can be mapped on these signals on the Logic Configuration Page. In the example below:

- all the active overcurrent protection trip signals are combined to generate the general trip Protection Trip 1 signal while general start Protection Start 1 is not used;
- the start signals of all the active earth fault protections are combined to generate the general start Protection Start 2 signal; the relative trip signals are combined to generate the general trip Protection Trip 2 signal.
- Blocking Rotor protection Start and Motor Start protection Start are mapped on the generic Interlock Output 1 and Interlock Output 2.

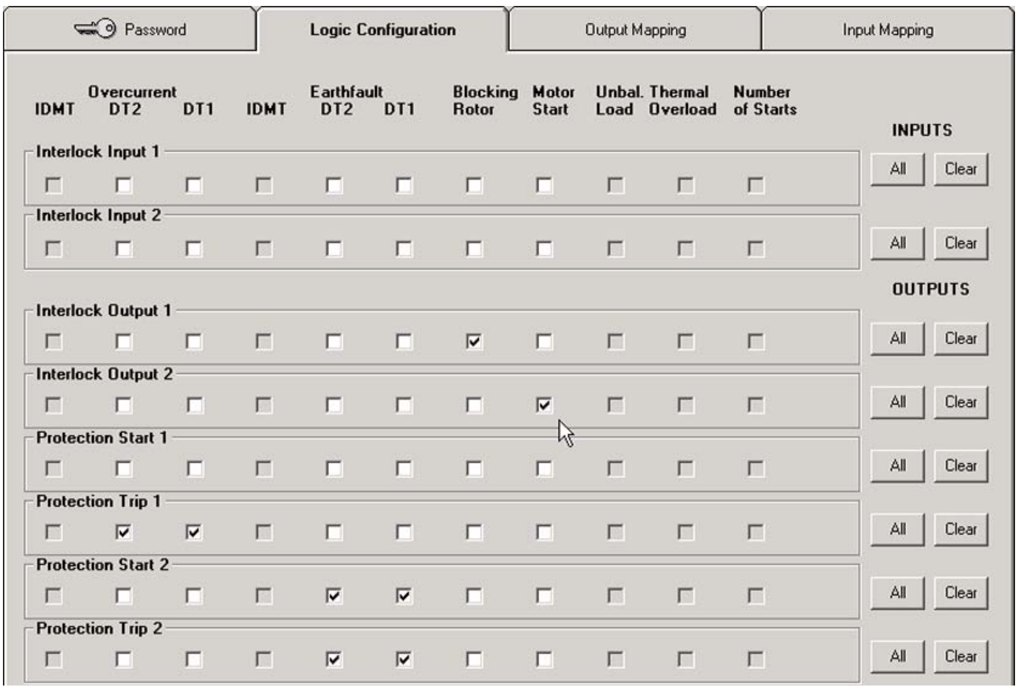


Fig. 52

This logic configuration of the enabled Start/Trip protection signals can be mapped on physical digital outputs as in the example below, where all six available signals are mapped on DO9,10,11,12 and 14,15. Protection Start 1 signal will always remains inactive (low) and DO10 open, as it has not been configured in the Logic Configuration window.

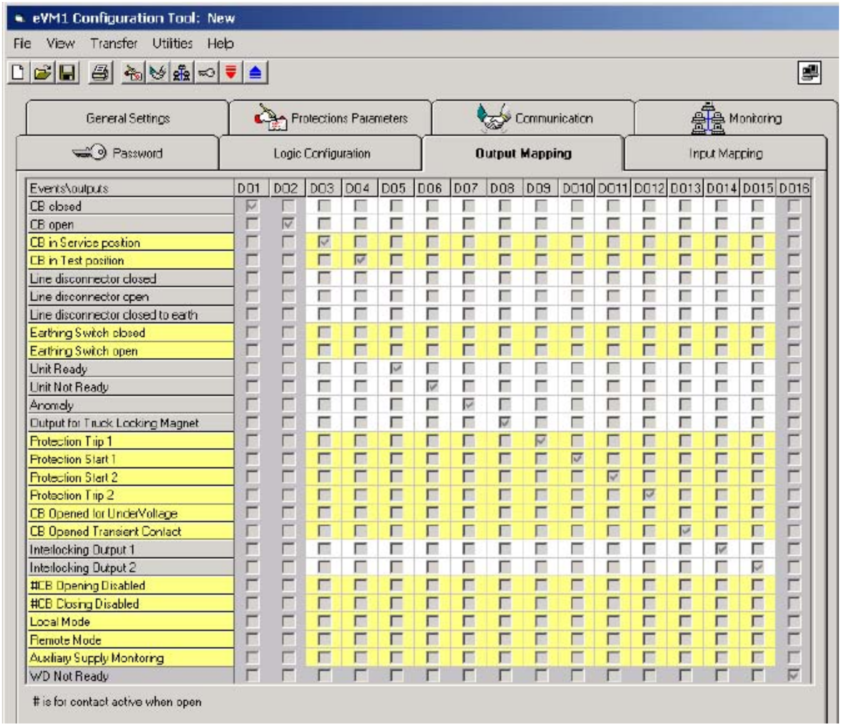


Fig. 53

14.7 Protection Parameters

Two protection sets are available; the basic set provides various types of phase overcurrent and earth fault overcurrent, and the full set adds motor protection functions. All protection functions are according to IEC 60255-3 and IEC 60255-8 Standards.

Name	Basic set	Full set
51 Overcurrent IDMT (NI, VI, EI, LI)	Yes	Yes
50 Overcurrent DT1	Yes	Yes
50 Overcurrent DT2	Yes	Yes
51N Earth fault IDMT	Yes	Yes
50N Earth fault DT1	Yes	Yes
50N Earth fault DT2	Yes	Yes
51 MS Motor start protection	No	Yes
66 Number of starts	No	Yes
51 LR Locked Rotor	No	Yes
49 Thermal overload	No	Yes
46 Unbalanced load	No	Yes

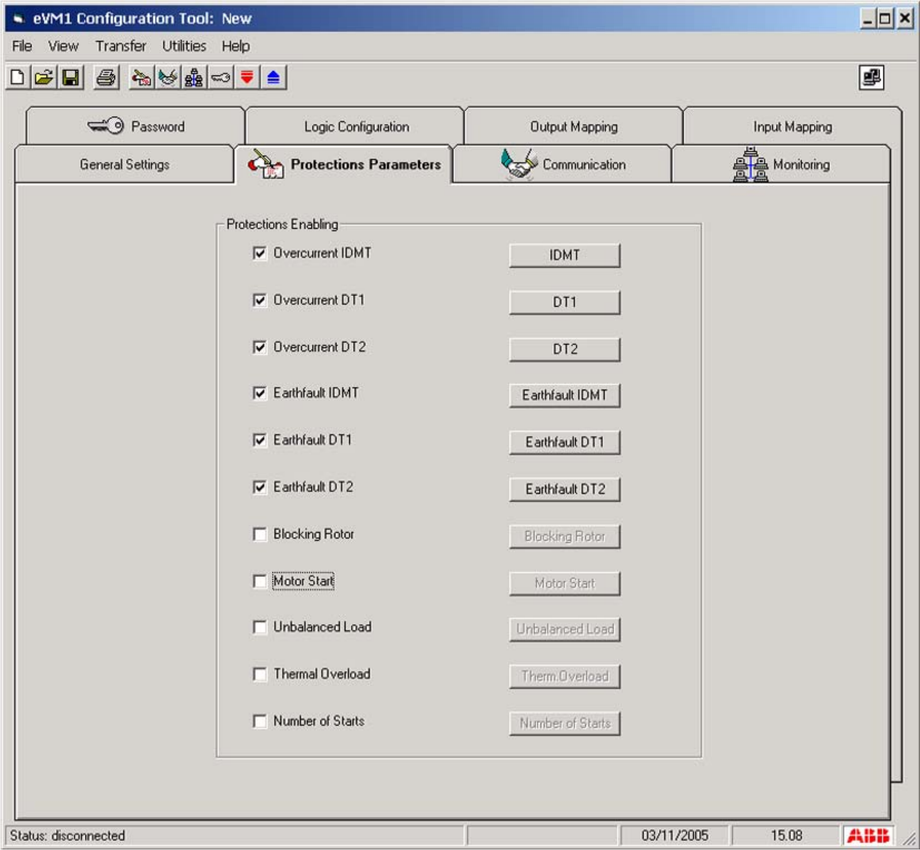


Fig. 54

Available protection functions can be independently activated in the “Protection Parameters” dialogue window by ticking the relative box.

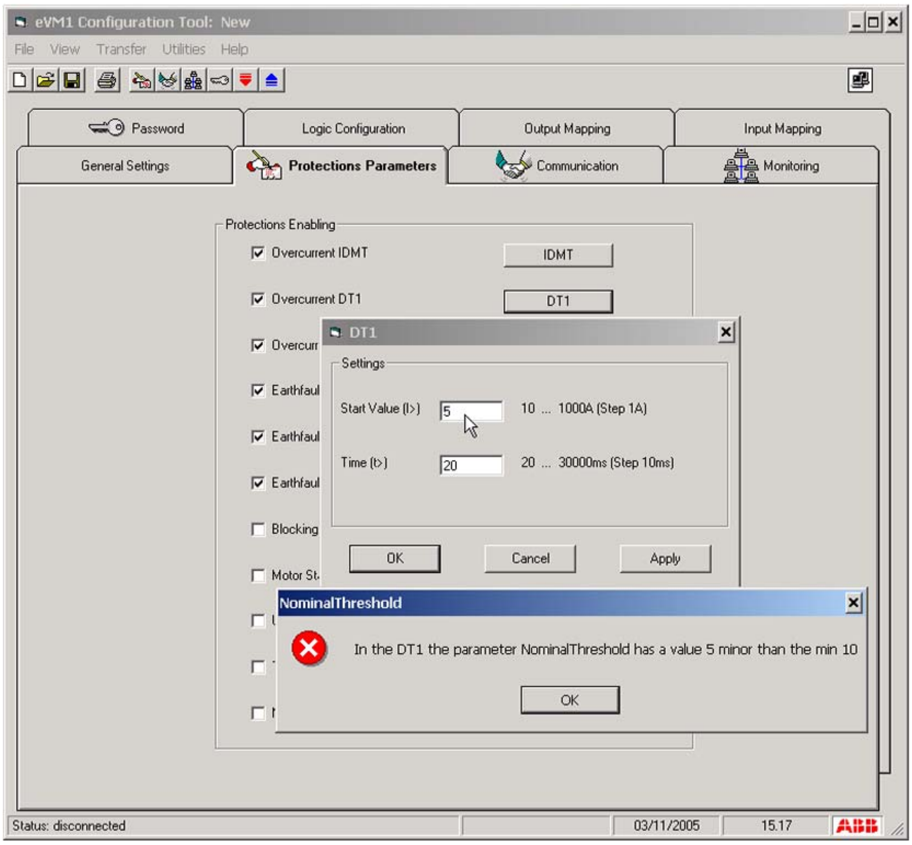


Fig. 55

When a protection is ticked it is enabled and the relative setting button is active; the protection parameters setting window will be opened by clicking the setting button.
The parameters can be modified and a check of their ranges is made before applying the new values.

14.7.1 General Protection Machine State

The machine state for a generic protection is shown in the figure below.

C1: The start condition is False for phases a, b, and c.
C2: The start condition is True for at least one phase.
C3: The start-drop off condition is True for all the phases.
C4: The start condition is True and t< Trip for at least one phase.
C5: The condition of start persistency is True and t< Trip for at least one phase.
C6: The condition of start persistency is True and t> Trip for at least one phase.
C7: The condition of trip persistency is True for at least one phase.
C8: The trip drop-off condition is True for all the phases.
C9: The logic state Block input is active.

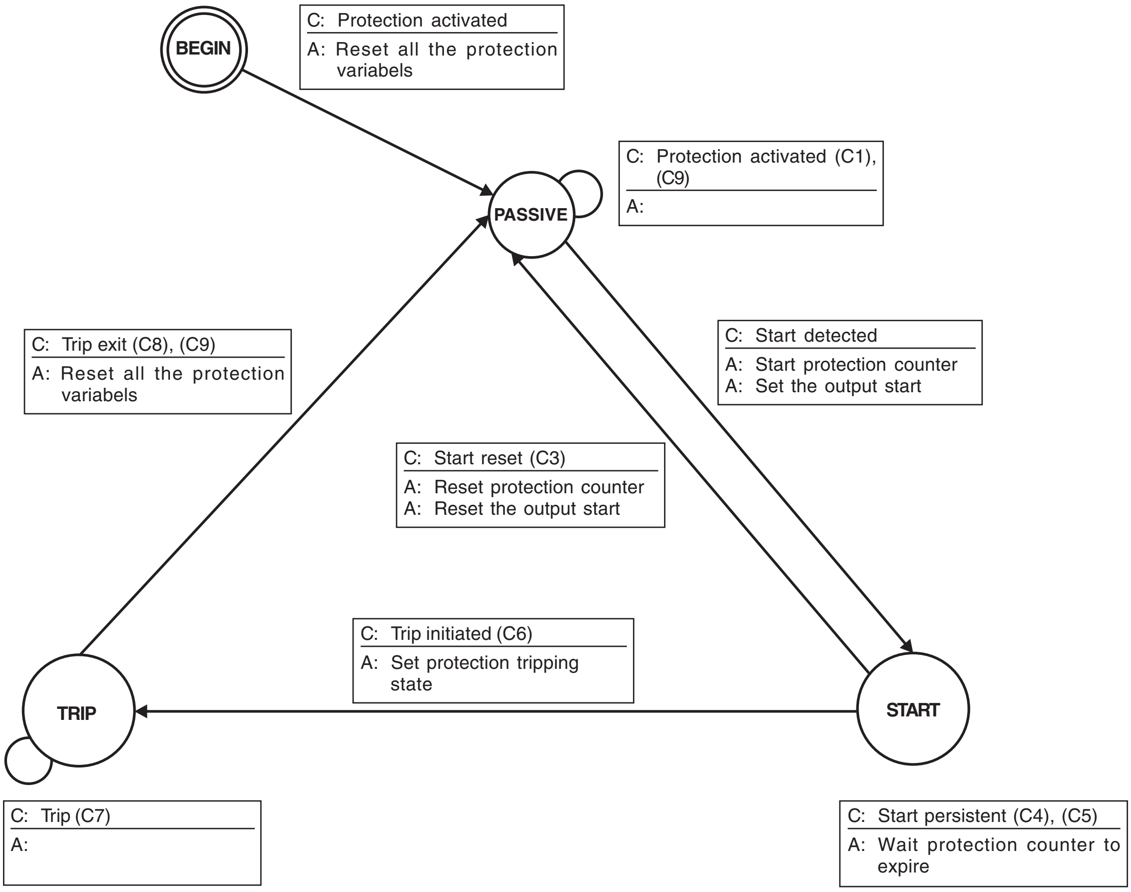


Fig. 56 General Protection Machine State

When the block input is passive and the measured current exceeds the setting threshold value (Start Value), and pick-up value, the protection function is started. If the value of at least one phase current is above the setting threshold value then the relative start signal will be activated. The protection function will remain in START status until there is at least one phase started. It will return to passive status and the start signal will be cleared when the block input becomes active or at drop-off value, if the current falls below 95% the set threshold value for all the phases.

After the protection has entered the start status and the preset operating time (Time) has elapsed, the function goes into TRIP status and the trip signal is generated.
The protection function will exit the TRIP status and the trip signal will be cleared when the measured current value falls below 0.4 of the set threshold value or when the block input becomes active.
If a different Machine State diagram characterises a protection function it will be represented in the specific paragraph of that function.

14.7.2 Current protection functions, Basic set

14.7.2.1 Definite Time Overcurrent Protection

Two overcurrent definite time protection functions are available. Each of them can be activated independently:

- Overcurrent definite time low setting DT1 (I>)
- Overcurrent definite time high setting DT2 (I>>)

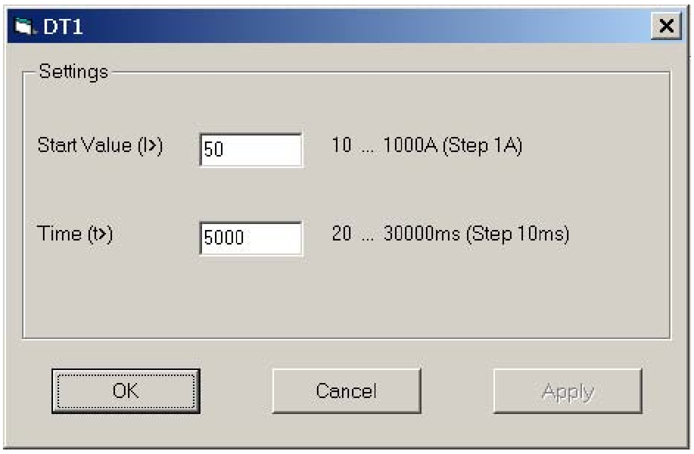


Fig. 57

14.7.2.1.1 Parameters

Start Value (I>): Current threshold for overcurrent condition detection.
Time (t>): Time delay for overcurrent Trip condition detection.

Parameter	Values	Default	Step	Unit	Explanation
Start Value DT1, I>	0,20 … 20 p.u. of In	1 In	1	A	Current threshold.
Time, t>	20 … 30000	5000	10	ms	Time delay.
Start Value DT2, I>>	0,20 … 20 p.u. of In	10 In	1	A	Current threshold.
Time, t>>	20 … 30000	100	10	ms	Time delay.

The threshold setting range is expressed in primary current Ampere [A], up to tens of In where In is the Nominal Primary Current value entered in the General Settings.

14.7.2.1.2 Operation criteria

If the measured RMS current exceeds the setting threshold value (Start Value) for at least one phase, the overcurrent protection function is started.

The protection function will remain in START status until there is at least one phase started. It will return to passive status and the start signal will be cleared if the current falls below 95% of the setting threshold value for all the phases.

After the protection has entered the start status and the preset operating time (Time) has elapsed, the function goes into TRIP status and the trip signal is generated.

The protection function will exit the TRIP status, the trip signal and the counter will be cleared when the measured current value for all the phases falls below 40% of the setting threshold value.

When the two overcurrent definite time functions are active simultaneously an overcurrent time-step characteristic can be generated, as shown in the following figure.

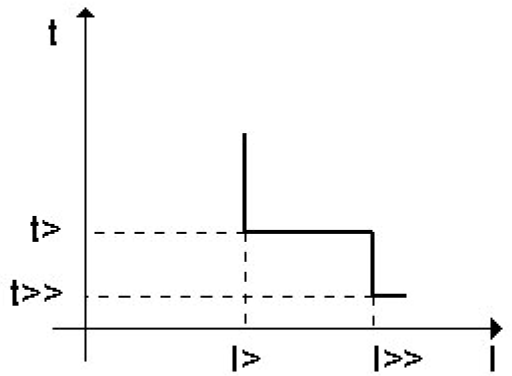


Fig. 58 Schematic view of the definite time tripping steps

14.7.2.2 Overcurrent IDMT

One IDMT protection function is available in which one of the four current-time characteristics can be activated at a time:

- Normal inverse,
- Very inverse,
- Extremely inverse and
- Long-term inverse.

14.7.2.2.1.1 Parameters

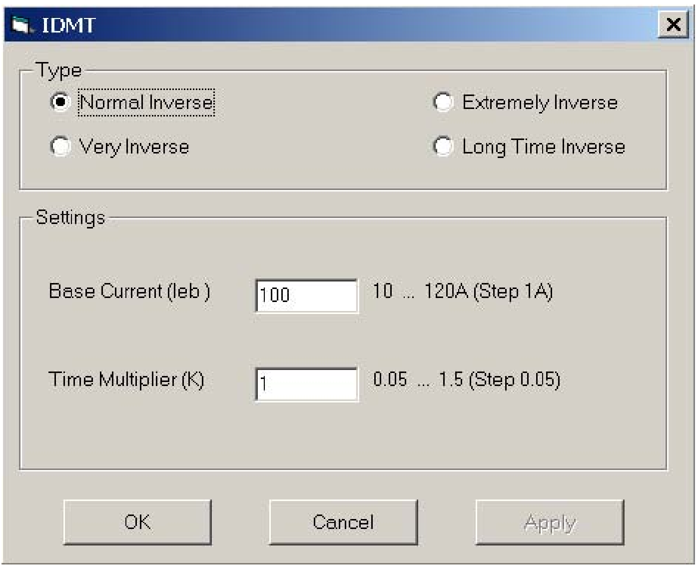


Fig. 59

Type:	Tripping characteristic according to the IEC 60255-3 curve definition.
Base current (Ieb):	Current threshold for start condition detection.
Time multiplier (k):	Time multiplier to vary time delay for Trip condition.

The trip time is calculated according to British Standard (BS 142) when the time multiplier k is used. When the time multiplier k is set to one (k=1) the IDMT curve is in accordance with IEC 60255-3.

Parameter	Values	Default	Step	Unit	Explanation
Type	NI, VI, EI, LTI	NI	–	–	Tripping curve.
Base Current (Ieb)	0.20 … 2.40 p.u. di In	2.0 In	1	A	Current threshold.
Time Multiplier (K)	0.05 … 1.50	1	0.05	–	Time multiplier (BS 142).

The threshold setting range is expressed in primary current Ampere [A], up to 2.40 In where In is the Nominal Primary Current value entered in the General Settings.

14.7.2.2.2 Operation criteria

If the measured RMS current exceeds the setting threshold value (Base current Ieb), by a factor of 1.2 for at least one phase, then the protection function is started.
The protection function will remain in START status until there is at least one phase started. It will return to passive status and the start signal will be cleared if the current falls below 115% of the setting threshold value for all the phases. When the protection enters the start status the operating time is continuously recalculated according to the set parameters and measured current value. If the calculated operating time is exceeded, the function goes into TRIP status and the trip signal becomes active.

The operating time depends on the measured current and the selected current-time characteristic. The formulas for the trip time according to British Standard (BS 142) and IEC 60255-3 are reported in the chapter: IDMT Protection Time-Current Characteristics.
The protection function will exit the TRIP status, the trip signal and the counter will be cleared when the measured current value for all the phases falls below 40% of the setting threshold value.
The overcurrent time-step characteristic shown in the next figure is obtained when the two definite time functions are combined with the IDMT. The IDMT function is generally used to provide low current protections with an exponential characteristic threshold.

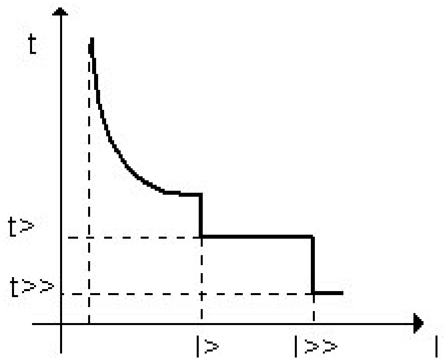


Fig. 60 Schematic view of the definite time and IDMT tripping characteristic

14.7.2.3 Earth fault Definite Time Overcurrent Protection

Two earth fault overcurrent definite time protection functions are available. Each of them can be activated independently:

- Overcurrent definite time low set Earth fault DT1 (Ie>)
- Overcurrent definite time high set Earth fault DT2 (Ie>>)

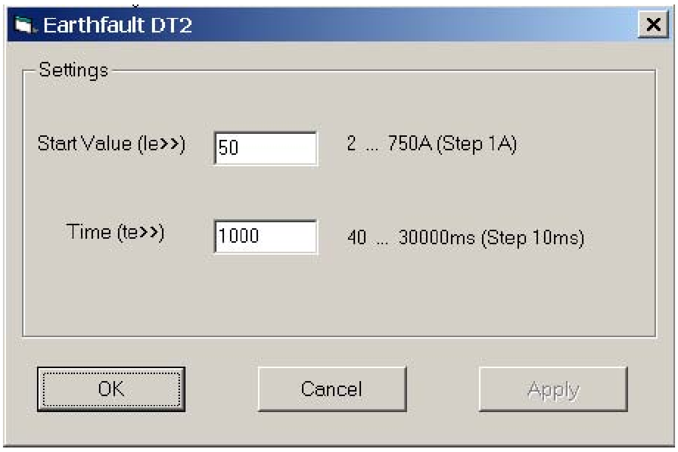


Fig. 61

Start Value (Ie>>):	Current threshold for earth fault condition detection.
Time (te>>):	Time delay for earth fault Trip condition detection.

Parameter	Values	Default	Step	Unit	Explanation
Start Value DT1, Ie>	0,30 … 15 p.u. di Ien	0.3 Ien	1	A	Earth fault Current threshold.
Time, te>	40 … 30000	40	10	ms	Earth fault Time delay.
Start Value DT2, Ie>>	0,30 … 15 p.u. di Ien	1 Ien	1	A	Earth fault Current threshold.
Time, te>>	40 … 30000	1000	10	ms	Earth fault Time delay.

The threshold setting range is expressed in primary current Ampere [A], up to tens of Ien where Ien is the CCT Earth Nominal Primary Current value entered in the General Settings. When the CCT presence box is not ticked, Ien is calculated by summing the three phase currents and setting range limits are referred to In - The Nominal Primary Current.
When Ie is measured directly (by ticking CCT presence box under “General settings”) Start Value begins from 0,05 Ien.

14.7.2.3.1 Measurement mode

Earth fault definite time protection functions evaluate the RMS residual current at the fundamental frequency in two ways:

- direct measurement of earth fault current at the dedicated analog input via an external residual current transformer (the lowest Start Value setting allowed is 0.05 Ien as the protection is more sensitive), or
- neutral current calculated by the vectorial sum of the three phase currents.

Ticking the CCT presence box in the General Settings enables the direct measurement mode.

14.7.2.3.2 Operation criteria

If the measured or calculated RMS earth current exceeds the setting threshold value (Start Value), the earth fault protection function is started.
The protection function will return to passive status and the start signal will be cleared if the earth current falls below 95% of the set threshold value.
After the protection has entered the start status and the preset operating time (Time) has elapsed, the function goes into TRIP status and the trip signal is generated.
The protection function will exit the TRIP status and the trip signal will be cleared when the earth current value falls below 40% of the setting threshold value.
An overcurrent time-step characteristic can be generated when the two overcurrent definite time functions are active simultaneously, as shown in the following figure.

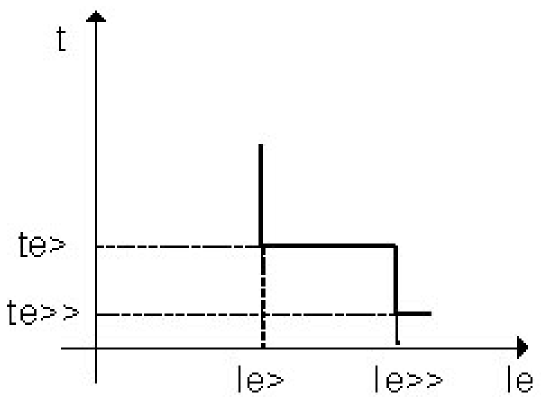


Fig. 62 Schematic view of the earth fault definite time tripping steps

14.7.2.4 Earth fault IDMT

The dependent time earth fault current protection, like the IDMT, is a time-delay function with a set of hyperbolic current-time characteristics. One earth fault IDMT function with one out of four selectable current-time characteristics can be activated:

- Normal inverse,
- Very inverse,
- Extremely inverse and
- Long-term inverse.

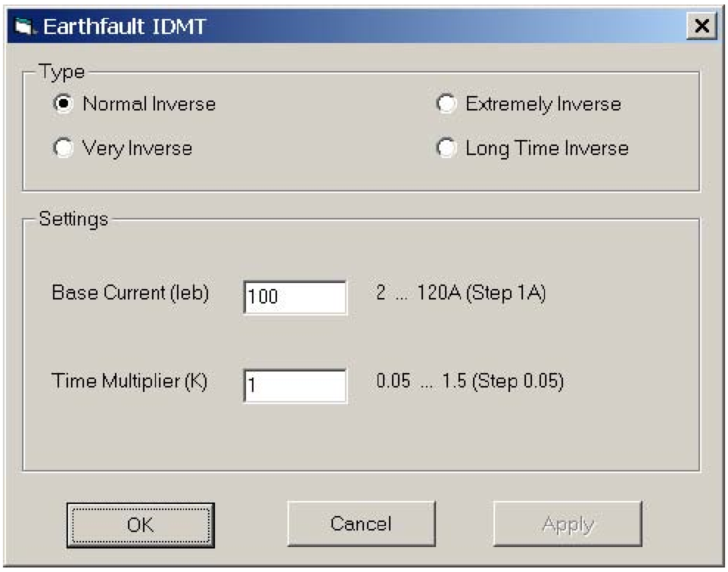


Fig. 63

Type: Tripping characteristic according to the IEC 60255-3 curve definition.
Base current (Ieb): Current threshold for start condition detection.
Time multiplier (k): Time multiplier to vary time delay for Trip condition.

The trip time is calculated according to British Standard (BS 142) when the time multiplier k is used. When the time multiplier k is set to one (k=1) the IDMT curve is in accordance to IEC 60255-3.

Parameter	Values	Default	Step	Unit	ExplanationType
Type	NI, VI, EI, LTI	NI	–	–	Tripping curve
Base Current (Ieb)	0.30 … 2.40 p.u. di Ien	2 Ien	1	A	Current threshold
Time Multiplier (K)	0.05 … 1.50	1	0.05	–	Time multiplier (BS 142).

The threshold setting range is expressed in primary current Ampere [A], up to 2.40 Ien where Ien is the CCT Earth Nominal Primary Current value entered in the General Settings.
When the CCT presence box is blank Ien is calculated by summing the three phase currents and setting range limits are referred to In, the Nominal Primary Current. The lowest Start Value setting allowed is 0.3 Ien as the protection is less sensitive).

When Ie is measured directly (by ticking CCT presence box under “General settings”) Start Value begins from 0,05 Ien.

14.7.2.4.1 Measurement mode

Earth fault IDMT protection function evaluates the RMS residual current at the fundamental frequency in two ways:

- direct measurement of earth fault current at the dedicated analog input via an external residual current transformer, or
- neutral current calculated by the vectorial sum of the three phase currents.

Ticking the CCT presence box in the General Settings enables the direct measurement mode.

14.7.2.4.2 Operation criteria

If the measured or calculated RMS earth current exceeds the setting threshold value (Base current Ieb) by a factor of 1.2, the protection function is started.
The protection function will return to passive status and the start signal will be cleared if the earth current falls below 115% of the setting threshold value.
When the protection enters the start status, the operating time is continuously recalculated according to the set parameters and earth fault current value. If the calculated operating time is exceeded, the function goes into TRIP status and the trip signal becomes active.
The operating time depends on the measured current and the selected current-time characteristic. The formulas for the trip time according to British Standard (BS 142) and IEC 60255-3 are reported in chapter: IDMT Protection Time-Current Characteristics.
The protection function will exit the TRIP status, the trip signal and the counter will be cleared when the measured or calculated earth current value falls below 40% of the setting threshold value.
The earth fault overcurrent time-step characteristic shown in the next figure is obtained when the two definite time functions are combined with the IDMT. The IDMT function is generally used to provide low current protections with an exponential characteristic threshold.

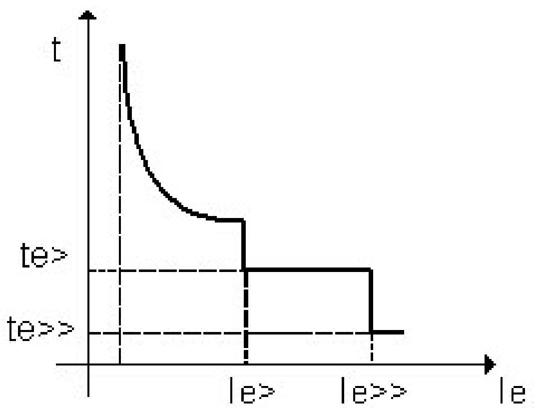


Fig. 64 Schematic view of the earth fault definite time and IDMT tripping characteristic

14.7.2.5 IDMT Protection Time-Current Characteristics

The Basic protection set provides two Overcurrent IDMT and Earth fault IDMT protection functions. For each protection of the four current-time characteristics, Normal, Very, Extremely and Long time Inverse can be activated one at a time:

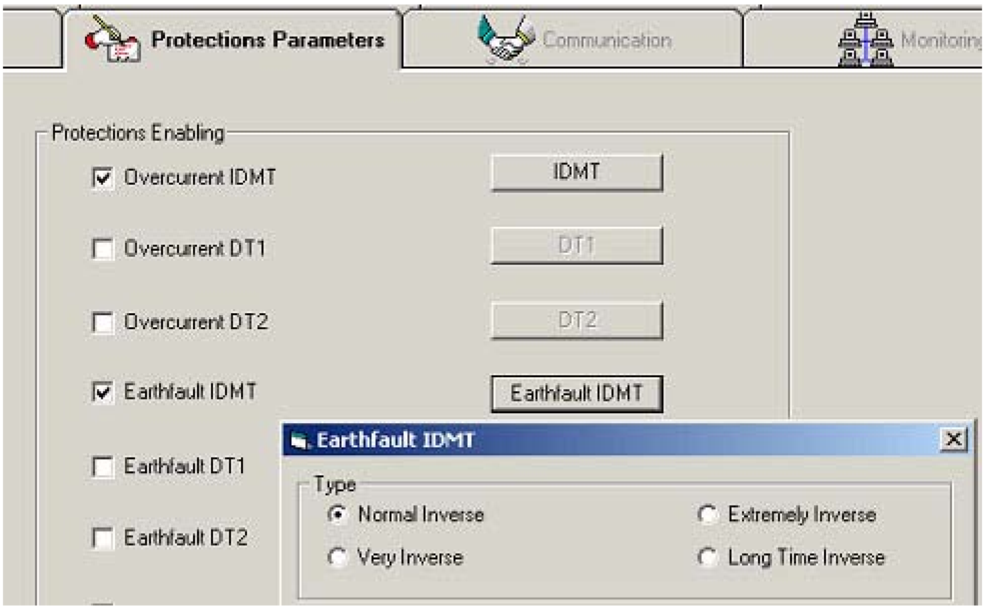


Fig. 65

14.7.2.5.1 Overcurrent IDMT

IDMT protection function evaluates the RMS value of phase currents at the fundamental frequency. It will be activated when phase current start conditions are true (at least one phase current value is above 1.2 times the setting threshold value, Base current Ieb).

14.7.2.5.2 Earth fault IDMT

Earth fault IDMT function evaluates the measured or calculated RMS amount of residual current at the fundamental frequency.
It will be activated when measured or calculated earth current start conditions are true (earth current value is above 1.2 times the setting threshold value, Base current Ieb).

Warning!

When setting the base current parameter Ieb, take care not to exceed the CB, panel or load rated current, especially for high Nominal Primary Current values In, to avoid damage due to overheating.

Example: In = 1000A, Ieb setting range = 200…2400A, CB rated current is 1250A.

YES: Ieb = In = 1000A, protection starts from 1.2Ieb = 1200A < 1250A CB rated current

NO: Ieb = 2000A, protection starts from 1.2Ieb = 2400A >> 1250A CB rated current

14.7.2.5.3 Operating time calculation

The operating time depends on the measured current and the selected current-time characteristic. The formulas for the trip time according to British Standard (BS 142) and IEC 60255-3 are the following:

$$t = \frac{k\,\beta}{(I/I_{EB})^{\alpha} - 1}$$

BS142

$$t = \frac{k}{(G/G_S)^{\alpha} - 1}$$

EC60255-3

where:

t:	Time to trip
k:	Time multiplier to vary time delay (BS 142, $0.05 \leq K \leq 1.5$)or time value (IEC 60255-3, see table)
á:	Constant according to the list below
â:	Constant according to the list below (BS 142)
I/Ieb:	Fault current factor
I = G:	Actual measured current
$I_{EB} = G_S$:	Base current setting value

The following table shows the two constants α and ß for the different current-time characteristics.

Current-time characteristic	α	ß (BS142) [s]	k (IEC 255-3) [s]
Normal inverse	0.02	0.14	0.14
Very inverse	1.0	13.5	13.5
Extremely inverse	2.0	80.0	80.0
Long time inverse	1.0	120.0	120.0

The formula is implemented in accordance with BS 142 and the k-factor ranges from of 0.05 to 1.50. When the time multiplier k in the "parameters" dialogue window is set to one (k=1) the IDMT protections operate in accordance with IEC 60255-3.

The tripping characteristics of the four different IDMT-curves are shown in the following figures. According to the Standard, the characteristic is only defined for G/Gs or I/I_{EB} in the range up to 20. If the values of the above-mentioned ratio G/G_S or I/I_{EB} is higher than 20, the operating time remains constant as the operation time at the border value of 20.

Note

The IDMT curves are time-dependent according to IEC up to 20 times Ieb when the Ieb value is set within the permissible range of In, the Nominal Primary Current. If Ieb is set to a value higher than In, for example 1250A, then the time to trip will be calculated according to IEC curves up to 20 times 1250A=25kA and will then remain constant.

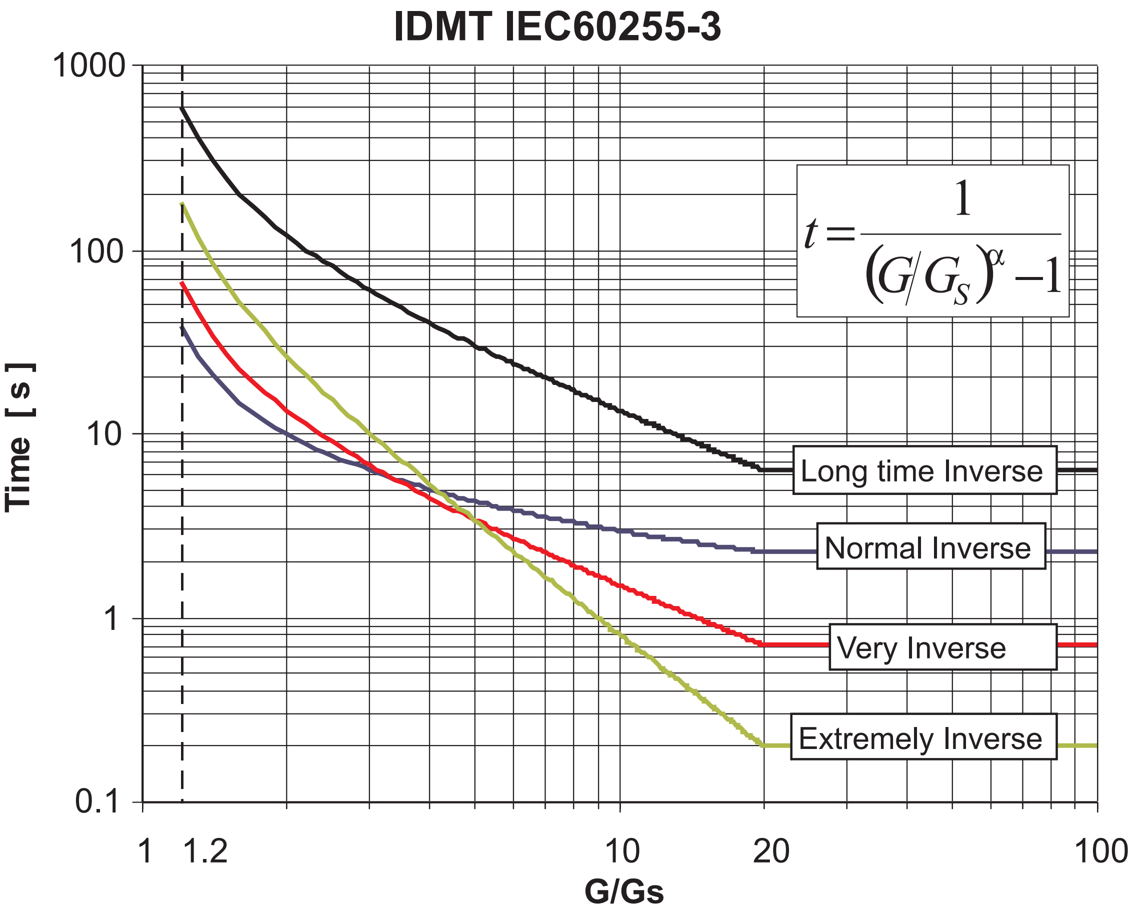

IDMT IEC60255-3
1000
100
10
1
0.1
Time [s]
$t = \frac{1}{(G/G_S)^{\alpha} - 1}$
Long time Inverse
Normal Inverse
Very Inverse
Extremely Inverse
1
1.2
10
20
100
G/Gs

Fig. 66

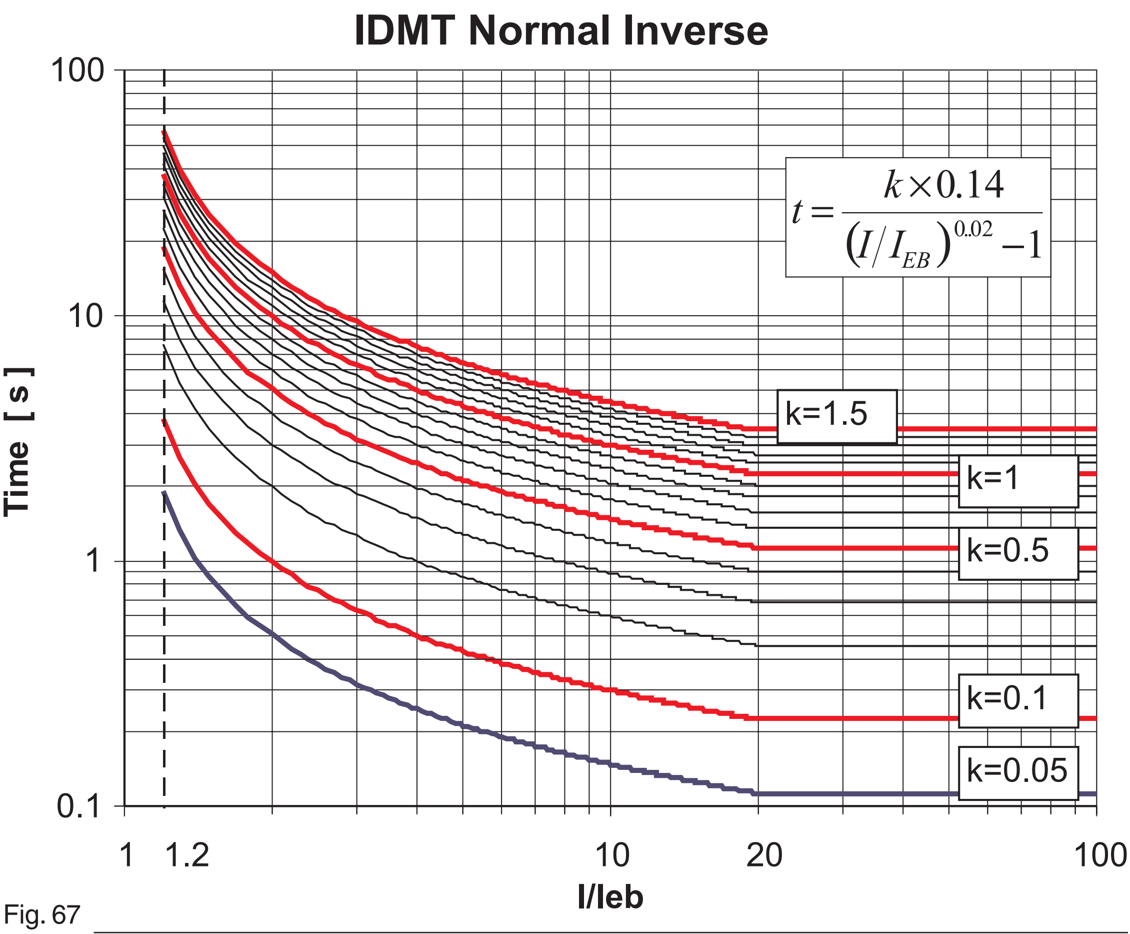

IDMT Normal Inverse
100
10
1
0.1
Time [s]
$t = \frac{k \times 0.14}{(I/I_{EB})^{0.02} - 1}$
k=1.5
k=1
k=0.5
k=0.1
k=0.05
1
1.2
10
20
100
I/Ieb

Fig. 67

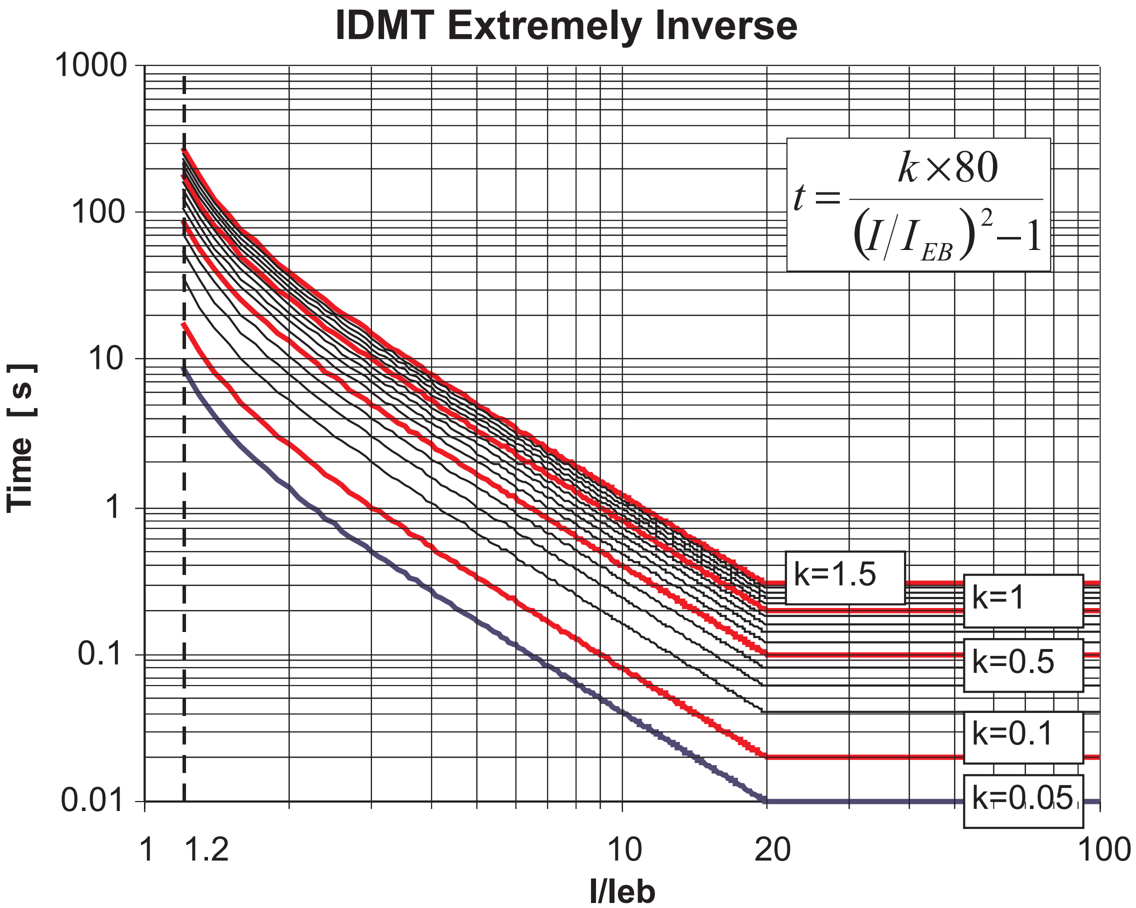

IDMT Extremely Inverse
$t = \frac{k \times 80}{(I/I_{EB})^2 - 1}$
k=1.5
k=1
k=0.5
k=0.1
k=0.05
Time [s]
I/Ieb
1000
100
10
1
0.1
0.01
1
1.2
10
20
100

Fig. 68

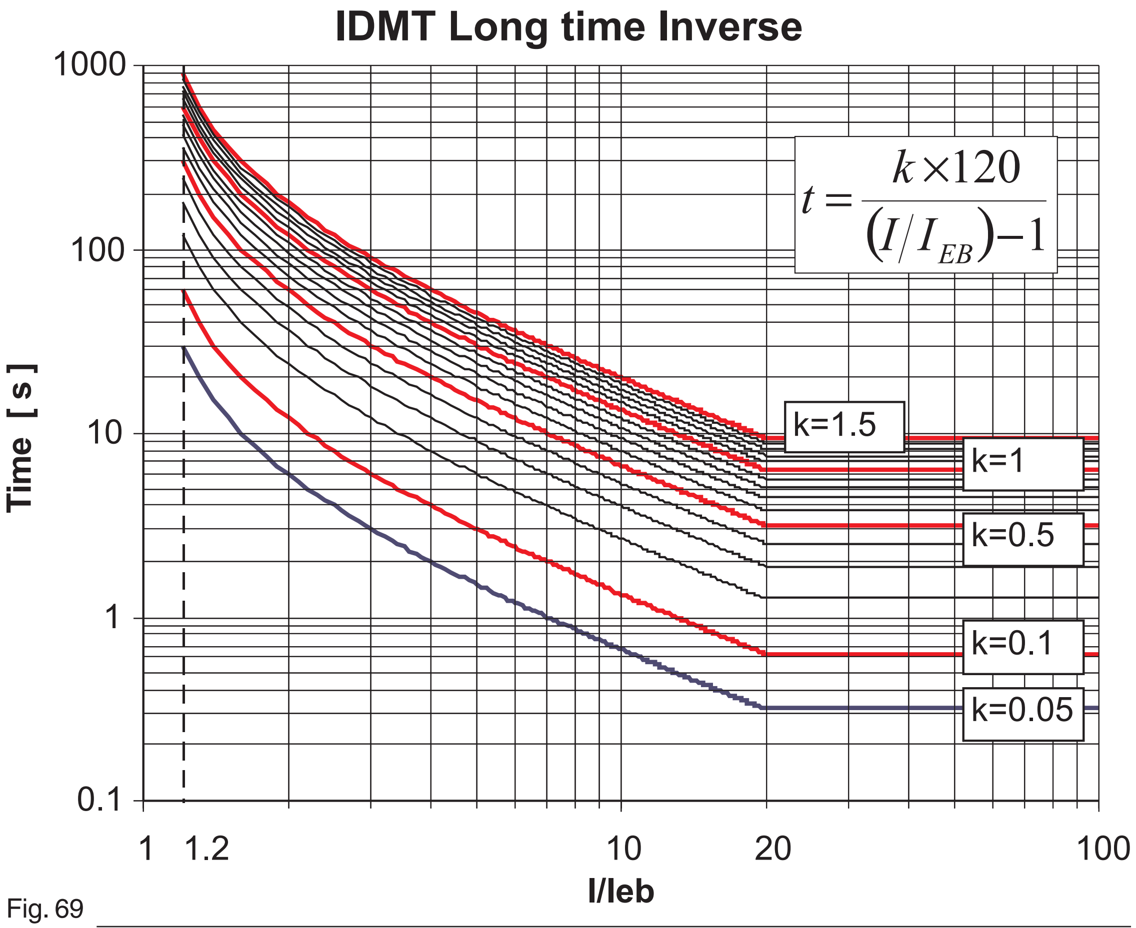

IDMT Long time Inverse
$t = \frac{k \times 120}{(I/I_{EB}) - 1}$
k=1.5
k=1
k=0.5
k=0.1
k=0.05
Time [s]
I/Ieb
1000
100
10
1
0.1
1
1.2
10
20
100

Fig. 69

14.7.3 Motor protection functions - Full set

The Full protection set provides all the following motor protection functions.

14.7.3.1 Blocked Rotor

The Blocked Rotor protective function detects a rotor blocking condition by sensing the current increase arising from the loss of synchronism between the revolving rotor and the phase voltages. An extreme condition is reached when the rotor is not moving and the steady state current equals the motor start peak value, i.e. several times the rated motor current.
It can be used to monitor the starting characteristics of three-phase asynchronous motors to check whether the rotor braking is on and other conditions preventing the motor from speeding up. If this malfunction occurs, the starting current would flow permanently and the motor would be thermally overloaded.
The protection operates like an Overcurrent Protection function.

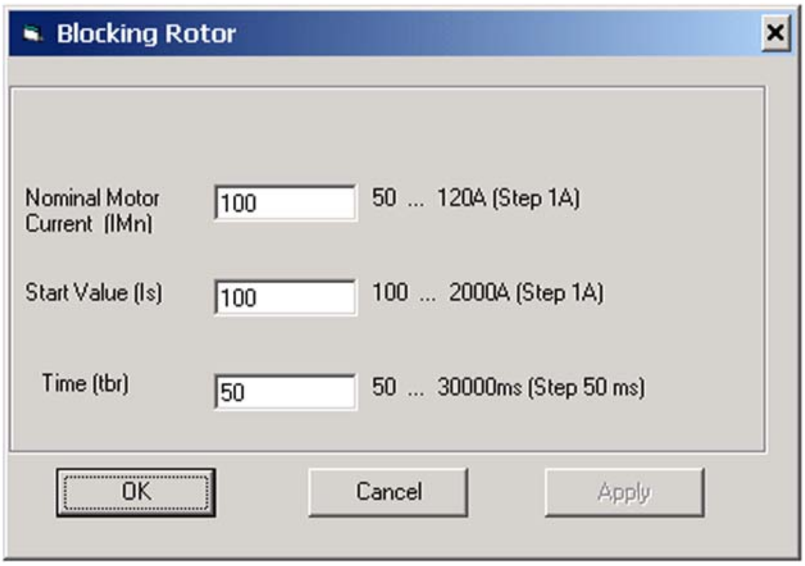


Fig. 70

Nominal Motor Current (IMn): Nominal Motor current
Start Value (Is): Current threshold for motor start condition detection.
Time (tbr): Time delay for Trip condition detection.

Parameter	Values	Default	Step	Unit	ExplanationType
Start Value Is	1.00 – 20.00 p.u. di IMn	100	1	A	Current threshold for BR condition detection.
Time, tbr	50 … 300000	50	50	ms	BR Time delay.
Nominal Motor Current,	50 – 1.20 P.U. di In	100	1	A	Nominal Motor Current in actual application

The threshold setting range is expressed in primary current Ampere [A], up to 20 IMn with IMn is the motor nominal current, by default equal to In, the feeder Nominal Primary Current value entered in the General Settings.

14.7.3.1.1 Operation criteria

If the measured RMS current exceeds the motor starting setting threshold value (Start Value, Is) for at least one phase, the protection function is started.

The protection function will remain in START status until there is at least one phase started. It will return to passive status and the start signal will be cleared if the current falls below 95% of the setting threshold value for all the phases.

After the protection has entered the start status and the preset operating time (Time tbr) has elapsed, function goes into TRIP status and the trip signal is generated.

The protection function will exit the TRIP status, the trip signal and the counter will be cleared when the measured current value for all the phases falls below 40% of the setting threshold value.

BLOCK

The Blocked Rotor protection function can be blocked to avoid operation during the normal starting phase of the motor. The blocking input can be provided by a speed switch, i.e. by an external signal on a digital input configured as an Interlocking Input, or by an internal logical signal as the start signal from the Motor Start protection function.

A tachometer generator or a speed switch is used to send a defined signal at a specified speed. If the rotor of the monitored motor is blocked, the missing speed signal will ensure that the overcurrent function in the protective function continues to remain active.

14.7.3.2. Thermal Overload Protection

In motor protection applications, the thermal overload protection is one of the key functions for monitoring the admissible motor temperatures with regard to potential operational overloading. In compliance with the applicable national and international standards, the Thermal Overload protection provides the motor thermal image with full memory function.

The Thermal Overload protection function estimates the instantaneous motor temperature (T) value, based on motor phase current measurement, which is compared with the user-defined thresholds.

The protection provides a warning and a tripping output, generated when the Twarn and Ttrip user-defined thresholds are exceeded.

The protection function also prevents reconnection of overheated machines until the estimated motor temperature has fallen below the warning threshold.

The user can configure a reset temperature (Trst) to be used as estimated motor temperature after temperature reset from the Configuration Tool (in Monitoring window).

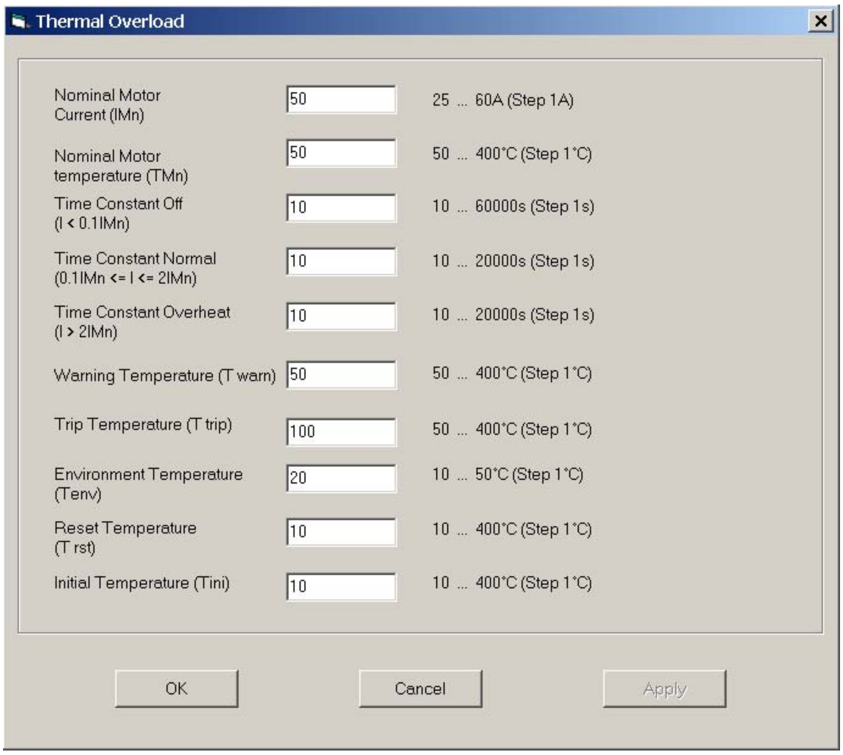


Fig. 71

Nominal Motor Current (IMn):	Nominal Motor current for operational condition detection.
Nominal Motor Temperature (TMn):	Nominal Motor Temperature, asymptotically reached at IMn with environment temperature Tenv.
Time Constant Off:	Time constant for cooling down.
Time Constant Normal:	Time constant for motor operational condition.
Time Constant Overheat:	Time constant for overload condition.
Warning Temperature (Twarn):	Temperature threshold for warning condition.
Trip Temperature (Ttrip):	Temperature threshold for trip condition.
Environment Temperature (Tenv):	Ambient temperature.
Reset Temperature (Trst):	Initial (i.e. after reset by Configuration Tool) motor temperature.
Initial Temperature (Tinit):	Initial motor temperature at protection initializing.

Parameter	Values	Default	Step	Unit	ExplanationType
Nominal Motor Current (IMn)	0.5 – 1.2 p.u. di In	50	1	A	Nominal Motor Current
Nominal Motor Temperature (TMn)	50 - 400	50	1	°C	Operating Temp. at Tenv and IMn
Time Constant Off (I < 0.1 IMn)	10…60000	10	1	s	Cooling constant
Time Constant Normal	10…20000	10	1	s	Working heating constant
Time Constant Overheat (I>2IMn)	10…20000	10	1	s	Overheating constant
Warning Temperature (Twarn)	50…400	50	1	°C	Overtemperature alarm <Ttrip
Trip Temperature (Ttrip)	50…400	100	1	°C	Overtemperature trip
Environment Temperature (Tenv)	10…50	20	1	°C	Ambient temperature <Tini
Reset Temperature (Trst)	10…400	10	1	°C	Reset temperature <Tini
Initial Temperature (Tini)	10…400	10	1	°C	Tenv < Tini < TMn

The threshold setting range is expressed in primary current Ampere [A], up to 20 IMn with IMn is the motor nominal current, by default equal to In, the feeder Nominal Primary Current value entered in the General Settings.

14.7.3.2.1 Measurement mode

The thermal overload protection function evaluates the square average of phase currents at the fundamental frequency. The instantaneous temperature estimation is based on the average of the measured phase currents and on the environment temperature set in the protection dialogue window (Tenv).

14.7.3.2.2. Operation Criteria

The Thermal Overload protection function estimates the instantaneous value of motor temperature.
If the estimated instantaneous temperature exceeds the first setting threshold value (Twarn), then the protection function enters the START status and generates a WARNING signal.
If the estimated instantaneous temperature exceeds the second setting threshold value (Ttrip), then the protection function generates a TRIP signal.
The protection function will exit START status, return to passive status and the start signal will be cleared if the estimated temperature falls below the setting threshold value Twarn.
The protection function will exit the TRIP status and the trip signal will be cleared when the estimated temperature falls below the setting threshold value Ttrip.
The protection function also prevents reconnection after a trip of overheated machines until the estimated motor temperature has fallen below the warning temperature Twarn (according to calculated motor cooling process, based on Time Constant OFF).
In the same way, an overheated motor, for example for a number of starts, cannot be reconnected until its estimated temperature has fallen below the warning temperature (Twarn), according to the motor cooling-down time estimation.
The Configuration Tool command “Reset Temperature” in the monitoring window forces the estimated motor temperature value to the configured value Trst (Reset Temperature).

t

14.7.3.2.3 Thermal model

It is assumed the heating (or cooling) process works according to the following equation

$$T = T_f \cdot \left(1 - e^{-\frac{t}{\tau}}\right) + T_{ini} \cdot e^{-\frac{t}{\tau}}$$

where:
T_f is the final (asymptotical) temperature
T_{ini} is the initial motor temperature
τ is the thermal constant of the heating (or cooling) process
is the actual time, counted from t=0 starting at T_{ini} .

It is also assumed that at nominal environment temperature (i.e. Environment Temperature Tenv) and at nominal current (i.e. Nominal Motor Current IMn) the motor will reach (asymptotically) its nominal temperature (i.e. Nominal Motor Temperature TMn), i.e.

$$T_f = T_{Mn} = \Delta T_n + T_{env}$$

where

ΔT_n is the nominal (asymptotical) temperature increment of motor

T_{env} is the environmental temperature

The value of ΔT_n is related to the thermal energy dissipation in the motor, and is proportional to the squared value of current

$$\Delta T_n \propto I^2$$

In general, the value of (asymptotical) temperature increment when the generic current *I* is flowing into the motor is then given by

$$\Delta T = \Delta T_n \cdot \frac{I^2}{I_{Mn}^2}$$

According to the above considerations, the estimated instantaneous temperature T of the motor, taking into account the environment temperature and the actual motor current, is calculated according to:

$$T = T_{env} + (T_{ini} - T_{env}) \cdot e^{-\frac{t}{\tau}} + (T_{Mn} - T_{env}) \left(\frac{I}{I_{Mn}} \right)^2 \left(1 - e^{-\frac{t}{\tau}} \right)$$

To better approximate different motor operational conditions, the time constant can assume three different values, depending on the actual motor current I, namely:

Time Constant OFF, when $I < 0.1 \cdot I_{Mn}$

Time Constant NORMAL, when $0.1 \cdot I_{Mn} \le I \le 2 \cdot I_{Mn}$

Time Constant OVERHEAT, when $I > 2 \cdot I_{Mn}$

The motor manufacturer can provide these values.

14.7.3.3 Motor Start Protection

A motor start can be critical if the load duration or the current increases. The motor start behaviour depends on the switching torque of the specific machine load. In general, these overloads are more critical for the rotor (rotor-critical motor) than the stator. The manufacturer assigns an allowable current-time start integral I^2t for motors. As an alternative, the motor manufacturer can provide information on the maximum allowable start current and the maximum allowable start time.

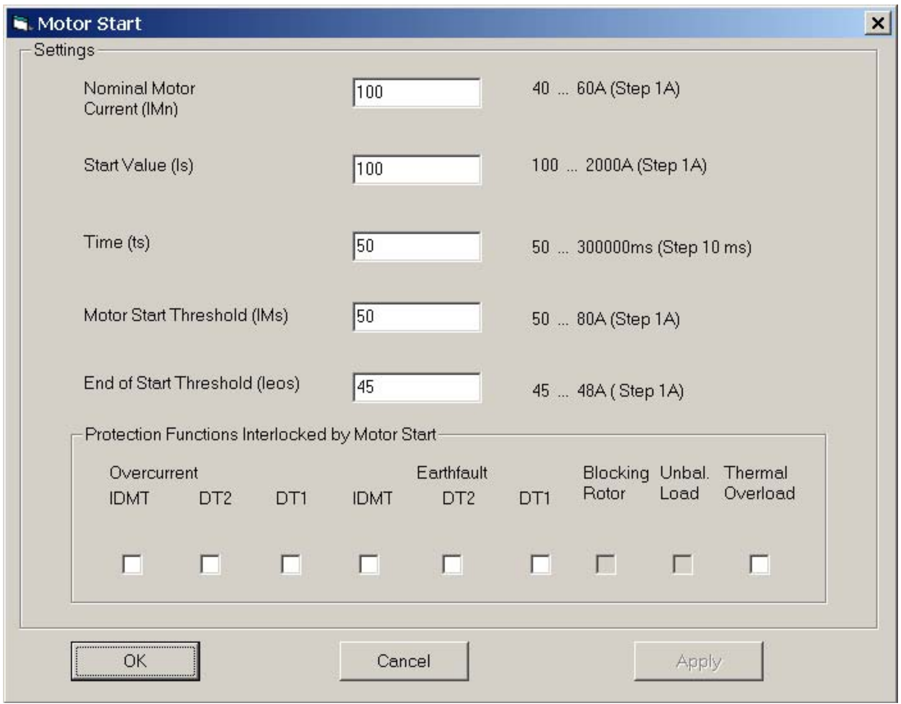


Fig. 72

Nominal Motor Current (IMn): Nominal Motor current for operational condition detection

Start Value (Is): Motor start current for Trip condition detection (start energy integral I^2t).

Time (ts): Time for Trip condition detection.

Motor Start (IMs): Current threshold for motor start condition detection.

Parameter	Values	Default	Step	Unit	Explanation
Nominal Motor Current (IMn)	0.80 – 1.20 p.u. di In	100	1	A	Motor nominal current.
Start Value (Is)	1.00 – 20.00 p.u. di IMn	100	1	A	Trip condition detection (integral I^2t).
Time (ts)	50 .. 300000	50	10	ms	Time for integral Trip condition.
Motor Start Threshold (IMs)	0.5 – 0.8 p.u. di Is	50	1	A	Current threshold for Start condition.
End of Start Threshold (Ieos) a 0,95 p.u. di IMs	da 0.45 di Is	45	1	A	Current threshold for Start/ exit condition.

The threshold setting range is expressed in primary current Ampere [A]. IMn is the motor nominal current, by default equal to In, the feeder Nominal Primary Current value entered in the General Settings.

Protection Function Interlocked by Motor Start

By ticking the relative box, the Motor Start can block all the other protection functions, to avoid a protection trip during the motor start phase.

The Block signal becomes active when the current exceeds 10% motor nominal current value IMn (condition a). The block signal is removed if condition b is not fulfilled or when the Motor start protection exits the START condition.

14.7.3.3.1 Operation criteria

Motor start protection function evaluates the current at the fundamental frequency.

The maximum measured motor current $I_{RMS\_\max}$ is used to detect Start and Trip conditions.

A motor start is detected if:

a) the maximum measured motor current exceeds 10% of the setting threshold value nominal motor current (i.e. Nominal Motor Current IMn)

AND

b) within a time of 100 ms the measured motor current exceeds the setting motor start detection (Motor Start IMs).

When a motor start is detected, the protection is started, the start signal is activated and the current-time integral is calculated:

$$\left(\int i(t)^2 dt \right)$$

The protection function will return to passive status and the start signal will be cleared if the maximum motor current falls below the End of Start setting threshold value (Ieos). At that time, calculation of current-time integral is stopped.

After the protection has entered the start status and the calculated current-time integration exceeds the default $I_s^2 \cdot T$ value, where:

- I_s is the Start current parameter (Start Value Is).
- T is the Time parameter (Time).

The function goes into TRIP status and the trip signal is generated.

The protection function will exit the TRIP status and the trip signal will be cleared when the measured current value falls below the End of Start setting threshold value (Ieos).

14.7.3.4 Number of Starts

A protection function supervises the number of starts of all the available protection functions. It is particularly significant for motors where it is also important to distinguish between cold starts and warm starts, the allowable number of which is generally provided by the motor manufacturer.
Motor temperature estimated by the Thermal Overload protection is used to determine whether a start is cold or warm. When the thermal overload function is not instantiated, a cold start is assumed and warm start parameters are dimmed and not available.
After the Reset Time (T rst) has elapsed the counted number of starts is decreased by one.
If the preset number of warm (or cold respectively) starts is reached, the start signal of the protection function is activated.
If there is another start, the protection function trips.

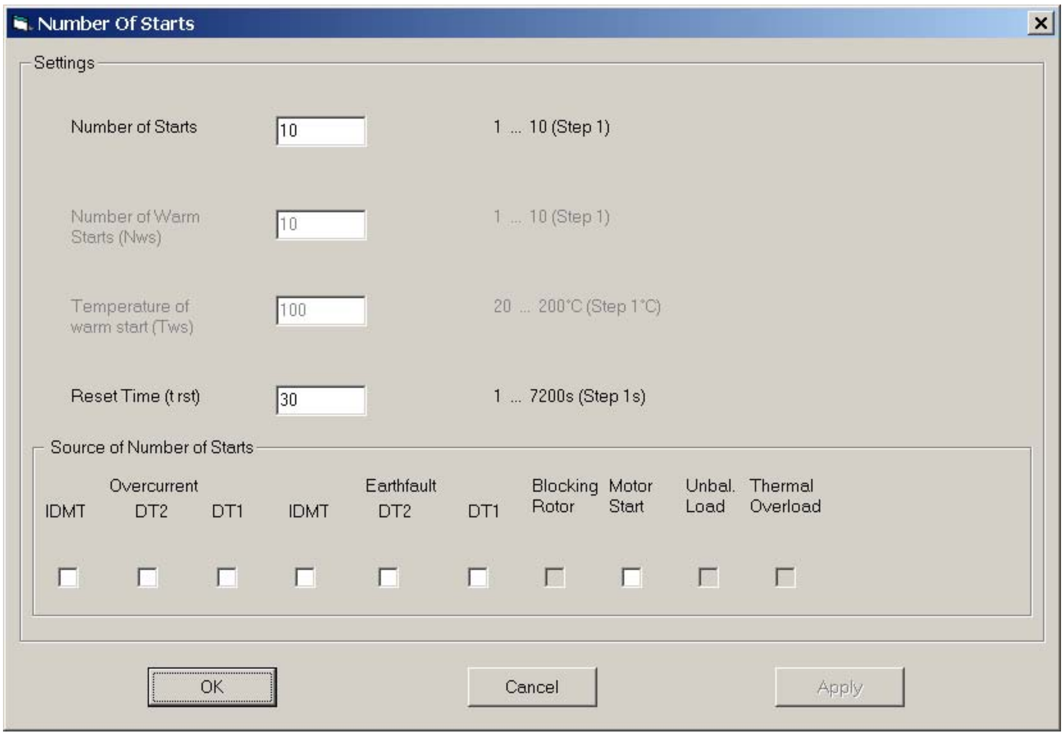


Fig. 73

Number of Starts :	N° of cold starts, below temperature threshold Tws, declared by the Motor manufacturer.
Number of Warm Starts (Nws):	N° of warm starts, above temperature threshold Tws, declared by the Motor manufacturer.
Temperature of Warm Start (Tws):	Above Tws temperature threshold a start is assumed to be “warm”.
Reset Time (t rst):	Cooling down motor time; time to dissipate the heat of a motor start.
Source of Number of Starts:	By checking the respective box the starting signal arising from any active protection function ticked is used to count starts.

Parameter	Values	Default	Step	Unit	Explanation
Number of Starts:	1 ... 10	10	1	-	Number of starts above Tws.
Number of Warm Starts (Nws):	1 ... 10	10	1	-	Number of starts below Tws.
Temperature of Warm Start (Tws):	20 …. 200	100	1	°C	Temperature threshold to define a warm start.
Reset Time (t rst):	1 … 7200	30	1	s	Time to cool down after a start.

14.7.3.4.1 Operation criteria

If the Thermal Overload protection is not enabled the estimated machine temperature is not available and the Warm counter is not increased (the Warm counter is frozen on zero). In this case, all counted starts are classified as cold.
When the Thermal Overload protection is enabled the estimated motor temperature is compared with the setting temperature threshold (Temperature of Warm Start Tws). Above Tws temperature threshold a start is assumed to be “warm”, below this it is assumed to be a cold start.
With every motor start, depending on the type of start (i.e. warm or cold start), the relative counter is incremented by one unit. With every warm start, both the warm counter and the cold counter are incremented.
If no start has occurred after the set time interval (Reset Time, t rst) it is assumed that the motor had time to cool down and both cold and warm start counters are decremented by one unit.
If the preset number of warm (Number of Warm Starts, Nws) or respectively of cold starts (Number of Starts, Ncs) is reached, then the protection function is started and the relative Start signal will be activated. If there is another start, the protection function will enter the TRIP status and the trip signal will be activated.
The protection function is in trip status and the trip signal remains active until the reset period t rst has expired; then both cold and warm start counters are decremented and the trip signal is cleared.
The protection function will exit start status, return to passive status and the start signal will be cleared if the cold and warm counters fall below the respective maximum setting values Ncs and Nws, i.e. after the reset period t rst has expired.

14.7.3.5 Unbalanced Load or Negative Sequence Protection

The protection against unbalanced load due to negative phase sequence (NPS below) of the current is necessary in electrical rotating machines. Because the NPS current has a rotation direction opposite to the positive phase sequence, thermal overheating of the rotor can occur. The NPS current will namely induce in the rotor currents with double frequency, which can produce large thermal loss in the iron core of the rotor. This results in different field intensities in the magnetic laminated cores. Points with particularly high field intensities - "hot spots" - lead to local overheating.
This protection function also prevents reconnection of overheated machines and handles situations of intermittent NPS current.

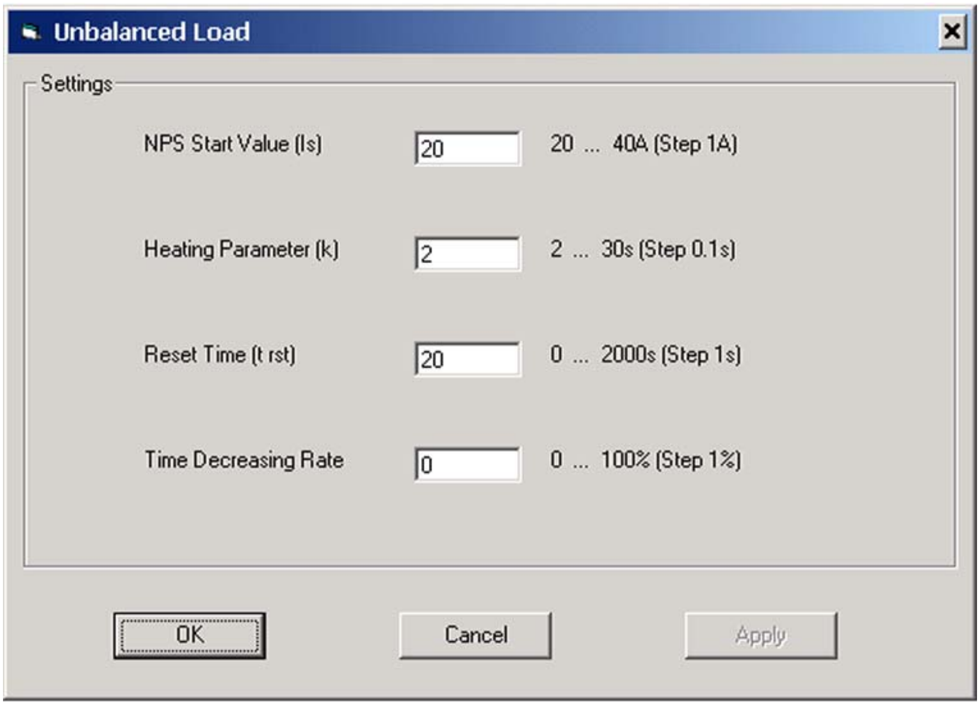


Fig. 74

Start Value (Is): Current threshold for negative sequence condition detection.

Heating Parameter (K): Heating parameter to vary time delay for Trip condition

Reset Time (t rst): The function remains in BLOCK status until the reset time has elapsed (e.g. to block the possibility of re-closing a motor).

Time Decreasing Rate: Parameter to vary thermal memory effect.

Parameter	Values	Default	Step	Unit	Explanation
NPS Start Value (Is)	0.2 – 0.40 p.u. di In	20	1	A	Current threshold for negative sequence detection
Heating Parameter (K)	2.0 - 30,0	2	0.1	s	Heating parameter
Reset Time (t rst)	0 - 2000	20	1	s	Time to reset BO after a trip
Timer Decreasing Rate	0 - 100	0	1	%	Parameter to vary thermal memory effect

The threshold setting range is expressed in primary current Ampere [A], up to 0.40 In where In is the Nominal Primary Current value entered in the General Settings.

14.7.3.5.1 Measurement mode

The Unbalanced load protection function evaluates the measured amount of negative phase sequence current at the fundamental frequency.

The negative-sequence three phase system L1 - L3 - L2 is superimposed on the three-phase system that corresponds to the standard phase sequence.

The NPS current is obtained from the three-phase current set (IR, IS, IT) DFT values at the fundamental frequency.

14.7.3.5.2 Operation criteria

If the calculated negative phase sequence current exceeds the setting threshold value (Is), the protection function is started and the start signal will be activated. The protection function will return to passive status and the start signal will be cleared if the NPS current I_2 falls below 95% of the setting threshold value.

When the protection enters the START status the operating time is continuously recalculated according to the set parameters (Heating Parameter K, Start Value Is) and the negative phase sequence current value I_2.

If the calculated operating time is exceeded, the function goes into TRIP status and the trip signal becomes active.

The protection function will exit the TRIP status and the trip signal will be cleared when the NPS current value falls below 40% of the setting threshold value.

The operating time depends on the calculated negative phase sequence as follows:

$$t = \frac{K}{\left(\frac{I_2}{I_N}\right)^2 - \left(\frac{I_s}{I_N}\right)^2}$$

where:

t: time until the protective function trips under sustained NPS overcurrent

K: heating parameter of the component

I_2 : calculated negative phase sequence current

I_S : start threshold

I_n : Nominal Primary Current value

According to the standard, the characteristic is only defined for I_2/Is in the range up to 20. If the value of the ratio mentioned is higher than 20, the operation time remains constant as the operation time calculated for I_2/Is = 20.

The operating time t must not be shorter than 50 ms.

To avoid reconnection of overheated machines, the machine cannot be reconnected after the trip event until a configurable Reset Time (t rst) has elapsed. The function remains in BLOCK status until the reset time has elapsed.

NS: **Time to Next Motor Start** (**s**) window in Monitoring Tab shows the remaining time before Number of Start protection setting Reset Time, t rst, expires and it is assumed that the motor has had time to cool down.

14.7.3.5.3 Thermal memory

To prevent machine overheating in the case of intermittent negative phase sequence current, the internal time counter is not cleared when the negative phase sequence current falls below the start threshold. Instead, it is linearly decremented with time, using a user-configurable slope (i.e. Time Decreasing Rate). 100% means full memory, 0% means no memory.

14.7.3.5.4 NPS function State Machine

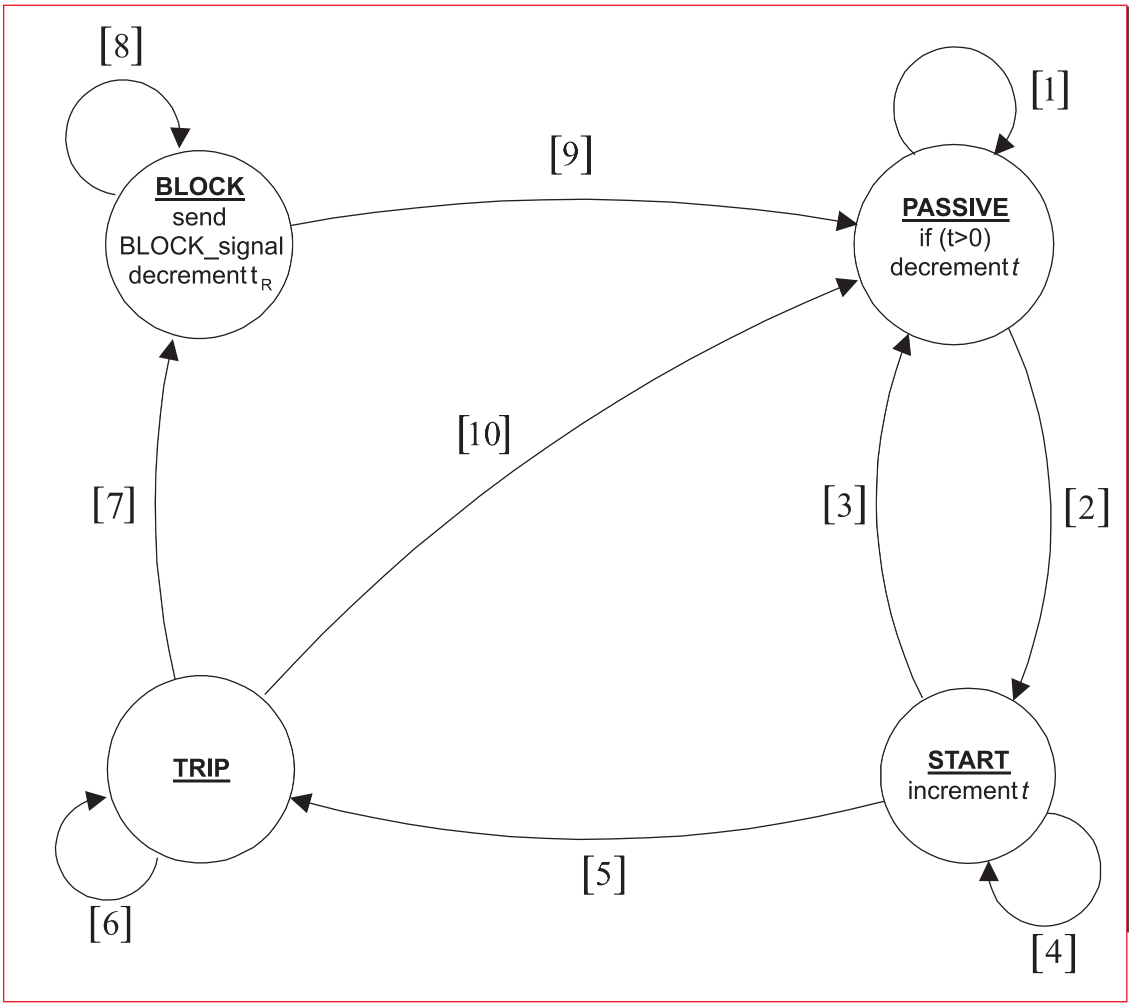


Fig. 75

Transition #	Initial Status → Final Status	Condition(s)
[1]	PASSIVE → PASSIVE	$I_2 < 1.01 \cdot I_e$
[2]	PASSIVE → START	$I_2 \geq 1.01 \cdot I_e$
[3]	START → PASSIVE	$I_2 < 0.95 \cdot I_e$ OR Reset_signal_received
[4]	START → START	$I_2 \geq 0.95 \cdot I_e$ AND $t < t_{TRIP}$
[5]	START → TRIP	$I_2 \geq 0.95 \cdot I_e$ AND $t \geq t_{TRIP}$
[6]	TRIP → TRIP	$I_2 \geq 0.4 \cdot I_e$
[7]	TRIP → BLOCK	$I_2 < 0.4 \cdot I_e$
[8]	BLOCK → BLOCK	$t_{RESET} > 0$
[9]	BLOCK → PASSIVE	$t_{RESET} = 0$ OR Reset_signal_received
[10]	TRIP → PASSIVE	Reset_signal_received

14.8 Input / Output Mapping

The Input Mapping / Output Mapping Tabs enable you to manage the mapping of the available 16 + 16 Digital Inputs (DI) and Digital Outputs (DO) with predefined meanings. The mappings are not configurable when one of the four available Single-line feeder diagrams is ticked in the General Settings page, while they can be fully configured by choosing the “Free” scheme.
Refer to schematic drawings 1VCD400060 dor withdrawable version and 1VCD400089 for fixed version for DI/O wiring and examples of meanings assigned to fixed DI/Os.

14.8.1 Digital Input Mapping

The configuration matrix provides the 16 available DIs in the columns and a choice of possible meanings in the rows. When a box identifying a column and a meaning is ticked, DI processing is enabled. For standard DIs, when the input signal goes High (i.e. an AC/DC voltage over the activation threshold of about 20 V is applied) for at least 10 ms (20 ms for Open Commands), the input will be valid, the corresponding meaning will be true and the specific function will be performed, see figure.

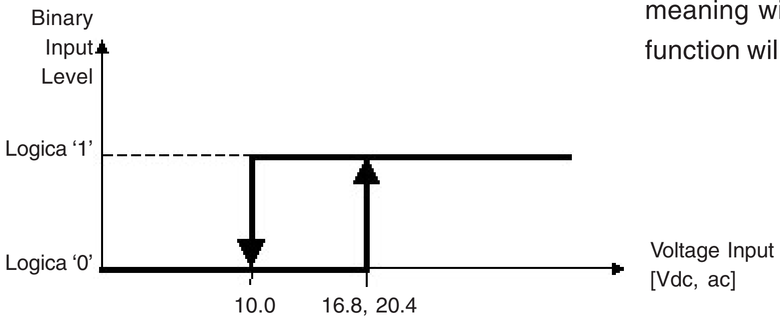


Fig. 76

In the example below, when DI2 goes high a CB Close command will be performed.
Meanings with the prefix “#” are negated - they will be activated for a transition of the signal from high to low. In the example below, DI1 will always be supplied with a voltage above the activation threshold (e.g. the panel auxiliary supply); when that signal is cut for at least 5 ms, the input will be valid, the corresponding meaning will be true and the specific function will be performed - in this case opening of the CB.

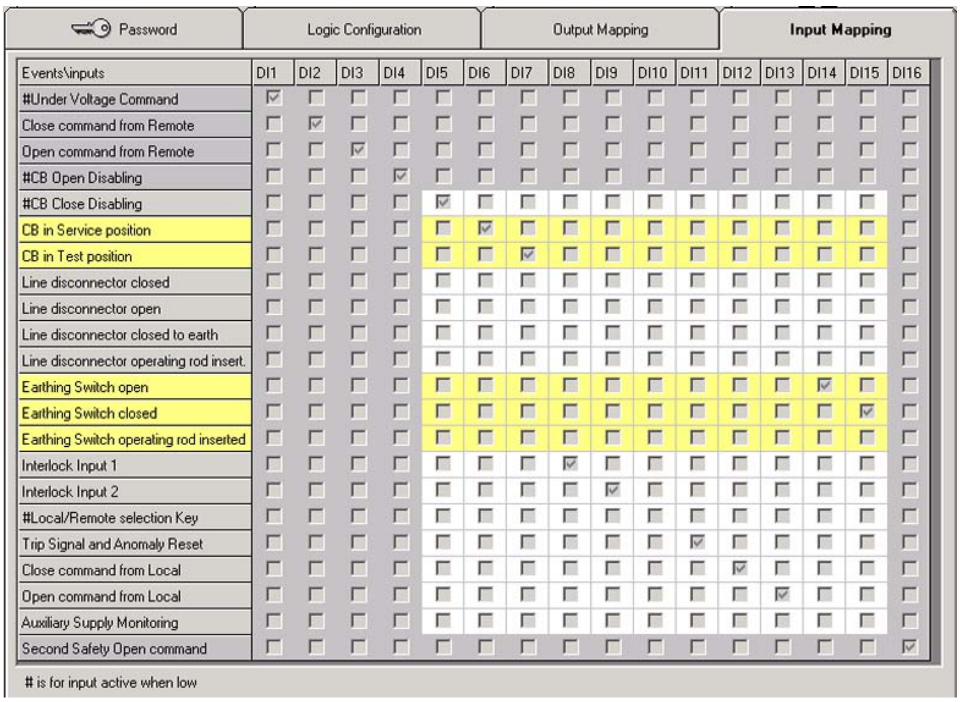


Fig. 77

14.8.1.1 Digital Input meanings

BI operates in transition between two statuses (e.g. High to low or low to high); for Open commands it operates both on transition and status.

# Under Voltage Command	Signal expected to be normally high; when it goes to low, an opening command is executed if the Under Voltage function is activated.
Close command from Remote	Close command, only processed when control mode is Remote or Local and Remote
Open command from Remote	Open Command, only processed when control mode is Remote or Local and Remote
# CB Open Disabling	If CB Open Disabling function is ticked the CB will be locked in the closed position when the DI is low and the LED on the local CB HMI is on
# CB Close Disabling	If CB Closing Disabling function is ticked the CB will be locked in the open position when the DI is low and the LED on the local CB HMI is on
CB in Service position	Status signal to acquire the CB truck position, in Service position when DI is high
CB in Test position	Status signal to acquire the CB truck position, in Test position when DI is high
Line disconnector closed	Status signal to acquire the three-position Line disconnector position, valid when DI is high = closed (1)
Line disconnector open	Status signal to acquire the three-position Line disconnector position, valid when DI is high = open
Line disconnector closed to earth	Status signal to acquire the three position Line disconnector position, valid when DI is high = closed to earth
Line disconnector operating rod inserted	Status signal to acquire presence of Line disconnector operating rod, valid when DI is high
Earthing Switch open	Status signal to acquire the two-position cable side earth disconnector position, valid when DI is high = open (1)
Earthing Switch closed	Status signal to acquire the two-position cable side earth disconnector position, valid when DI is high = closed
Earthing Switch operating rod inserted	Status signal to acquire presence of cable side earth disconnector operating rod, valid when DI is high
Interlock Input 1	Interlocking input, valid when DI is high. Blocks all protection functions linked to this signal in Logic Configuration Tab
Interlock Input 2	Interlocking input, valid when DI is high. Blocks all protection functions linked to this signal in Logic Configuration Tab
# Local/Remote selection Key	Input to select control mode, control is set to: low = Local, high = Remote; if not present, control is Local. When not enabled in the DI configuration (default) the control mode is Local & Remote, i.e. Global. When the Panel HMI is present it is not configurable, the same function is provided by the HMI Local/Remote selection key
Trip Signal and Anomaly Reset	Resets Trip signal condition (and DOs) and Anomaly condition (and blinking No Anomaly LED on the local CB HMI), valid on transition from low to high
Close command from Local	Close command, only processed when control mode is Local or Local and Remote
Open command from Local	Open Command, only processed when control mode is Local or Local and Remote
Auxiliary Supply Monitoring	DI to verify availability of aux supply, generally used to read a contact of the LV circuit-breaker protecting the secondary panel cabinet. It generates an anomaly when input goes from high to low (closing of auxiliary contact on LV CB opening). If ticked, the information is replicated on DO (DO is closed after 5s from signal on DI goes low).
Second Safety Open command	HW opening commands, can override microprocessor malfunction and perform a safety opening command of the CB when CB Open Disabling for Second Safety Open function is not active (not ticked).

(1) Congruence of position status read is verified by the IED. If two position status indications go high or no position status is high for a time longer than the expected earthing switch operating time, an anomaly is issued.

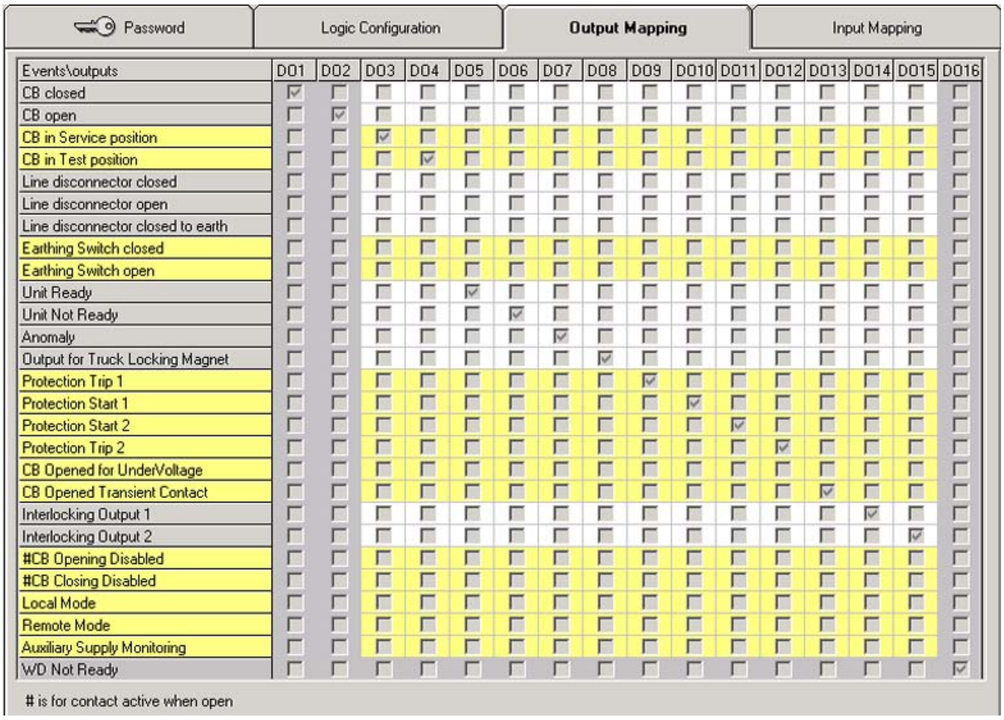
14.8.2 Digital Output Mapping

The configuration matrix provides the 16 available DOs in the columns and a choice of possible meanings in the rows.

When a box identifying a column and a meaning is ticked, the DO processing is enabled. When the assigned meaning becomes true, the free potential output contact, normally open, will be closed and keep the state as long as the condition assigned is valid.

All DOs are free potentially normally open (NO), apart from DO 16 that provides the WatchDog not Ready function and is normally closed.

In the example below, when the CB is closed and its status becomes Closed, DO1 will close its output contact. As the CB status is mapped on two outputs - DO1 and DO2 - at the same time DO2, which was previously closed, will open the output contact.



Events\outputs	DO1	DO2	DO3	DO4	DO5	DO6	DO7	DO8	DO9	DO10	DO11	DO12	DO13	DO14	DO15	DO16
CB closed	✓															
CB open		✓														
CB in Service position			✓													
CB in Test position				✓												
Line disconnector closed																
Line disconnector open																
Line disconnector closed to earth																
Earthing Switch closed																
Earthing Switch open																
Unit Ready					✓											
Unit Not Ready						✓										
Anomaly							✓									
Output for Truck Locking Magnet								✓								
Protection Trip 1									✓							
Protection Start 1										✓						
Protection Start 2											✓					
Protection Trip 2												✓				
CB Opened for UnderVoltage																
CB Opened Transient Contact													✓			
Interlocking Output 1														✓		
Interlocking Output 2															✓	
#CB Opening Disabled																
#CB Closing Disabled																
Local Mode																
Remote Mode																
Auxiliary Supply Monitoring																
WD Not Ready																✓

is for contact active when open

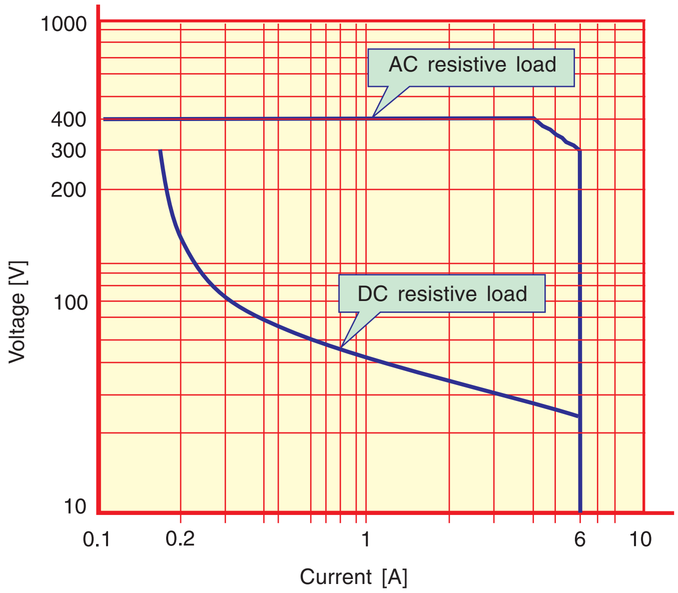
Fig. 78

14.8.2.1 Digital Output meanings

CB closed	Output contact to signal CB position, contact closes when CB status = closed
CB open	Output contact to signal CB position, contact closes when CB status = open
CB in Service position	Output contact to signal CB truck position, contact closes when CB truck status = inserted
CB in Test position	Output contact to signal CB truck position, contact closes when CB truck status = withdrawn
Line disconnector closed	Output contact to signal LD position, contact closes when LD status = closed
Line disconnector open	contact closed when LD status = open
Line disconnector closed to earth	contact closed when LD status = closed to earth
Earthing Switch open	Output contact to signal ES position, contact closes when ES status = open
Earthing Switch closed	contact closed when ES status = closed to earth
Unit Ready	Output contact to signal logical condition of IED ready: no microprocessor failure, coil continuity ok, capacitor charged, no position incongruence, no failure anomaly, contact closes when the IED status = Ready
Unit Not Ready	Negation of logical condition of IED ready, contact closes when the IED status = Not Ready
Anomaly	Output contact to signal presence of an anomaly condition, depending on its seriousness, it can cause the not Ready condition. Contact closes when at least one Anomaly is present
Output for Truck Locking Magnet (-RL2)	Fixed output to enable safety lock of truck position depending on CB status. Only when CB is open and ready and the DI (Digital input) Earting switch open is high = 1 = present, enabling supply to the –RL2 locking magnet and to rack the CB out or in. If the digital Earthing Switch open is flagged on the “Input mapping” page, the IED assumes that it is present and high.
Protection Trip 1	General protection trip, contact closes when at least one protection function associated in the Logic Configuration Tab goes into trip status.
Protection Start 1	General protection start, contact closes when at least one protection function associated in the Logic Configuration Tab goes in start status.
Protection Start 2	General protection start, contact closes when at least one protection function associated in Logic Configuration Tab goes into start status.
Protection Trip 2	General protection trip, contact closes when at least one protection function associated in the Logic Configuration Tab goes into trip status.
CB Opened for underVoltage	Output contact to signal CB was opened due to Undervoltage function; contact closes when UnderVoltage performs CB opening and stays latched until the Anomaly is reset. When the CB is closed again (close allowed) while UV is active, the BO stays closed.
CB Opened Transient Contact	Output contact to signal CB was opened due to an open command from remote; contact closes when the IED performs CB opening and stays closed for 100ms
Interlock Output 1	General protection start, contact closed when at least one protection function associated in the Logic Configuration Tab goes into start status.
Interlock Output 2	General protection start, contact closes when at least one protection function associated in the Logic Configuration Tab goes into start status.
# CB Opening Disabled	Output contact to signal CB Open Disabling function is active (function ticked and DI low). The CB is locked in the closed position and the LED on the local CB HMI is on
# CB Closing Disabled	Output contact to signal CB Closing Disabling function is active (function ticked and DI low). The CB is locked in the open position and the LED on the local CB HMI is on
Local Mode	Output contact to signal IED control mode is Local. The LED on the local CB HMI is on
Remote Mode	Output contact to signal IED control mode is Remote. The LED on the local CB HMI is off
Auxiliary supply monitoring	Output contact to signal whem the namesakeinput becomes low for at least 5s
WatchDog Not Ready	Output contact to signal a µP failure, high reliability HW circuit only. Contact is closed when the IED is not supplied and open when supplied and functional. It will close again on IED µP failure.

14.8.3 Digital Output Contacts characteristics

Maximum power applicable (VDC and VAC on resistive load)



????

Fig. 79

Characteristics of the control module contacts without potential

The contacts without potential control module by special relay.

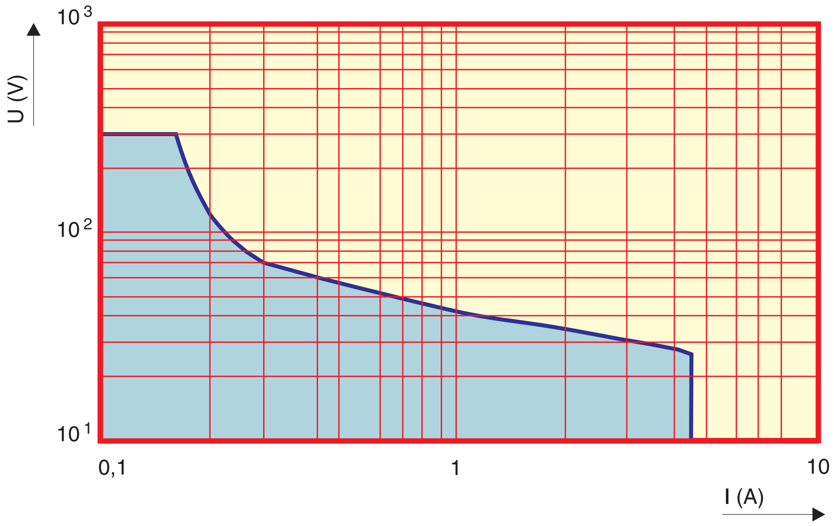
For the characteristics of the contacts, please see the table and curves givenbelow

Rated voltage	0 ... 264 V~ 50/60 Hz
(operating range)	0 ... 280 V–
Maximum power applicable	1500 VA (V a.c. on resistive load)
	(V d.c. on resistive load - curve **A**)
Maximum voltage applicable	400 V~ 50/60 Hz
	300 V–
Maximum current applicable	6 A
Rated current	6 A (250 V~ 50/60 Hz - resistive load)
Maximum contact resistence	≤ 100 mohm (measured at 6 V– / 1 A)
Maximum capacity	≤ 1.5 pF
Maximum closed time	≤ 5 ms
Maximum opening time	≤ 3 ms
Isulation between contacts and coil	4000 Vrms (50 Hz / 1 min)
Resistance with contacts open	Min. 10^3 Mohm (measured at 500 V–)
Storage temperature	- 40 °C ... + 85 °C
Temperatura di stoccaggio	- 40 °C ... + 100 °C
Mechanical life	500,000 operation (at 250 V~ 50/60 Hz - 180 operation/min)
Electrical life	50,000 operation (at 6 A / 277 V~ 50/60 Hz - resistive load - see curves **B** and **C**)

Notes

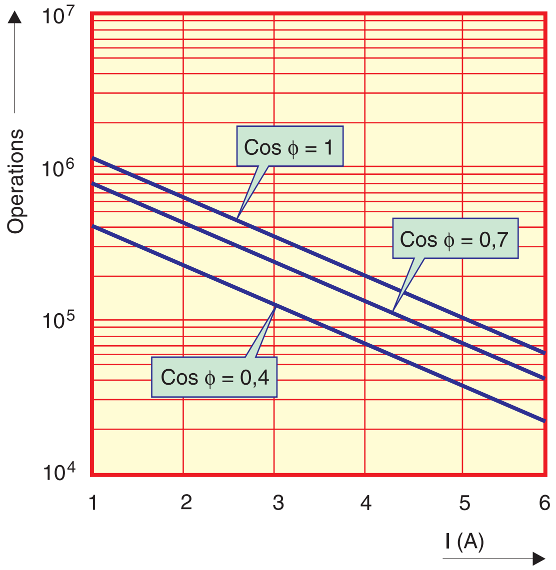
– In the case of indicative loads, the contacts must the protected against over voltage by means of varistors

– For the other characteristics, please refer to the IEC 60694.5.4.4.5.4 (Ed. 2.2), Classe 3 Standards.



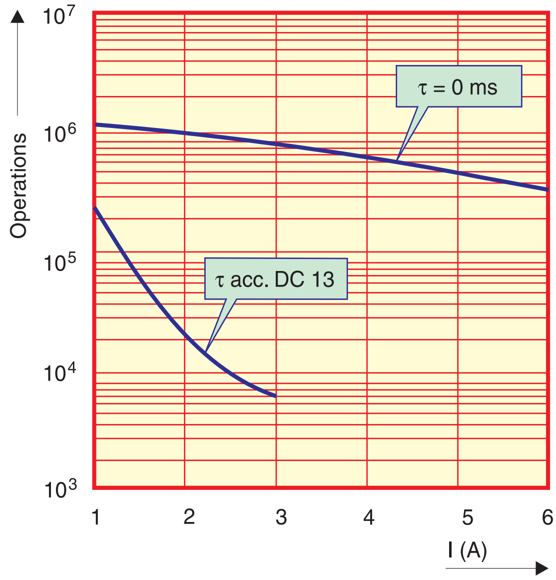
Curve A
Maximum power applicable (V d.c. on resistive load).

Fig. 80



Curve B
Electrical life of the contacts at 250 V a.c.

Fig. 81



Curve C
Electrical life of the contacts at 24 V d.c.

Fig. 82

14.8 Monitoring

The monitoring Tab enables access to the IED to monitor DI/O status, CB currents, start/trip conditions, etc. when an active communication link has been established with the electronic Device (IED).

The left column of the Monitoring page provides the same control capabilities (CB Open/Close) and status LEDs available on the local CB HMI.

The show pushbutton enables you to list Anomalies detected when the No Anomalies LED is blinking.

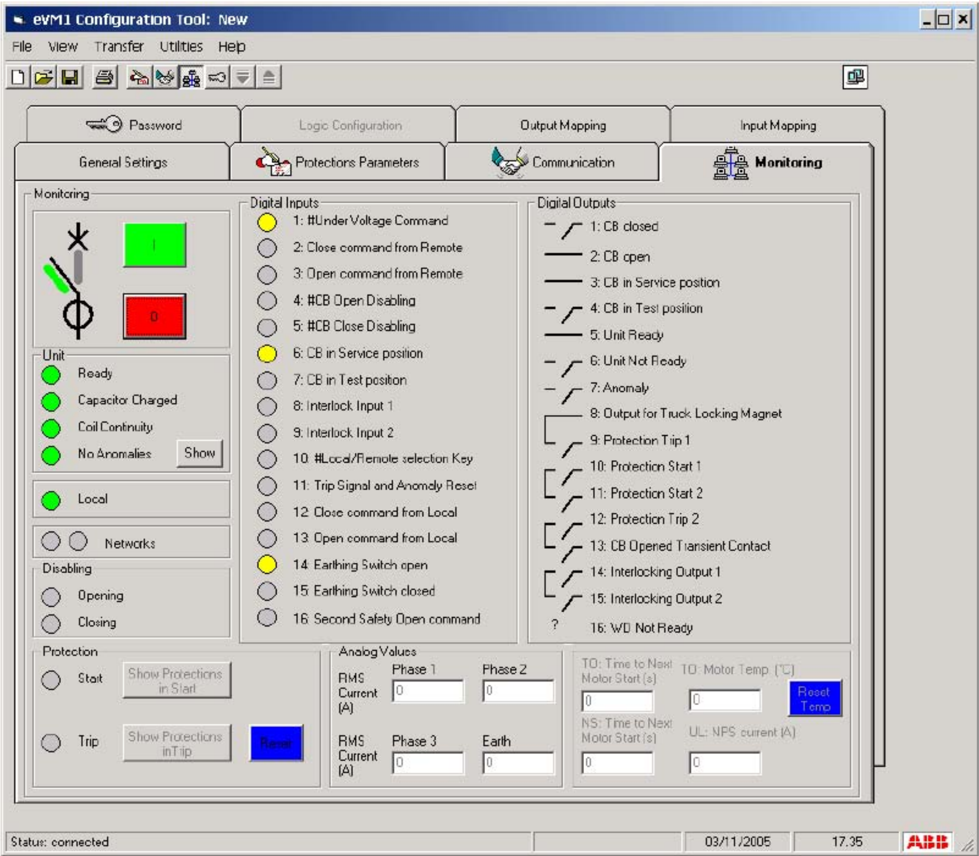


Fig. 83

14.8.1 Digital Input monitoring

The 16 available inputs are mapped on the monitoring page according to the meanings selected in the Input Mapping tab.

Note

Caution: the input meanings shown are only updated after a configuration upload from the IED.

When the input signal goes High (i.e. an AC/DC voltage over the activation threshold of about 20 V is applied) for at least 10 10 ms (20 ms for opening command), the input will be active and the associated LED on the Monitoring Tab goes from grey to yellow.

Note

Caution: for negated digital inputs, the LED is on (yellow) when the input signal goes High but the associated function will be executed when there is no signal and the LED is off (grey). E.g. #CB Close disabling: when the LED is off the CB will not execute close commands because the function is active.

14.8.2 Digital Output Monitoring

The 16 available outputs are mapped on the monitoring page according to the meanings selected in the output Mapping tab.

Caution: the output meanings shown are only updated after a configuration upload from the IED.

Note

When the assigned meaning becomes true, the free potential output contact - normally open - will be closed and keep the state as long as the condition assigned is valid.
The first 15 contact statuses are shown as open or closed switches associated with the meanings on the Monitoring Tab. The 16^{th} output is the WatchDog contact and is not controlled by the IED but signals its failures independently (contact closed with the IED switched off or failed).

14.8.3 Protection

Two LEDs show if any protection enters the Start or Trip status (the General Start and General Trip signals). Using the associated Show pushbuttons, the list of Started / Tripped protection and event details is provided.
The Reset pushbutton enables you to reset the Trip condition and re-close the CB.

14.8.4 Analog values

The analog values window shows the instantaneous RMS phase and earth current (measured or calculated) values.

14.8.5 Motor protection values

The analog values window shows quantities related to motor protection functions:

T0: Time to Next Motor Start (s)	motor cooling-down time estimation according to the Thermal Overload protection model. It is the time needed for an overheated motor until its estimated temperature has fallen below the warning temperature (Twarn).
T0: Motor Temperature (°C)	instantaneous temperature estimation based on the average of the measured phase currents and on the environment temperature set in the Thermal Overload protection dialogue window (Tenv).
Reset Temperature	the Configuration Tool command “Reset Temperature” forces the Thermal Overload protection estimated motor temperature value to the configured value Trst (Reset Temperature).
NS: Time to Next Motor Start (s)	shows the remaining time before Number of Start protection setting Reset Time, t rst, expires and it is assumed that the motor has had time to cool down.
UL: NPS current (A):	shows the instantaneous RMS calculated value for Negative Sequence current I_2.

14.10 Communication

The Communication Tab enables you to set the serial communication parameters.
It is available when the Communication board option is ticked in the General Setting window.

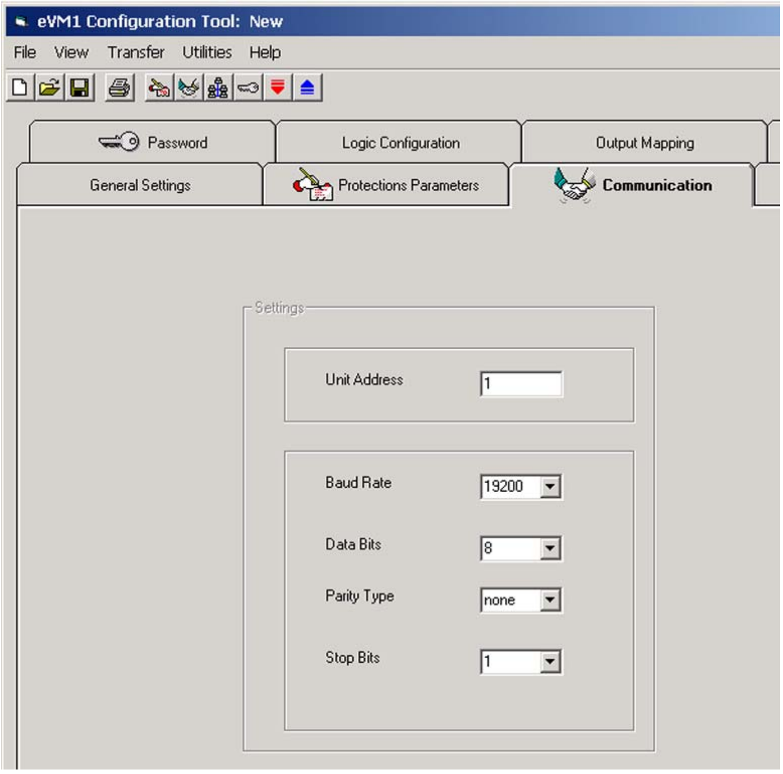


Fig. 84

14.10.1 Communication Link to the IED

All read/write and monitoring functions of the Configuration Tool are available when an active communication link from a PC has been established with the electronic Device (IED) inside the CB, either directly through the D-Sub connector –XB24 (refer to schematic drawings 1VCD400060) or through the 58 pin connector, directly or via the Panel HMI.
When the communication to the IED is active the left “Networks” signalling LED on the CB HMI is on. When the communication is not active or the port is busy, a pop-up window provides the information and the LED goes off.

14.10.1.1 Direct communication with an eVM1

Remove the circuit-breaker screen and connect and male D-Sub 9-pin connector to the –XB24 connector on the IED basic card. It is possible to make the connection to the PC with a RS232/ RS485 half-duplex or full-duplex converter or with a USB/RS485 half duplex converter.
Enable the serial communication port of the PC by means of the Transfer, Open Port menu and selection of one of the available ports among COM1, … COM3.
In the case where the PC has already used the addresses COM1...COM3 for other peripherals or in the case of using a USB port, to which a com number higher than COM3 is typically assigned by the PC, it is necessary to re-assign an address in the COM1...COM3 field to the serial port or USB used, following the Windows procedure with the application System in the Control Panel.

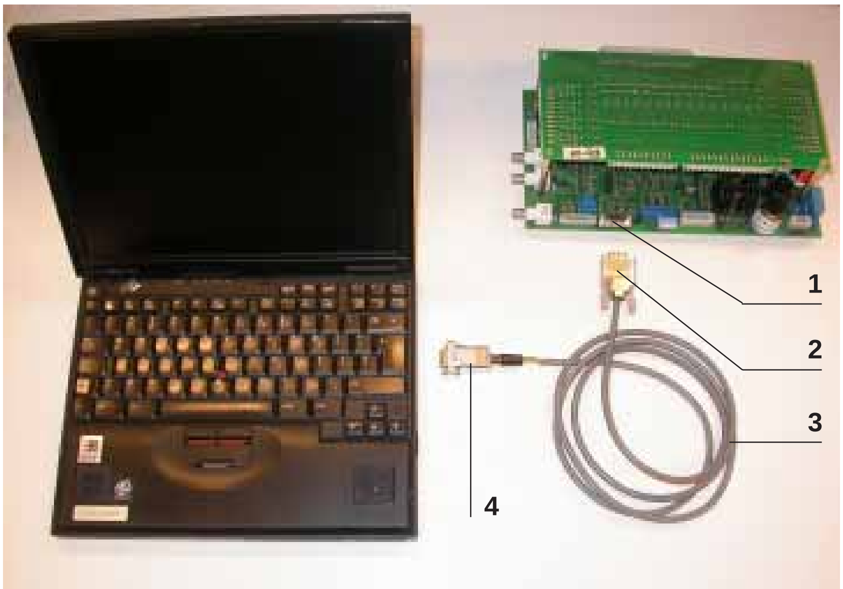


Fig. 85

Direct PC connection (by means of RS232 serial port) / IED Card.

1. -XB24 connector of the basic IED card
2. Male D-Sub 9-pin connector
3. Cable
4. 232-485 Full-Duplex or Half-Duplex converter

Connections with Full-Duplex RFC-9R connector (With this type of converter, Jumper JP6 must be used)

5-pin connector of the Full-Duplex (RFC-9R) converter	Male D-Sub 9-pin connector
1	4
2	9
3	3
4	8
5	1-5

Connections with Half-Duplex RFC-9R connector

5-pin connector of the Full-Duplex (RFC-9B) converter	Male D-Sub 9-pin connector
1	3
2	1-5
3	8

Fig. 86

1. -XB24 connector of the basic IED card.
2. Female/male D-Sub 9-pin adapter.
3. Male USB/RS485 converter.
4. USB extension

Male USB/RS485 connector	D-Sub 9-pin adapter Female	Male
1	Data (-)	8
2	Data (+)	3
5	GND	5

Direct connection by means of the USB PC port with the IED card is available only in the Half Duplex mode.

14.10.1.2 Communication by means of the -XB 58-pin connector

Connect the PC with a serial cable to the female D-Sub 9-pin connection on DIN rail in the secondary switchgear compartment. Connection to the PC is possible with a RS232/RS485 half-duplex converter or with a USB/RS485 half-duplex converter. (Enabling the serial port of the PC must be done in the same way as the previous case).

Indirect PC connection (on RS232 port) / IEC card by means of D-Sub 9-pin connector for DIN rail in secondary compartment.

1 Female D-Sub 9-pin connector for DIN rail.
2 Male D-Sub 9-pin connector.
3 RS232/RS485 half-duplex converter.

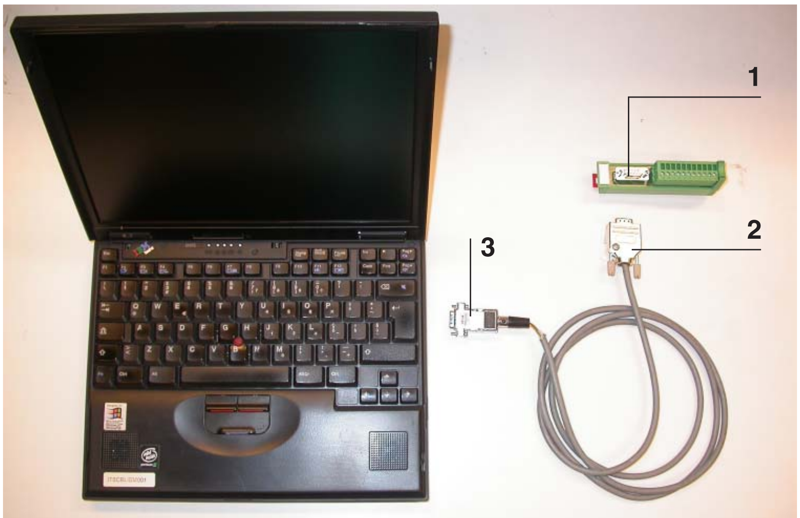


Fig. 87

3-pin connector of the half-duplex converter (RMC-9R)	Male D-Sub 9-pin connector	Female D-Sub 9-pin connector on DIN rail
1	3	3
2	1-5	1-5
3	8	8

Indirect PC connection (on USB port) / IEC card by means of D-Sub 9-pin connector for DIN rail in secondary compartment.

1 Female D-Sub 9-pin connector for DIN rail.
2 Female/male D-Sub 9-pin adapter.
3 USB/RS485 male converter.
4 USB extension.

Fig. 88

Male USB/RS485	D-Sub 9-pin adapter	
connector	Female side	Male side
1	1	8
2	2	1
5	5	5

14.10.1.3 Communication by means of the -XB 58-pin connector and the panel HMI

Connect to the IrDA interface on the panel HMI with the ABB optic cable (RS232/IrDA converter). Connect the male D-Sub 9-pin connector (of the HMI cable/D-Sub 9-pin for DIN rail) to the female D-Sub 9-pin connector on DIN rail in the secondary cabinet.

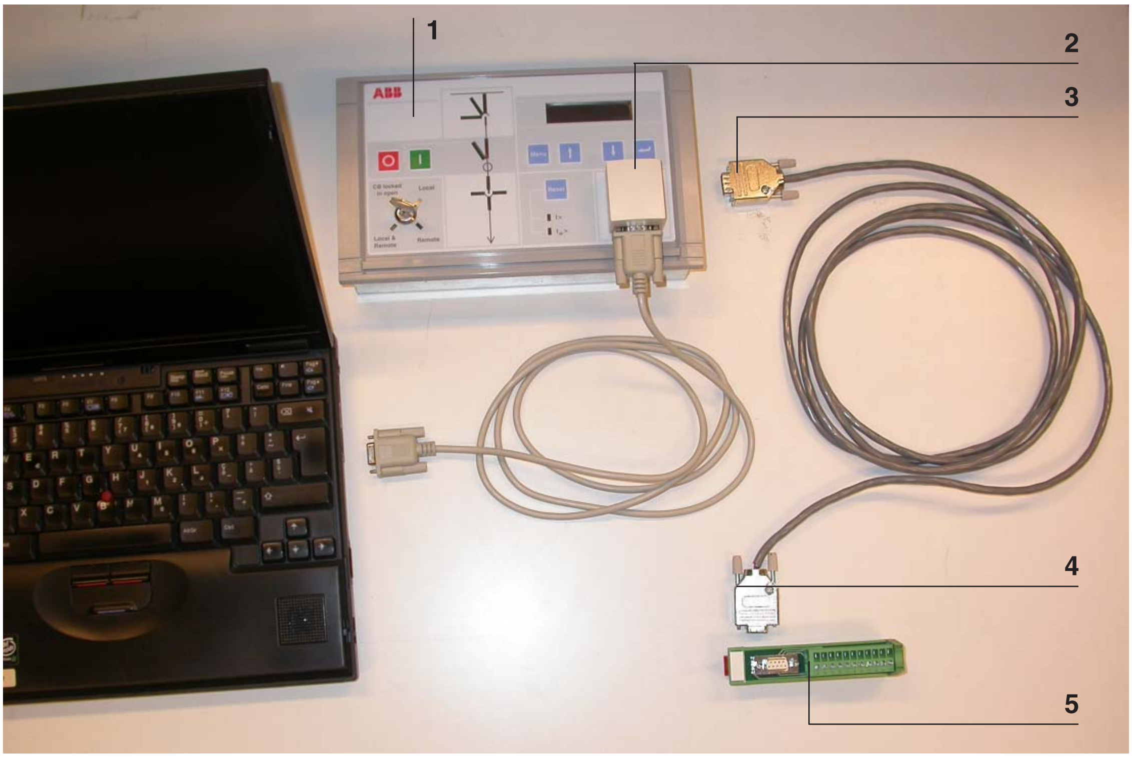


Fig. 89

1 Panel HMI.
2 ABB optic cable (RS232 /IrDA converter)
3 Female D-Sub 9-pin connector for DIN rail.
4 Male D-Sub 9-pin connector (of the HMI cable/D-Sub 9-pin for DIN rail).
5 Female D-Sub 9-pin connector for DIN rail.

Indirect PC connection (on RS232 port) / IEC card by means of HMI and D-Sub 9-pin connector for DIN rail in secondary compartment.

Female D-Sub 9-pin connector HMI cable / D-Sub 9-pin for DIN rail	Male D-Sub 9-pin connector HMI cable / D-Sub 9-pin for DIN rail	Female D-Sub 9-pin connector for DIN rail
8	3	3
1-5	1-5	1-5
3	8	8

Indirect connection to the IED by means of HMI, RS232 / IrDA converter and D-Sub 9-pin connector for DIN rail in secondary compartment is available only in the Half Duplex version.

14.10.1.4 Communication Kits

The communication kits are obligatory accessories provided with every eVM1 to allow communication. They allow a communication port in a secondary compartment for each eMV1 which you can connect up to with a PC with an optional Kit.

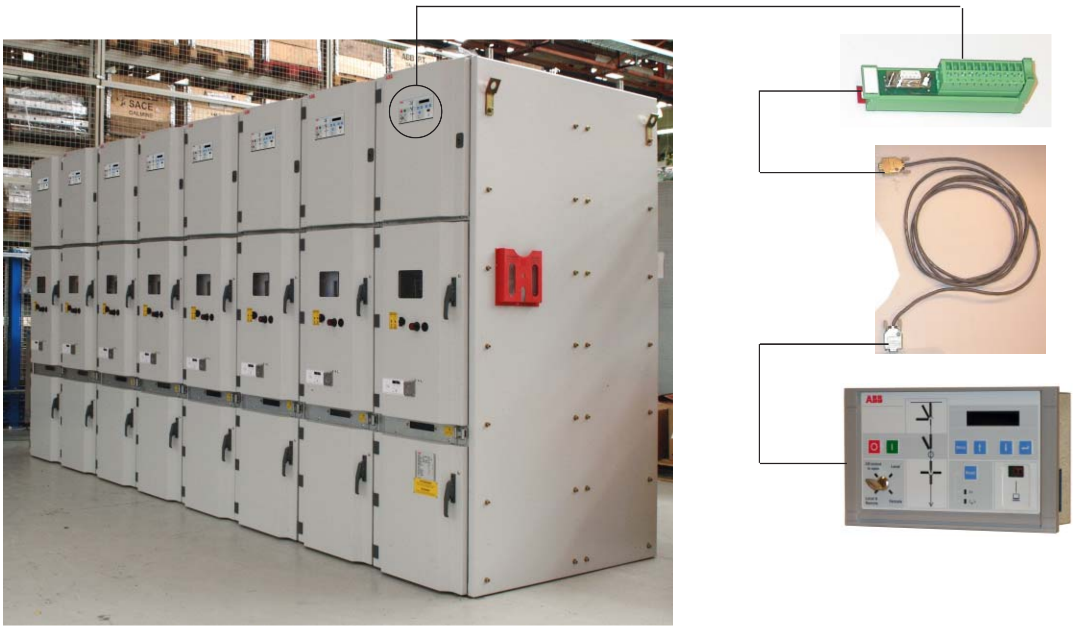
Two versions are available:

- Kit without HMI. Consists of D-Sub 9-pin connector for assembly on DIN rail.
- Kit with HMI. Consists of D-Sub 9-pin connector for assembly on DIN rail, HMI and serial connection cable.

Kit without HMI.

Consists of D-Sub 9-pin connector for assembly on DIN rail.

Fig. 90



Kit with HMI.

Consists of D-Sub 9-pin connector for assembly on DIN rail, HMI and serial connection cable.

Fig. 91

14.10.1.5 Optional components for communication

The optional Kits for communication are accessories provided with the eVM1 circuit-breakers to allow communication with the PC. An optional Kit every 5 eVM1 is recommended. The following versions are available:

RS232/485 Half Duplex converter cable - male D-Sub 9-pin connector.

Fig. 92

USB/485 Half Duplex converter cable - male D-Sub 9-pin connector D-Sub 9-pin interfacing adapter.

Fig. 93

RS232/485 Full Duplex converter cable - male D-Sub 9-pin connector.

Fig. 94

ABB optic cable RS232/IrDA converter and D-Sub 9-pin extension.

Fig. 95

14.11 Password

The Password Tab enables users with higher rights (ABB service personnel, production line personnel, etc.) to access reserved functionalities, that are otherwise disabled and highlighted in the Menu in a light grey colour.

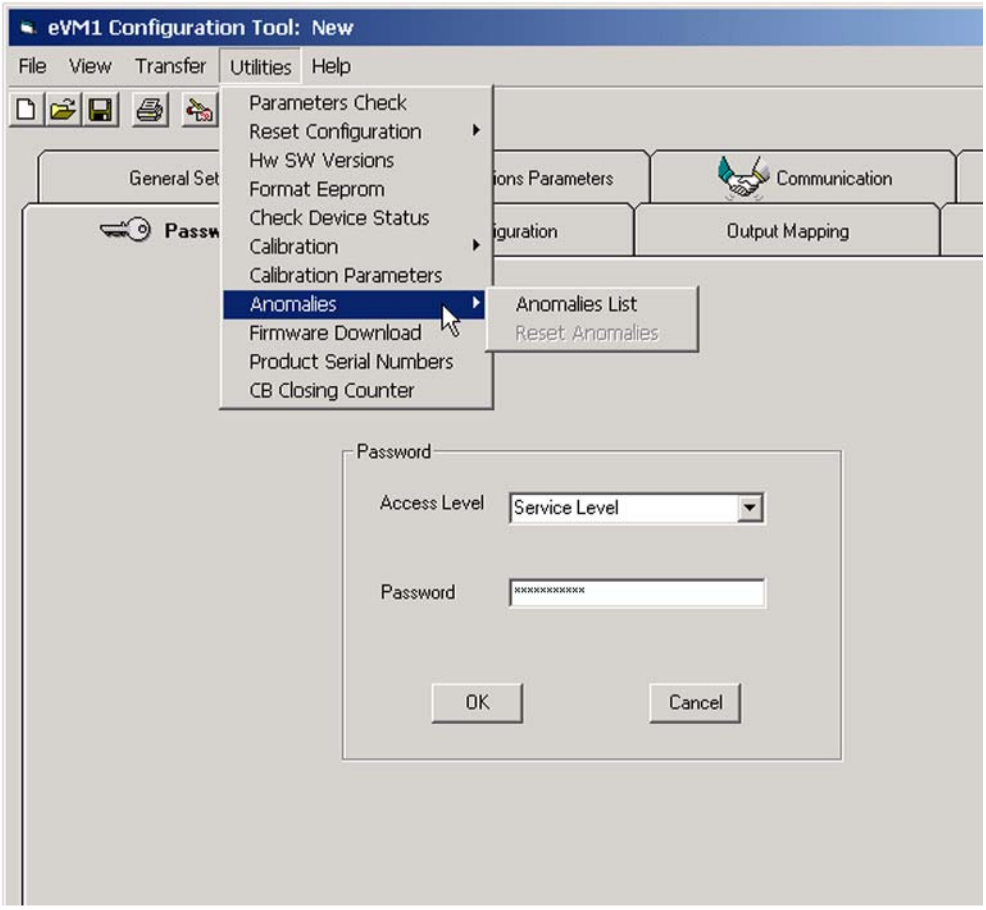


Fig. 96

14.12 LCD Panel HMI

The LCD Panel HMI mounted on the secondary cabinet provides local control by pushbuttons to Open/Close the CB when the IED is in Local or Local and Remote (Global) mode. Green/red LED bars display the single-line diagram: circuit-breaker open/closed position, cable side or busbar side earth switch position, in service or in test position for withdrawable circuit-breaker.
By means of a 4-position key, local or remote control of the CB, global control (global /remote) or CB lock in the open position is possible.
Circuit-breaker locked in Open position enables to use the selection key as the responsibility key for the circuit-breaker .
A two-line LCD enables direct reading of the phase and earth currents (ammeter) and navigation around protection settings and the IED data via the Menu, enter and arrow pushbuttons.
Protection trips are signalled by the I> and Iearth> LEDs and can be reset by the pushbutton in Local mode, remote, global (local and remote).
The IrDa interface enables an active communication link from a PC to the electronic Device (IED) inside the CB.

The arrows enable scrolling in each menù, the enter enables confirming the menù item choice, the Menù pushbutton enables to return to the higher level selection.
The HMI is connected to the electronics on board the circuit-breaker by means of two bushing conductors using the plug socket of the circuitbreaker itself.
The HMI has a universal power supply and it can be supplied with direct voltages from 24 to 250 Vdc or with alternating voltages at 50 and 60 Hz from 24 to 240 Vac.

Fig. 97

14.13 Local CB HMI

The local CB HMI provides local control by pushbuttons to Open/Close the CB when the IED is in Local or Global (Local and Remote) mode. Green/red LED bars display CB open/closed position.

Note

Green/red LED bars are alternatively switched ON and OFF when the CB position is not defined (position sensor indication is not consistent).

μC Ready:	LED on, signalling the IED μ**C** is functional

Unit

Ready:	LED on, all the conditions for CB operation are correct
C Charged:	LED on, the capacitor is fully charged and the energy stored is available for operation
Coils OK:	LED on, the opening –MO and closing –MC coils are connected and ready to operate
No Anomalies:	LED on, no other IED anomaly is detected (otherwise blinking)

Disabling

Opening:	LED on when DI4 is low (active) and Opening disabling function is activated
Closing:	LED on when DI (DI5 by default) is low (active) and Closing disabling function is activated

Protection

Start:	LED on when at least one protection function is in Start condition (general Start signal is active)
Trip:	LED on when at least one protection function has entered Trip condition (general Trip signal is active and latched), see Reset
Local:	LED on when the IED is in Local control Mode (Off when in remote or global mode)
Networks:	LEDs blinking when an active communication is established with the IED; left for communication with Panel HMI, right for communication with system

Fig. 98

14.14 Anomaly list

Whenever the IED detects an Anomaly condition the No Anomaly LED on the Local CB HMI changes status from On to blinking. Active Anomalies can be displayed from the Panel HMI or from the Monitoring tab by the Show pushbutton when an active communication link from a PC has been established with the electronic Device (IED). Basic anomalies can be solved by the user and their root cause and remedial action is described below.
Anomalies that require a higher skill and knowledge of the eCB are coded; the code will be given to ABB service personnel to analyse and solve the Anomaly condition.

Some Anomaly conditions may be a block to the IED since critical information may be missing preventing safely operating the CB (e.g. CB position sensor failure in open position).When a blocking Anomaly is detected the IED goes permanently into Not ready status and will not operate. Resetting the No Anomaly signal will clear only temporary Anomaly conditions; if the Anomaly persists the CB will signal it again in real time.

Note

Classes	Shortdescription of Anomalies	LCD Panel HMI	Anomaly Code
CB anomaly	Call ABB Service with code	ANOMALY CODE	1
CB anomaly	Inconsistency among CB statuses	Error in CB status	2
		Undefined CB status	3
CB anomaly	Reached max No. of opening attempts	Achieved max No. of Opening attempts	4
IED anomaly	Call ABB Service with code	ANOMALY CODE	5
IED anomaly	Call ABB Service with code	ANOMALY CODE	6
		ANOMALY CODE	7
		ANOMALY CODE	8
IED anomaly	Call ABB Service with code	ANOMALY CODE	9
		ANOMALY CODE	10
IED anomaly	Call ABB Service with code	ANOMALY CODE	11
		ANOMALY CODE	12
		CB panel missing	13
		IO Board Missing	14
		ANOMALY CODE	15
		HMI device missing (CoT) Comm. Error with CB (HMI)	16
IED anomaly	Call ABB Service with code	ANOMALY CODE	17
Panel anomaly	Inconsistency among CB truck statuses	CB TRUCK ERROR	18
		CB TRUCK UNDEF	19
Panel anomaly	Inconsistency among Earthing Switch statuses	Earth Switch ERROR	20
		Earth Switch UNDEF	21
CB anomaly	Wrong Position Autotrip performed	ERROR CODE	22
System anomaly	Energy Failure Autotrip performed	ENERGY FAILURE AUTOTRIP	23
System anomaly	Opening due to UnderVoltage function	UV OPEN	24
Panel anomaly	Inconsistency among Line Disconnector statuses	Load Disconnector ERROR	25
		Load Disconnector UNDEF (ONLY after 5s)	26
		Load Disconnector ERROR	27
System anomaly	Configuration not allowed	Configuration not allowed	28
Panel anomaly	Auxiliary Supply failure	ANOMALY CODE	29

14.15 Procedure for discharging the capacitor

Whenever the circuit-breaker has to be moved or the cover removed (i.e. in case of maintenance), the capacitor energy storage, operating at 80V DC, must be discharged afeter cutting the circuit-breaker auxiliary supply off.

Warning!

Direct contact with DC voltage on Capacitor energy storage might result in fatal personnel injures.

The capacitor is discharged by the IED power consumption in some minutes following disconnection of the circuit-breaker power supply voltage.
The **C Charged** LED indication on the CB HMI will go off and after some time the **Unit Ready** LED indication will go off, showing the capacitor voltage is below the level required for CB operation (50V DC). Several minutes are then needed until the capacitor voltage drops to a value of less than 15 V.
After the ready indication goes off it is possible to apply the Capacitor Fast Discharge (CFD) device to the capacitor flying connector (refer to schematic drawings 1VCD400060) to fully discharge the capacitor.

Fig. 99

The red LED indication on the CFD device will go off at full discharge.

14.16 Insulation Test on CB secondary wiring

The IED unit is tested during production at 2kV, 50 Hz on all the input/output connections.
The routine insulation test is repeated during circuit-breaker manufacturing after wiring.

Warning!

To avoid stressing the IED excessively, it is advisable to avoid repetition of the insulation tests on the installation. In any case, the communication connection to the IED, connector -XB24 and the auxiliary supply connection connector -XB22 (protected by common mode varistor of 275 V) both on the IED motherboard, must be disconnected prior any insulation test. On the contrary, any malfunction can be occour causing loss of warranty.
If connection to IED is made with connector D-Sub 9 pin for DIN rail in the low voltage compartment, disconnect this connection.

Notes

For more information please contact:

ABB S.p.A.
Power Products Division
Unità Operativa Sace-MV
Via Friuli, 4
I-24044 Dalmine
Tel.: +39 035 6952 111
Fax: +39 035 6952 874
E-mail: sacetms.tipm@it.abb.com

ABB AG
Calor Emag Medium Voltage Products
Oberhausener Strasse 33
D-40472 Ratingen
Phone: +49(0)2102/12-1230,
E-mail: calor.info@de.abb.com

Petzower Strasse 8
D-14542 Glindow
Fax: +49(0)2102/12-1916

www.abb.com

1VCD600326 - Rev. B, en - Instruction Manual - 2009.08 (eVM1)