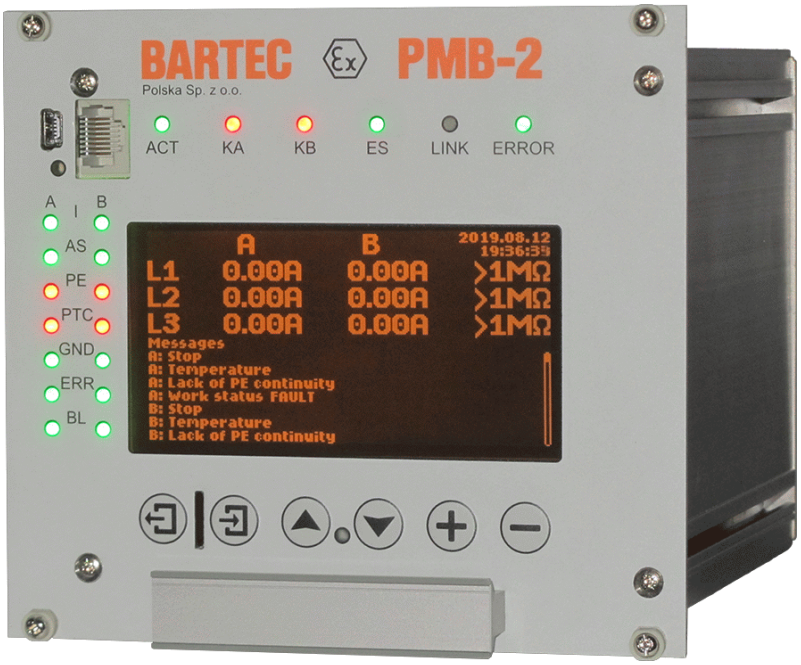
Type PMB-2 Multifunctional Relay

Operation Manual
no. BP/IO/01/16

BARTEC



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Contents

List of Figures

List of Tables

1 Introduction

The Operation and Safety Manual, no. BP/IO/01/16 is intended to provide the users of the PMB-2 multifunctional relay (also referred to as „the product") with the product design, operating principle and procedures of safe and correct operation.

1.1 Copyright

1.2 Warranty terms and conditions

The warranty terms and conditions are specified in BARTEC's „General Terms and Conditions of Sale and Delivery".

All warranty claims and/or claims for material or personal damage will be rejected whenever caused by:

- non-intended use of the product,
- improper transport, handling, storage, installation, wiring, commissioning, servicing, maintenance, repairs, removal and/or recycling,
- non-compliance with this Manual,
- unauthorized modifications in the connection layout of the product,
- improper inspection of wearing parts of the product,
- emergency caused by contact with foreign bodies or other causes.

2 Safety of operation

The product shall only be installed by qualified personnel trained in operation of Ex-rated electrical equipment.

During operation, observe the requirements for maintaining the efficiency of the device, in accordance with the documentation.

The protection features shall be calibrated according to their operating manuals approved for use by the mine operations manager or another competent authority.

All repairs and maintenance of the PMB-2 shall be attempted with the live supply voltage isolated and locked out from the equipment unit it is integrated with.

3 Identification of hazards

3.1 Hazards

The Operation Manual specifies sufficiently the correct maintenance of the product. However, the personnel attempting maintenance shall hold valid electrical licenses.

WARNING: Read this Operation Manual prior repairing or maintaining this product.

WARNING: Do not attempt to repair the product if you do not have the required qualifications. Only BARTEC is authorized for the repairs. Improper or careless repair can lead to serious accidents or death.

WARNING: Modification of the product or use of any spare part which does not comply with BARTEC's engineering conditions may result in severe injury and/or death hazards and will result in loss of warranty rights and product approval.

3.2 Application restrictions

The field installation of the product shall follow the Operation Manual.

RESTRICTION: Do not attempt any makeshift installation of the product.

RESTRICTION: The application of leakage monitoring modules is only possible with ED 100 and ED 100i chokes (or suitably rated wire resistors).

RESTRICTION: The installation shall be done with the required separation distances from the external terminals of the product in compliance with EN 60079-11 Section 6.2.1

RESTRICTION: The ambient temperature limits are: $-20°C \leq Ta \leq +70°C$.

RESTRICTION: Replace the battery only outside of explosion zones. Use only the following battery cell types „VARTA 6032 101 501". This will ensure that the product isolated from the mains and becomes an „ia" rated circuit with negligible terminal ratings.

3.3 Directions for safe use

1. Prior to operating the product, read and understand this Operation and Safety Manual. Refer also to the documentation of the system in which the product is operated.
2. Compliance with the Operation Manual and the guidelines and parameters listed in the system documentation will guarantee reliable operation of the product. The user shall strictly comply with the rules of operation. Non-compliance may result in loss of warranty right, damage of the product or create operating hazards.
3. The management in the product user's organisation is required to provide adequate training for prospective operators of the product.
4. The only operators authorized to work with the product shall be properly qualified.
5. Follow all applicable health and safety regulations and this Manual.
6. Do not modify the product or use it with any spare parts which do not meet BARTEC's specifications for genuine spare parts. Unauthorized attempts at repairs of the product may result in severe hazards to the operators and other personnel, and void the warranty, certification and/or approvals.
7. All test instrument used for servicing of electrical equipment components shall comply with applicable regulations.

8. Troubleshoot and maintain the product in witness of a trained assistant capable of isolating the main power supply and providing first aid as necessary.
9. Any attempt at starting failed electrical equipment may result in hazards to operator's health or life and failure to other equipment.

4 Intended use

The PMB-2 multifunctional relay type is designed for protection and control functions of two three-phase outlets / loads. The individual power outlets are designated with characters „A'' and „B'', respectively[1]. The relay also features an emergency stop device circuit and a earth leakage trip designated „C'' for an auxiliary load which requires no other protection.

Product functions:

- current protection (overload, shorting, current asymmetry, motor stalling, or pump dry run),
- interlocking/central-interlocking leakage protection,
- motor overtemperature protection,
- PE wire discontinuity or PE wire over-resistance protection,
- warning alarm for load making,
- remote or local power load operation control,
- remote or local operation of actuators,
- contactors control,
- display of operating status and messages,
- recording of starting and protection trip current values,
- data output to other control and monitoring system.

The PMB-2 multifunctional relay can be applied in the following equipment types:

- contactor switches,
- compact stations,
- transformer units,
- transformer and power distribution substations,
- other switchgear types of 3-phase AC power systems rated at up to 1140V AC, 50 Hz, installed in underground mine workings or other industrial facilities.

The product is also intended as a protection of power loads and motors operated in explosion hazard zones.

The output circuits of the PMB-2 enable operation in explosion hazard zones and are intended for Methane Explosion Hazard Levels „a'', „b'', and „c'', and Coal Dust Explosion Hazard Classes „A'' and „B''.

5 Operating conditions

For explosion hazard zones, the product is intended for operation if confined to an external flameproof enclosure marked with the Ex d making or in non-hazardous areas if confined to an enclosure with a minimum ingress protection rating IP54 (IP65).

[1] The designations of the outlets read on the display can be modified.

Table 1: Enclosure technical specifications

Enclosure technical specifications		
Oveall dimensions (width x height x depth)	141,9 × 128,4 × 144,5	mm
Weight	1,8	kg

Table 2: Operating conditions

Operating conditions		
Maximum installation elevation	≤1000	m
Ambient temperature	−20…+70	°C
Relative humidity (non-condensing) at 40°C	≤95	%
Transport temperature	−20…+60	°C
Transport relative humidity	≤95	%
Mechanical exposure – frequency	10…55	Hz
Mechanical exposure – amplitude	0,35	mm
Vibration resistance (10…55Hz)	0,5	g
Impact strength	7	Nm
Deviation from the vertical during operation	±15	°
Operating orientation	horizontal	—
Duty	continuous	—

6 Technical parameters

Table 3: Technical parameters

Technical parameters		
DC/AC input power	18/22	W/VA 50Hz
Rated DC/AC supply voltage	24/42	V
Permitted AC supply voltage	32…53	V
Permitted DC supply voltage	20…75	V
Mechanical strength of the K0 relay of the emergency stop circuit	$>10^7$	
The switching capacity of the K0 relay of the emergency stop circuit	230VAC 3A 24VDC 2,5A	AC15 DC13
Maximum contact current of relay K0 of the emergency stop circuit	3,8	A
Mechanical strength of relays Kn[2]	$3 \cdot 10^7$	
Switching capacity of other relays	250VAC 4A 120VAC 3A 240VAC 1,5A 30VDC 4A 120VDC 0,22A 250VDC 0,1A	AC1 AC15 AC15 DC1 DC13 DC13
Maximum switchable power rating of relays IKn[2]	30	VA
Open contact insulation strength	1000	V AC/DC

[2] n – relay sequential number: 1, 2, 3, …

Technical parameters		
Coil-to-contact insulation strength	5	kV
Housing / connector ingress protection rating	IP30 / IP00	
Rated mains voltage for leakage monitoring	≤ 1140	V AC
Rated frequency of protected leakage monitoring mains	50	Hz
Leakage stage tripping time (preferred connection layout, see Fig. 14a-14d, with incremental change of leakage resistance from infinity to 1kΩ ref. PN-G-42040)	≤ 100	ms
Leakage stage tripping time (preferred connection layout, see Fig. 14e-14h, ref. PN-EN 50628)	≤ 200	ms
Leakage protection resistance	2…120	kΩ
Leakage protection injected resistance	0…10	kΩ
Thermal protection resistance	0,1…5	kΩ
Maximum serial resistance in the control loop	$50^{-20\%}$, $100^{-20\%}$, $600^{-20\%}$	Ω
Maximum parallel resistance in the control loop	$2000^{+20\%}$	Ω
Maximum serial resistance in the emergency stop circuit	$600^{-20\%}$	Ω
Maximum parallel resistance in the emergency stop circuit	$2000^{+20\%}$	Ω
Diode type applied in resistance-monitored lines	1N4007	
All current stages tripping time	< 30	ms
Short-circuit stage setting range	2,0…12	I_r/I_n
Phase current asymmetry stage setting range	10…60	% I_n
Rated current I_n for 25mV/A transducer[3]	0,1…128	A
Rated current I_n for 10mV/A transducer[3]	0,25…320	A
Rated current I_n for 5mV/A transducer[3]	0,5…640	A
Rated current I_n for 3mV/A transducer[3]	1,0…1066	A
Rated current I_n for 1mV/A transducer[3]	2,5…2500	A
Motor stall stage setting range	2,5…6,0	I_r/I_n
Pump dry run stage setting range	10…90	% I_n
Relative error of indication (at $I > 0.1I_n$) [50Hz]	5	% I_n
Measurement line input resistance	32	kΩ
Measurement line input capacity	100	nF
Maximum transient peak voltage at measurement inputs (L to N poles)	53,5 (meas. I) 184 (meas. U)	$V_{max\ peak}$
Analogue output voltage range	0…10	V
Analogue output current range	0…20	mA
Digital input voltage range (RST and In[4] to IC)	*(ref. supply voltage)*	
Digital input resistance	20	kΩ

[3] With the short-circuit stage rate set to 12.
[4] n – input sequential number: 1, 2, 3, …

7 Identification

7.1 Type

PMB–2/****

communication options:
M – ModBus protocol

settings input method:
O – all settings made electronically
E – manual input of current settings[a]

integrated storage capacity:
1M – 128MB

special version:
X*n* – special version identifier[b]

[a] special order
[b] applies to special versions only

7.2 Ex-proof protection rating identification

Ⓔx I (M1) [Ex ia Ma] I
OBAC 17 ATEX 0391U

7.3 Marking

The PMB-2 relay features a rating plate which reads:
- Manufacturer's name
- Type
- Manufacturer's serial number / manufacturer's logo / year of manufacture
- IP rating
- Ex-proof protection identification, marking, and characters and the Ex supervisor's number
- Supply voltage, input power, and U_m parameter
- Notice that all other ratings are specified in the Operation Manual

8 Design

8.1 Mechanical structure

The PMB-2 multifunctional relay is housed in an EURO-standard enclosure with a width of 138.8mm (28HP), a height of 111.5mm (3U – EURO card) and a depth of 125.5mm (Fig. 1).

The product can be installed in commercially available, standard EURO cartridges. The enclosure body (the side, top and bottom panels) are made of sections with an external anodized coating. The top and bottom of the enclosure features ribbed heat sinks which improve evacuation heat from the components installed in the enclosure.

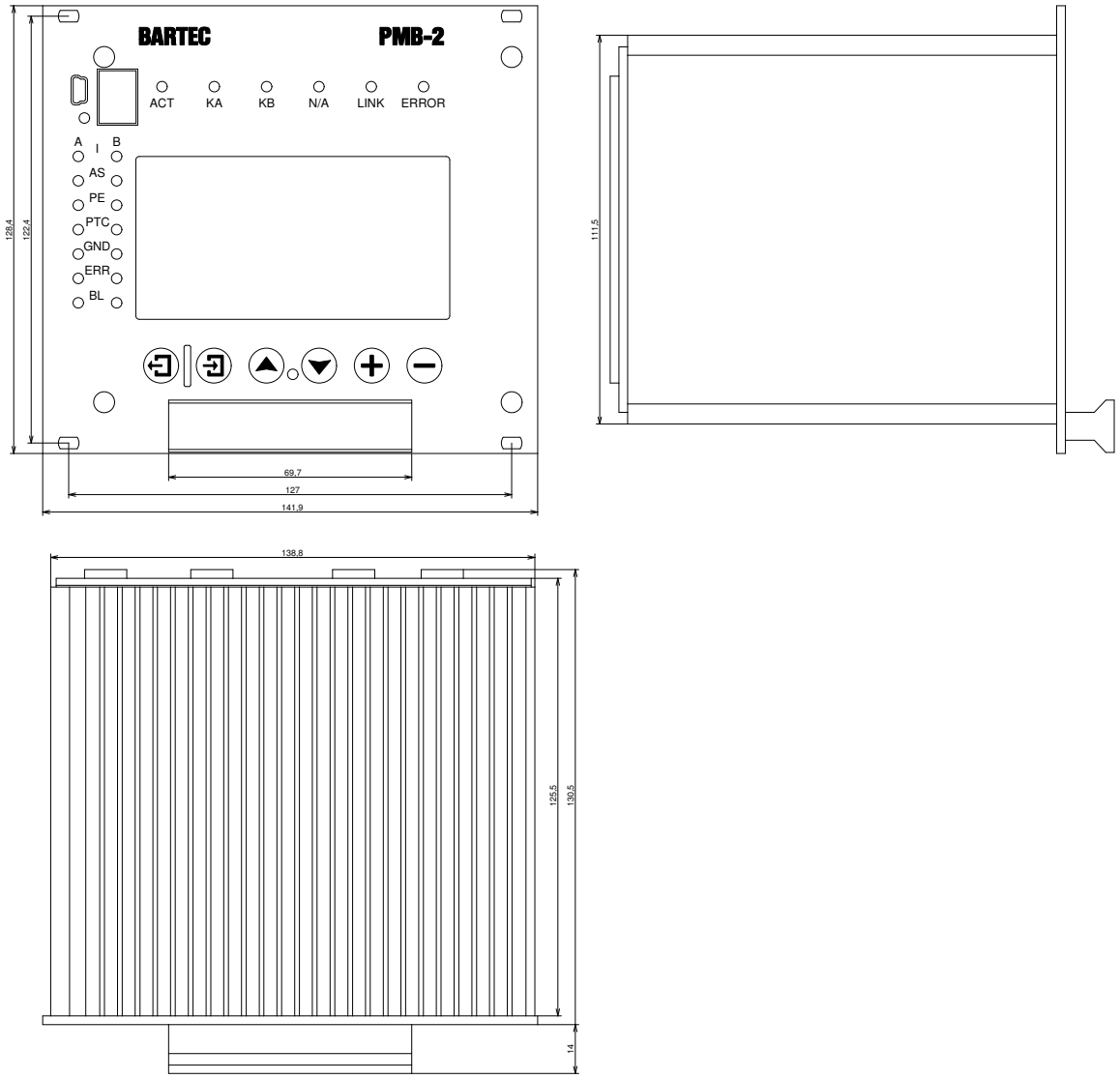


Figure 1: Enclosure

8.2 Electrical equipment

The product features a large and clear display unit, LED indicators, control buttons, and interface ports: mini USB, 8P8C, and micro SD. Optional versions may also include pot-meter knobs for voltage-free adjustment of electrical current settings. The back of the PMB-2 features 32-pin interface slots in the EN 60603-2 (DIN 41612) type D standard and designated as follows: X1 and X2, and X3 and X4 – the latter pair serves as intrinsically safe outputs (Fig. 2). The PMB-2 relay is installed by sliding it into a matching installation unit with pre-installed connectors to match the output slots in the back of the PMB-2. This design forces a single and correct installation position of the PMB-2.

Presented overload and short-circuit protection is designed to protect the 3-phase outlet against the effects of short-circuit, overloading or phase currents asymmetry. If the asymmetry stage is switched off it is possible to use the protection for single-phase circuits. In such a case, it is recommended to connect the unused measuring inputs to AK or BK terminal.

The protection operates with external current-voltage transducers connected to AL1, AL2, AL3, AK and BL1, BL2, BL3, BKterminals. It has a broad range of settings, depending on applied

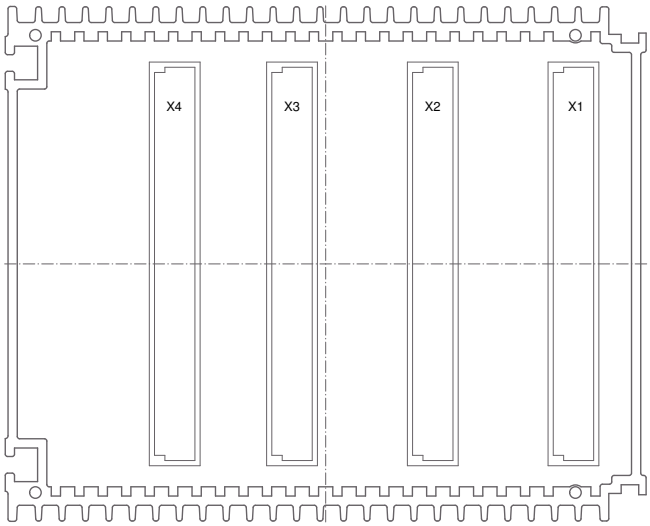


Figure 2: Interface slots

transducers. It is also possible to apply the current transformers, because after their shorting with a small resistance a signal can be expressed in [mV/A]. The transducers should be connected with a twisted pair cable (in case of difficulties in measurements, especially for small currents, it is recommended to use a shielded twisted pair cable with a shield connected to PE, connection to PE in one point exclusively), and the connection of transducers' "k" poles should be made as close to X1:4 terminal as possible to the AK and BK terminals. An example of correct and incorrect connection is shown in Figure 3.

The communication with the device is realized through text messages shown on the display. The device menu is operated with buttons. The protection is fitted with diodes signalling its operational state. The device can be accessed remotely through the RS−485 interface, with using of Modbus RTU protocol.

The product features a digital input labelled RST, which can provide an external command for clearing the messages on the product's display. The remaining inputs, labelled I1 ÷ I16, are multifunctional. The PMB-2 features a programmable intrinsically-safe analogue output and intrinsically-safe control inputs, labelled D1 ÷ D6.

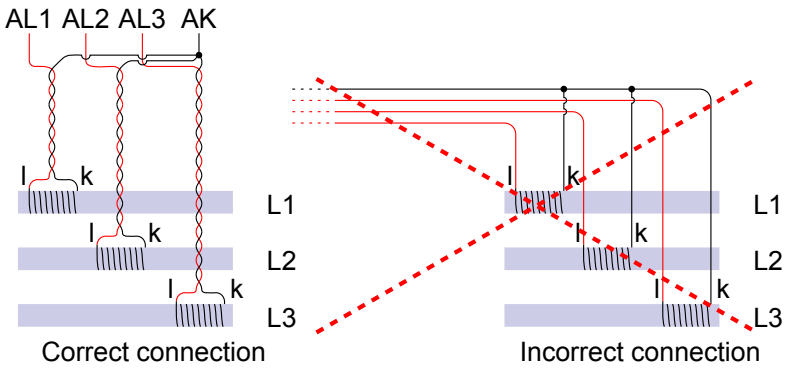


Figure 3: Transducers connection

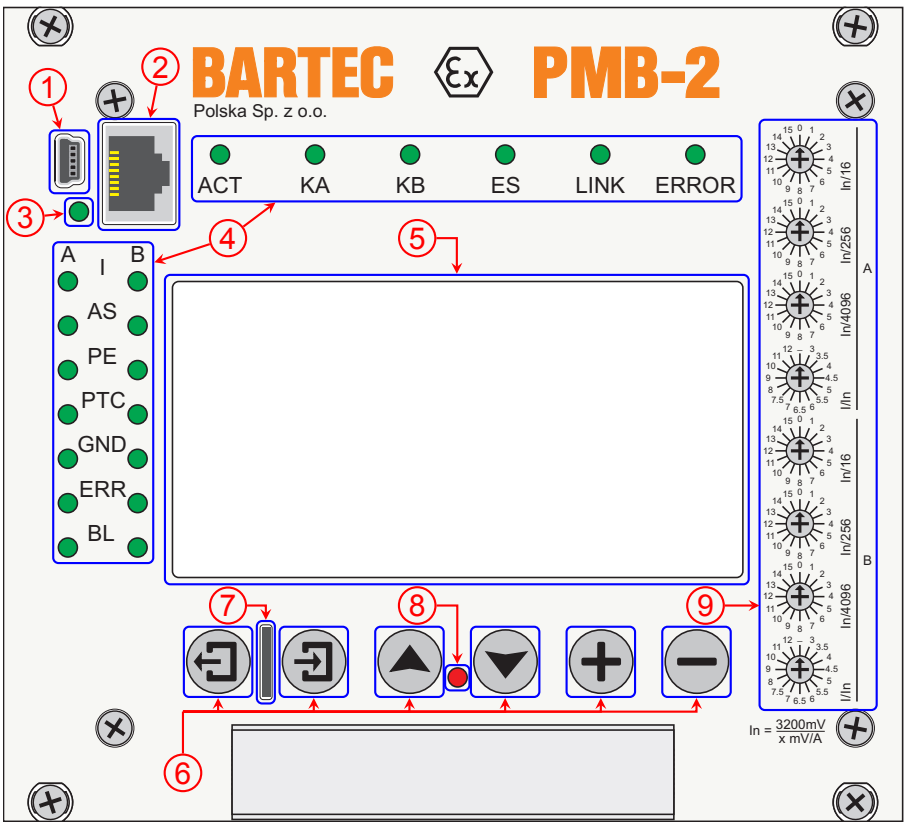


Figure 4: Front panel view of the PMB-2

8.3 PMB-2 front panel

The front panel of the product (Fig. 4) features the following:

(1) – USB port[5],

(2) – 8P8C (Ethernet) connector,

(3) – Ethernet connection LED indicator,

(4) – a cluster of LED indicators over the display and with the following meaning:

ACT – operating status indicator,
KA – outlet A contactor status,
KB – outlet B contactor status,
ES – emergency stop status,
LINK – communication indicator,
ERROR – device fault indicator;

the LED indicators in the left-hand part of the front panel are assigned to the individual outlets of the product (and assigned to columns A and B, respectively):

I – current protections trip status,
AS – current asymmetry,
PE – PE wire discontinuity,
PTC – overtemperature,
GND – leakage (earth fault) control indicator,
ERR – outlet error status,
BL – outlet lock status,

[5] A service interface connector for configuration and firmware updates of the product.

(5) – display,
(6) – control buttons:
- – Escape,
- – Enter,
- – Up,
- – Down,
- – Plus,
- – Minus,

(7) – micro SD card slot,
(8) – IR receiver,
(9) – encoding switches for current settings (available in version „E” only).

8.4 Specification of outputs

8.4.1 Slot X1 (non-intrinsically safe)

definition	designation	c	a	designation	definition
Safety relay, COM1 contact[a]	K04 –	2		– K03	Safety relay, NO1 contact[a]
Safety relay, COM2 contact[b]	K02 –	4		– K01	Safety relay, NC2 contact[b]
Relay K2, NO contact	K24 –	6		– K14	Relay K1, NO contact
Relay K2, COM contact	K21 –	8		– K11	Relay K1, COM contact
Relay K4, NO contact	K44 –	10		– K34	Relay K3, NO contact
Relay K4, COM contact	K41 –	12		– K31	Relay K3, COM contact
Relay K6, NO contact	K64 –	14		– K54	Relay K5, NO contact
Relay K6, COM contact	K61 –	16		– K51	Relay K5, COM contact
Relay K6, NC contact	K62 –	18		– K52	Relay K5, NC contact
Relay K8, NO contact	K84 –	20		– K74	Relay K7, NO contact
Relay K8, COM contact	K81 –	22		– K71	Relay K7, COM contact
Relay K8, NC contact	K82 –	24		– K72	Relay K7, NC contact
Relay K10, NO contact	K104 –	26		– K94	Relay K9, NO contact
Relay K10, COM contact	K101 –	28		– K91	Relay K9, COM contact
Relay K10, NC contact	K102 –	30		– K92	Relay K9, NC contact
Supply input	AC1 –	32		– AC2	Supply input

[a] actuator contact (e.g. trip command output)
[b] data contact (e.g. to a PLC input)

8.4.2 Slot X2 (non-intrinsically safe)

definition	designation	c	a	designation	definition
Outlet A, current measurement ph. L1	AL1 –	2		– BL1	Outlet B, current measurement ph. L1
Outlet A, current measurement ph. L2	AL2 –	4		– BL2	Outlet B, current measurement ph. L2
Outlet A, current measurement ph. L3	AL3 –	6		– BL3	Outlet B, current measurement ph. L3
Outlet A, current meas. com. terminal	AK –	8		– BK	Outlet B, current meas. com. terminal
Analogue output „+”	AP –	10		– AN	Analogue output „−”
Communication port 1 (e.g.: Modbus)	A1 –	12		– B1	Communication port 1 (e.g.: Modbus)
Communication port 2 (reserved)	A2 –	14		– B2	Port Communication port 2 (reserved)
Digital input common pin	IC –	16		– RST	Reset input
Digital input I16	I16 –	18		– I15	Digital input I15
Digital input I14	I14 –	20		– I13	Digital input I13
Digital input I12	I12 –	22		– I11	Digital input I11
Digital input I10	I10 –	24		– I9	Digital input I9
Digital input I8	I8 –	26		– I7	Digital input I7
Digital input I6	I6 –	28		– I5	Digital input I5
Digital input I4	I4 –	30		– I3	Digital input I3
Digital input I2	I2 –	32		– I1	Digital input I1

8.4.3 Slot X3 (intrinsically safe)

definition	designation	c	a	designation	definition
Emergency stop, cathode input	ESC –	2		– ESA	Emergency stop, anode input
		4			
Control line input nr 2	D21 –	6		– D11	Control line input nr 1
Control line input nr 2	D22 –	8		– D12	Control line input nr 1
Control line input nr 4	D41 –	10		– D31	Control line input nr 3
Control line input nr 4	D42 –	12		– D32	Control line input nr 3
Control line input nr 6	D61 –	14		– D51	Control line input nr 5
Control line input nr 6	D62 –	16		– D52	Control line input nr 5
		18			
		20			
Relay IK2, NO contact	IK24 –	22		– IK14	Relay IK1, NO contact
Relay IK2, COM contact	IK21 –	24		– IK11	Relay IK1, COM contact
Relay IK2, NC contact	IK22 –	26		– IK12	Relay IK1, NC contact
Relay IK4, NO contact	IK44 –	28		– IK34	Relay IK3, NO contact
Relay IK4, COM contact	IK41 –	30		– IK31	Relay IK3, COM contact
Relay IK4, NC contact	IK42 –	32		– IK32	Relay IK3, NC contact

WARNING: All unlabelled (non-designated) outputs SHALL NOT be wired.

8.4.4 Slot X4 (intrinsically safe)

definition	designation	c	a	designation	definition
Outlet C, leakage monitoring „+”	CLP –	2		– CLN	Outlet C, leakage monitoring „−”
		4			
		6			
		8			
		10			
Outlet B, leakage monitoring „+”	BLP –	12		– BLN	Outlet B, leakage monitoring „−”
		14			
Outlet B, temperature monitoring „+”	BTP –	16		– BTN	Outlet B, temperature monitoring „−”
		18			
Outlet B, PE continuity monitoring „+”	BPP –	20		– BPN	Outlet B, PE continuity monitoring „−”
		22			
Outlet A, leakage monitoring „+”	ALP –	24		– ALN	Outlet A, leakage monitoring „−”
		26			
Outlet A, temperature monitoring „+”	ATP –	28		– ATN	Outlet A, temperature monitoring „−”
		30			
Outlet A, PE continuity monitoring „+”	APP –	32		– APN	Outlet A, PE continuity monitoring „−”

WARNING: All unlabelled (non-designated) outputs SHALL NOT be wired.

9 Intrinsically-safe line specifications

Full device (slots X1 and X2):

$U_m = 250V$

Relay outputs (terminals IK* on X3):

$U_i = 60V$ $I_i = 1{,}5A$ $P_i = 30VA$

Emergency stop input module (terminals ESA and ESC on X3):

$U_o = 5{,}06V$ $I_o = 5mA$ $P_o = 12{,}8mW$ $L_o = 100mH$
$C_o = 1000\mu F$

Temperature control modules (terminals *TP and *TN on X4):

$U_o = 13{,}65V$ $I_o = 1{,}37mA$ $P_o = 4{,}66mW$ $L_o = 100mH$
$C_o = 22\mu F$ $L_i = 3mH$ $C_i \approx 0$ (negligible)

Control and driving inputs (terminals D* on X3, and *PP and *PN on X4):

$U_o = 13{,}65V$ $I_o = 15{,}5mA$ $P_o = 53mW$ $L_o = 100mH$
$C_o = 22\mu F$ $L_i = 3mH$ $C_i \approx 0$ (negligible)

Leakage monitoring module (terminals *LP i *LN on X4):

$U_o = 18{,}9V$ $I_o = 208\mu A$ $P_o = 0{,}99mW$ $L_o = 1000H$
$C_o = 8{,}1\mu F$ $L_i = 404H$ $C_i \approx 0$ (negligible) $R_i = 90{,}85k\Omega$

10 Service and operation

10.1 Application diagram

An example of an application diagram for the PMB-2 relay is shown in Fig. 5, on p. 20.

10.2 Installation

The PMB-2 multifunctional relay can be installed in areas not endangered by explosion, in the housings with minimal rating of IP54 or in areas endangered by explosion, in the flame-proof housings. The protection cannot be installed in separated flame-proof connecting chambers of devices.

10.3 Electric shock protection

Due to the fact that dangerous voltages may occur on the protection's terminals the safety regula-tions and general rules of proceeding in such conditions should be observed.

10.4 Storage and transport conditions

The protection should be kept in closed storage rooms, at the temperature −20…+40°C and relative humidity up to 75%, free from harmful vapours and gases.

The device should be transported using covered means of transport in the factory packaging that prevents damage at ambient temperature of −20…+40°C and relative humidity of up to 93%. During transport, secure the load against shifting.

10.5 Inspections and maintenance principles

It is recommended to carry out periodic checks on the relay PMB-2 functionality and the correctness of electrical connections. Check the security settings according to the legal acts applicable in a specific country.

Programming of relay PMB-2 settings should be carried out by employees authorized to control and verify protection.

10.6 Repairs

Repairs of type PMB-2 relay security by users are prohibited. BARTEC reserves the exclusive right to remanufacture and repair type PMB-2 protection. Any design changes made by the user of the PMB-2 relay will void the warranty and the user will be liable for any consequential losses.

10.7 Disposal

After passing of the operational period the device must be disposed in accordance with applicable regulations regarding the environment protection.

In case when user does not have an appropriate knowledge in this scope he should obtain information from a proper office of local authorities.

Electrical or electronic equipment contains components, materials or components that should be removed from waste equipment and which may have potentially negative effects on the environment and human health.

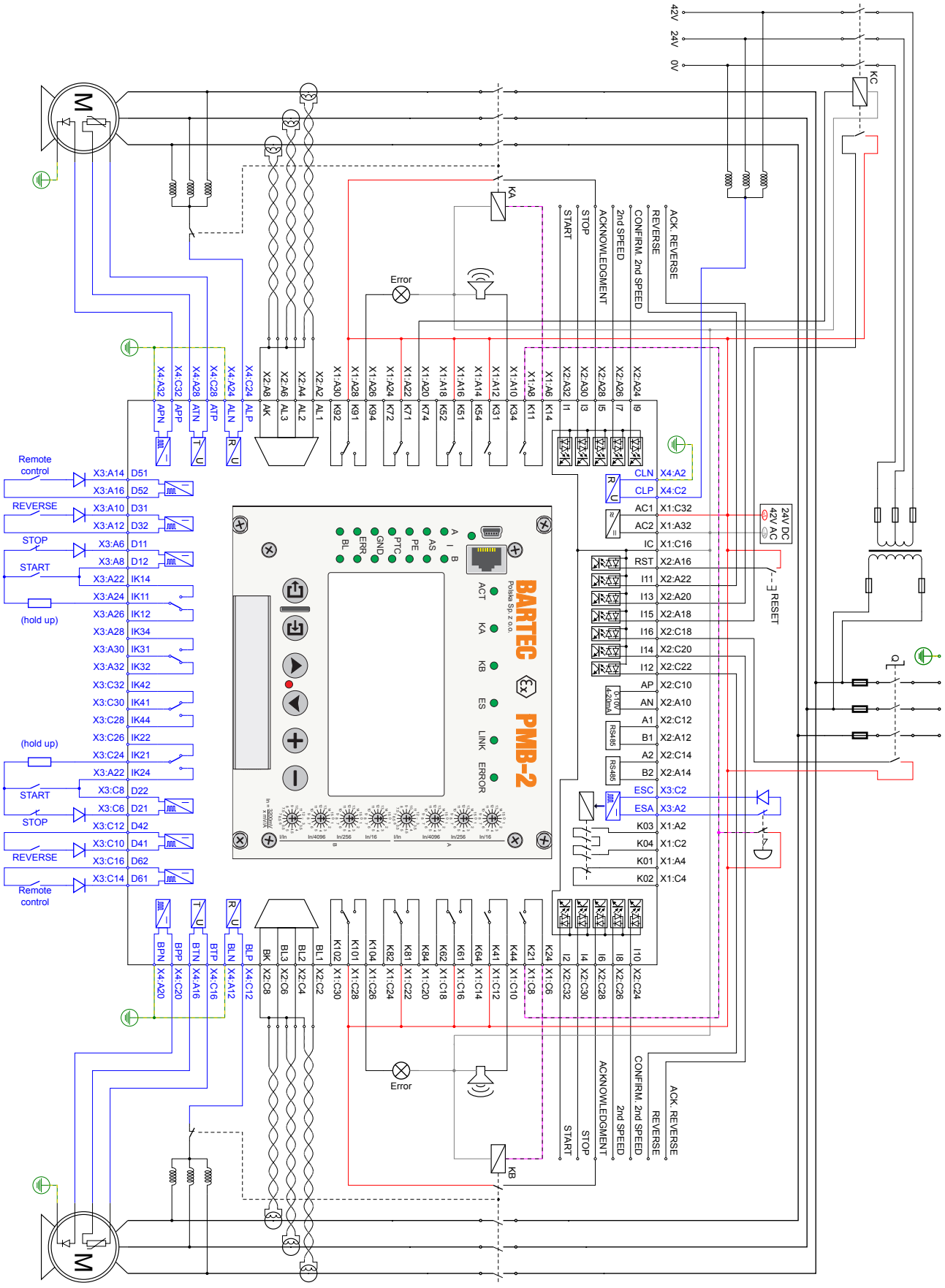


Figure 5: Application diagram for the PMB-2 relay

10.8 Selection and wiring of current transformers

In case when current transformers are applied it is suggested to short the transducers with secondary current of 5 A with 0.1 Ω 5W resistor, and to short the transducers with secondary current of 1 A with 0.5 Ω 2W resistor. The resistors with tolerance worse than 1% should not be applied in order to avoid an excessive measurement errors resulting from limited accuracy of the transducers. Generally the maximal voltage level resulting from a transducer and resistance, the tolerance and power dispersed on resistors and transformers should be taken into consideration when selecting the resistor.

The user must be aware that if the settings are close to the minimal settings, i.e. I_n = 0.5 A and short-circuit multiplication of 10 for 25 mV/A transducer, then the signal corresponding to the rates current of 0.5 A is 2.5 mV, for the short-circuits 5 A and 25 mV/A respectively. The device can work with such signals, but the interference with amplitudes on the level of measured signals and even many times higher may occur in given conditions. The user must be aware of such phenomena because they can make the measurement completely impossible. In such cases at least one of the following methods of this problem resolving should be applied: use a transducer with a higher ratio and/or pull the wire with measured current many times through the transducer window. If the currents are small then the wires with small sections are sufficient, as they cause no problem to pull them many times through the transducer. Another method is to apply a shielded twisted pair cable between the transducer and the device, shielding the transducers from the environment or even between each other. The shield should be connected to PE, the only correct way of shield connection is to connect it in one point only. It is not recommended to run the wires parallel with power cables or other cables, in which the current or voltage signals with high amplitudes occur. Using of too long wires transmitting the signal from transducers can also be troublesome. Then they should be shortened. Also the use of air-core transducers is a high risk of susceptibility to interference. It is then necessary to use transducers with magnetic circuit. This is especially important in systems with inverters and taking measurements of currents of several amperes and smaller. Due to the fact that it is impossible to predict the configurations in which the protection will work the decision on necessary measures is left to the end user's assessment and responsibility.

10.9 Difference between versions „O" and „E"

The main difference between the two types of devices lies in the way of setting the rated current and short circuit stage. In version **O** the electrical current values are set electronically via the product menu. Version **E** features encoding switches for voltage-free setting of both configuration parameters.The first three knobs allow dividing a maximum current, which is equivalent of setting the value of the rated current. The maximum current is dependent on the ratio of the current transducers and is expressed as 3200[mV]/(x[mV/A]), where x is the ratio of the current transducers multiplied by number of turns of wires going through the current transducer. For example ratio 5 mV/A and 2 wire turns in transducers is same as ratio 10 mV/A. The first knob allows you to split the maximum current value by 16 (x/16). The second divides the smallest unit of the first knob by 16 (y/16), which results in division of the maximum current by 256. Consequently, the third knob divides the smallest unit of the second knob by 16 (z/16), so the maximum current is divided by 4096. The fourth knob is used for setting short circuit stage. Menu options for these settings are read only.

Example: You need to set the rated current of 91 A and on the outlet are installed transducers 5 mV/A. The maximum current in this case is 3200[mV]/5[mV/A] = 640A. At first you should set all knobs to zero. Then start adjustment of the first knob (640/16 = 40). For x = 2 rated current is 80 A, for x = 3 it is 120 A so leave knob in position which results in less than the desired value,

i.e. x = 2. Next, start adjustment of the second knob (640/256 = 2,5) where for y = 4 rated current is 90A (4 • 2,5A = 10A; 80A + 10A = 90A) and for y = 5 it is 92,5A, so the second knob should be left in the position y = 4. Then follows adjustment of the third knob (640/4096 = 0,156), where for z = 7 is obtained rated current 91A (7 • 0,156A = 1,09A; 90A + 1,09A ≈ 91A). The whole can be written as follows:

$$I_n = I_{\max} \bullet \left(\frac{x + \frac{y + \frac{z}{16}}{16}}{16} \right) = 640\text{A} \bullet \left(\frac{2 + \frac{4 + \frac{7}{16}}{16}}{16} \right) \approx 91\text{A}$$

Or otherwise:

$$I_n = I_{\max} \bullet \left(\frac{x}{16} + \frac{y}{256} + \frac{z}{4096} \right) = 640\text{A} \bullet \left(\frac{2}{16} + \frac{4}{256} + \frac{7}{4096} \right) \approx 91\text{A}$$

Whilst performing these adjustments there should be no current flow to outlet. The device after powering up shows the set value of the rated current, which frees the user from carrying out calculations described above.In case of setting parameters out of range of allowed settings, the device will imme-diately disconnect all relays and return an error alarm indication.

10.10 Analogue output

The product features a separated active analogue output. Its output signal value is programmable in the following ranges 0…(5)10V or (0)4…20mA. Here, each limit value is separately configurable to use the 4…20mA range within which the output signal value is proportionally dependent to the specific value measured by the product. Example np.: 4mA = 15A and 20mA = 222A.

11 Operating principle of the controller

11.1 Starting the product

Whenever the PMB-2 is powered on, it enters a self-test routine to verify its components, including the internal memory, the supply voltage, internal temperature, operation of actuator relays and the current trip measurement lines. If the self-test routine detects an fault in the operation of any of the components, the product switches to the FAILURE status. The display will read an error message with the cause of failure (ref. 5). The performance of the internal components is monitored while the product is working.

11.2 Outlet operating modes

The PMB-2 multifunctional relay can operate two outlets. Each can enter one of the following operating modes:

1. Disabled,
2. Ready,
3. Signal,
4. Running,
5. Lockout,
6. Failure,
7. Sync,
8. Self-test.

11.2.1 Disabled

All control of the outlet is disabled.

11.2.2 Ready

In the READY status, the PMB-2 awaits the „Start" command to switch on the outlet.

11.2.3 Signal

Some applications require the main contactor is made (switched on) with a certain delay or with a preceding warning signal. The PMB-2 relay can have the signal duration programmed (ref. 8). If it is configured, the outlet will switch to the SIGNAL status before the main contactor is made. The display will then read the countdown to the making of the main contactor. „Stop" command is input during the warning signal countdown, the outlet will revert to the READY status. If a lockout or an error occurs, the operation will be interrupted.

11.2.4 Running

When the „Start" command is input and (if programmed) the warning signal countdown expires, the outlet switches to the RUNNING status. Pressing the „Stop" button while the RUNNING status is active will switch the output to READY.

11.2.5 Lockout

If an internal or external lockout blocks the outlet, the outlet will switch to the LOCKOUT status and disable (break) the activated contactors. The configuration of the lockout of the inputs and the lockout message contents are specified in Section 13.3.1. The selection of the lockout inputs to block the outlets is specified in Section 13.2.7.

11.2.6 Failure

The outlet switches to the FAILURE status if any of the following is tripped: a current trip, PE continuity monitoring, overtemperature, or the leakage monitoring module; or when the emergency stop button is pressed.

This operating status can also be activated if the outlet control fails. This may happen when the product fails to receive the required contactor make acknowledgement or a contactor make acknowledgement is received while no contactor make command was output. The FAILURE status can also be activated when an external Start 2nd Speed command is input while the 2nd speed enable current threshold configuration prevents switching to the 2nd speed, since the applicable trigger criteria are not met.

The FAILURE status is activated whenever the current trips fail the power-on self-test. This will display an error message complete with the error code. If the self-test persistently returns an error, the PMB-2 relay must be replaced with a fully functional counterpart.

11.2.7 Sync

If the Synchro control mode is activated (see Section 13.2.3), the display reads SYNC instead of RUNNING or READY.

The „Sync" setting is only used when the user wishes to synchronise the contactor make and break operations with another contactor. When this setting is enabled, the contactor control relay is permanently made and it will only operate to break when a lockout is activated or a failure status occurs (due to a short-circuit, overload, or PE conductor discontinuity). In this mode, the product performs no control functions.

11.2.8 Self-test

Whenever the PMB-2 relay is powered on, it starts a self-test routine to check the current trip lines[6]. This status is indicated with the AUTOTEST message on the display. During the self-test, the measurement inputs for both outlets of the product are isolated from the external lines connected to slot X2. In the meantime, the current indications on the display will vary due to the progress of the self-test routine.

The user may force the self-test manually by inputting the message reset command to the input of the PMB-2relay. The self-test routine will only begin when none of the outlets is running. Otherwise, the command will only clear the display messages.

12 Operating the PMB-2 relay

12.1 Programming the configuration settings

The PMB-2 configuration settings can be programmed as follows:

- With the control buttons on the front panel.
- With the binary inputs to which external command buttons are wired.
- Remotely via the serial input interface.
- With the IPP-1[7]intrinsically-safe IR remote control, which is certified for operation in underground mine workings with methane and coal dust explosion hazards. The IR remote control can read and input the configuration settings of the relays installed in flameproof enclosures without breaking the seal of the latter to access the devices.

12.2 Navigating the display menu

The product menu has a tree structure shown in Section 12.4. The general navigation method for the display menu follows:

- the higher menu level is accessed by pressing „Escape”,
- the lower menu level is accessed by pressing „Enter”,
- the previous item in the menu is selected by pressing „Up”,
- the next item in the menu is selected by pressing „Down”,
- the selected item value is increased by pressing „Plus”,
- the selected item value is reduced by pressing „Minus”,
- the checkbox (☑, ☐, ⊙, ○) is ticked / unticked with „Plus” or „Minus” respectively,
- the options in multiple selection items can be navigated up and down with the „Up” and „Down” buttons, respectively, while pressing and holding „Enter”,
- when the message history list is displayed, pressing and holding „Enter” modifies the action of the „Up” and „Down” buttons to scroll the whole screen up and down, respectively,
- error messages can only be reset with „Escape” on the main screen level of the display menu,
- each menu can be left by pressing „Enter” once while „Escape” is pressed and held – this will discard all changes made in the menu.

[6] The short-circuit, overload, current asymmetry, etc…

[7] Ex-proof protection rating identification of the IR remote control: Ⓔx I M1 Ex ia op is I Ma, JSHP 18 ATEX 0019X. Operation Manual no. BP/IO/18/17.

If an unsupported or invalid combination of configuration settings is selected, access to the higher menu level is not possible and the respective LED indicator starts flashing.

12.3 Display abbreviations

Some indications on the display and their active status are shown in the menus in abbreviated forms which are explained in Table 4.

Table 4: Display abbreviations

Abbreviation	Description	Active status
I1…I16	binary inputs	high
D1…D6	control inputs (intrinsically safe)	diode
It>[8]	overload (dependent overcurrent trip)	acc. to the setting
I>>	short-circuit (independent overcurrent trip)	acc. to the setting
AS[8]	phase current asymmetry	acc. to the setting
I>	stalling (overcurrent trip)	acc. to the setting
I<	dry run (undercurrent trip)	acc. to the setting
PTC[8]	overtemperature trip	acc. to the setting
PE[8]	PE wire discontinuity monitoring	diode
!⏚	earth leakage trip warning	acc. to the setting
⏚	earth leakage trip triggered	acc. to the setting
B[8]	lockout	acc. to the setting
ACK[8]	contactor make acknowledgement	high
AER[8]	contactor make acknowledgement error	high
OER[8]	outlet error	high
ES[8]	emergency stop	diode
Q[8]	disconnector Q	low
RST[8]	reset input	high
COn[8]	auxiliary outlet C activated indication	high
!⏚C	outlet C earth leakage trip warning	acc. to the setting
⏚C	outlet C earth leakage trip triggered	acc. to the setting

12.4 Display menu

The icons next to the menu items in this manual are hyperlinks which jump to their specifications[9]. Their meaning follows:

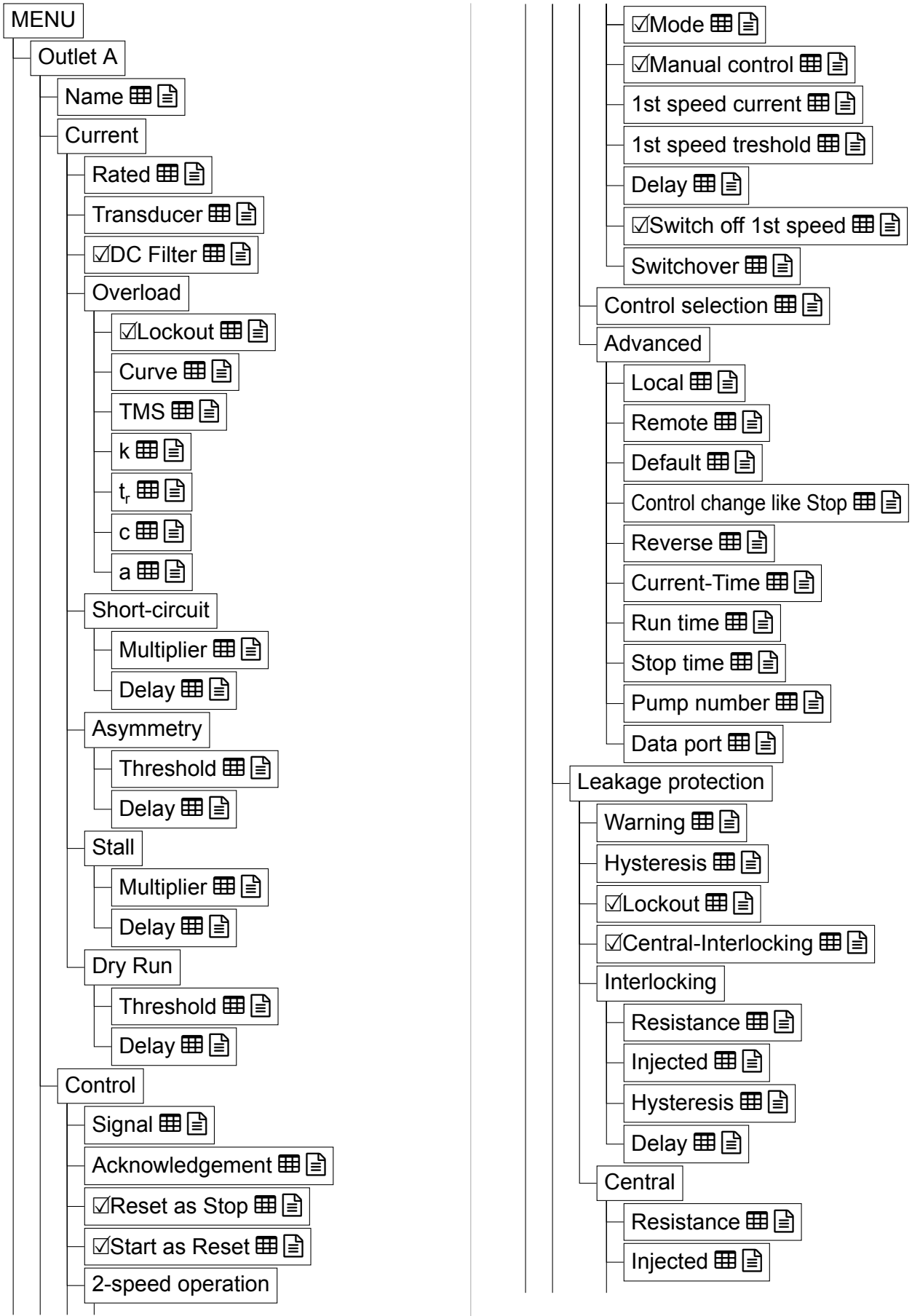
- ▦ – Link to 8 with the default configuration settings.
- 🗎 – Link to the specification of the option.
- 🌲 – Link to the specific location in the following display menu tree structure.

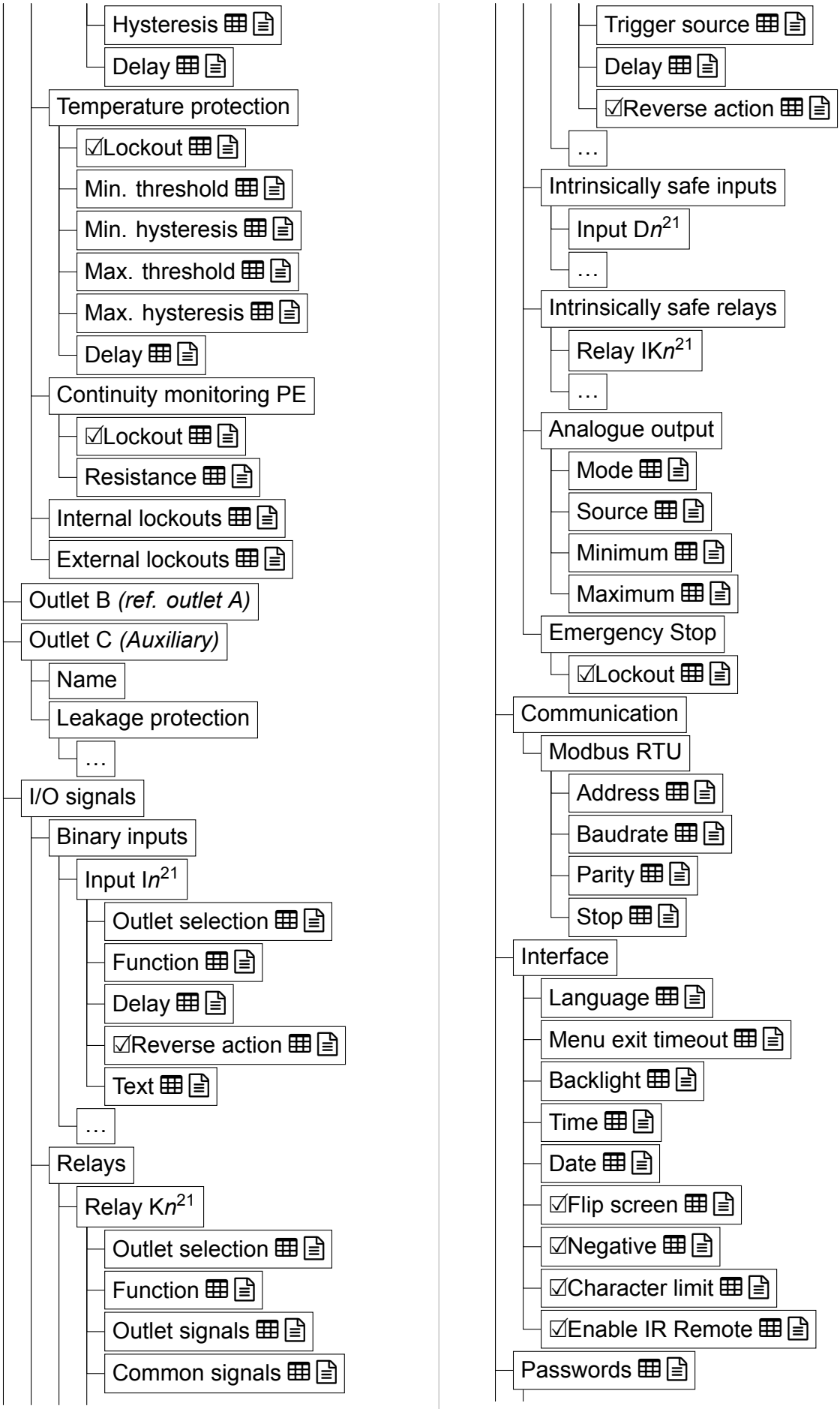
[8] The abbreviations are based on English language terminology:

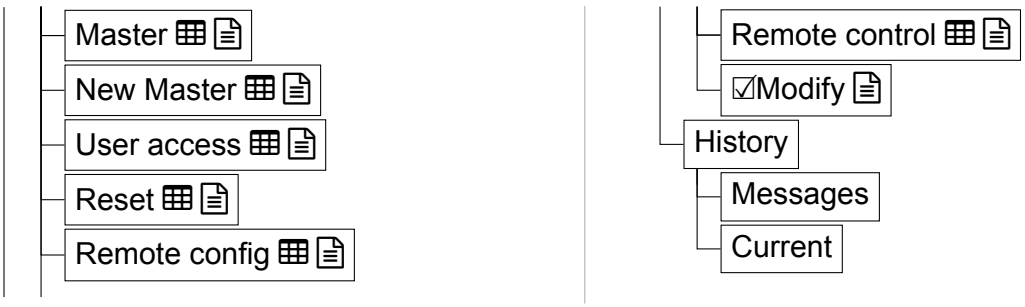
I**t**> – **t**ime	B – **B**lockade (lockout)	ES – **E**mergency **S**top
AS – **AS**ymmetry	ACK – **ACK**nowledge	Q – disconnector **Q**
PTC – thermistor **PTC**	AER – **A**cknowledge **ER**ror	RST – **R**e**S**e**T**
PE – **P**rotective **E**arth	OER – **O**utlet **ER**ror	COn – Outlet **C On**

[9] Applies to the electronic format of this document.

The three dots … indicate the menu items which are repetitive and have been omitted.




Hysteresis
Delay
Temperature protection
☑Lockout
Min. threshold
Min. hysteresis
Max. threshold
Max. hysteresis
Delay
Continuity monitoring PE
☑Lockout
Resistance
Internal lockouts
External lockouts
Outlet B (ref. outlet A)
Outlet C (Auxiliary)
Name
Leakage protection
…
I/O signals
Binary inputs
Input In21
Outlet selection
Function
Delay
☑Reverse action
Text
…
Relays
Relay Kn21
Outlet selection
Function
Outlet signals
Common signals
Trigger source
Delay
☑Reverse action
…
Intrinsically safe inputs
Input Dn21
…
Intrinsically safe relays
Relay IKn21
…
Analogue output
Mode
Source
Minimum
Maximum
Emergency Stop
☑Lockout
Communication
Modbus RTU
Address
Baudrate
Parity
Stop
Interface
Language
Menu exit timeout
Backlight
Time
Date
☑Flip screen
☑Negative
☑Character limit
☑Enable IR Remote
Passwords

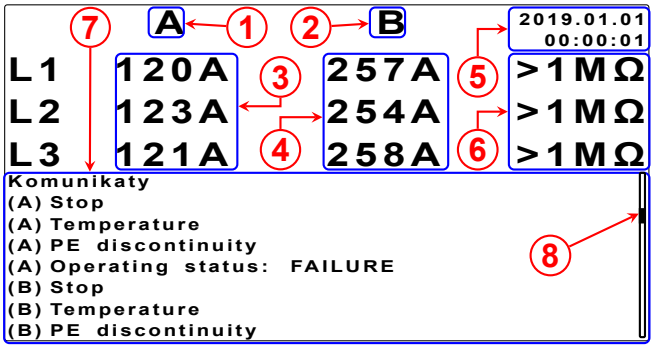


13 Menus

13.1 Menu screens

13.1.1 Main menu screen

The figure to the right shows the layout of the main menu screen displayed when during normal operation. The on-screen items are explained below:



(1) – Designation of outlet A.
(2) – Designation of outlet B.
(3) – Actual phase RMS current values for outlet A.
(4) – Actual phase RMS current values for outlet B.
(5) – Current date and time.
(6) – The resistance values as measured by the earth leakage trips for outlets A, B and C (from top to bottom).
(7) – The message area which shows notifications, trip activation messages, errors, outlet operating statuses, etc. The list of all messages is shown in Table 5.
(8) – The scroll bar, which shows the current position on the displayed menu screen (here, the message area is shown). Each screen can be scrolled with the ▲ and ▼.

Table 5: Messages

Message contents	Extra argument	Meaning
(A/B)[10] Overload	—	Motor overload
(A/B) Short circuit	—	Outlet short-circuit
(A/B) Asymmetry	—	Phase current asymmetry
(A/B) Stall	—	Motor stalling (the rotor is locked)
(A/B) Dry run	—	Motor dry run (no-load operation)
(A/B) Lockout	—	Outlet locked out
(A/B) Start	—	Start command active
(A/B) Stop	—	Stop command active
(A/B) Start 2nd Speed	—	Start 2nd Speed command active

[10] The outlet designation the message applies to.

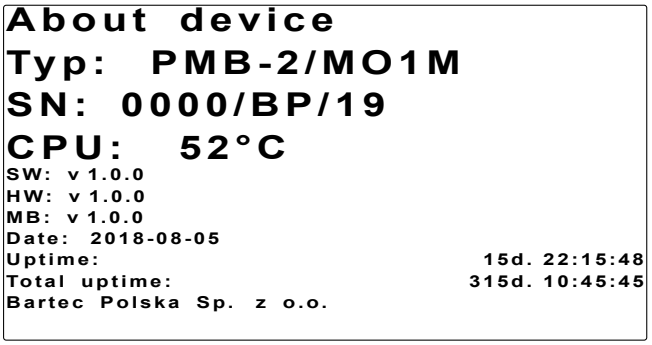
Message contents	Extra argument	Meaning
(A/B) Reverse	—	Outlet in reverse operating mode
(A/B) Rem/Loc control	—	Remote control indication
(A/B) Make acknowledgement	—	Contactor make acknowledgement
(A/B) Temperature	—	Motor operating overtemperature
(A/B) PE discontinuity	—	Brak ciągłości żyły ochronnej PE
(A/B/C) Earth fault warning	—	Outlet insulation resistance low (warning)
(A/B/C) Earth fault	—	Outlet insulation resistance low (trip)
(A/B) Signal	—	Warning signal prior to the contactor make operation
(A/B) Main contactor	—	Main contactor made
(A/B) Contactor Reverse	—	Reverse contactor made
(A/B) Contactor 2nd speed	—	2nd speed contactor made
(A/B) Pumps	—	„Pumps” signal activated in multiple pump control
(A/B) Acknowledgement error	—	Contactor make acknowledgement error
(A/B) 2nd speed error	—	2nd speed control error
(A/B) Temporary control	—	This indicates that the current control source (local or remote) is a temporary selection only and when the power is cycled, it will be reverted to the control source saved in the configuration settings
(A/B) Operating status	—	This indicates the current operating status of the outlet (and the countdown, if active).
(A/B) Self-test error	error code	The self-test of current measurement lines failed
Internal lockout	lockout text	Internal lockout active
External lockout	lockout text	External lockout active
Message	message text	Message displayed by input
Reset	—	The Reset signal is active
Emergency stop	—	The emergency stop is active
Disconnector Q	—	Disconnector Q open
(C) Aux outlet activated	—	Auxiliary outlet C is active
Memory card found	—	A memory card is inserted in the memory card slot
USB connected	—	A connection with a PC is detected
System clock error	—	The system clock is in a fault state
CPU overtemperature	—	The CPU operating temperature is above the maximum limit
Power failure	error code	Wrong internal supply voltage values
EEPROM error	error code	EEPROM module error
Time setting error	—	The RTC time setting is invalid
CR2032 battery error	—	The RTC battery is in a fault state
RTC error	—	RTC error
Memory card format	—	The memory card is being formatted
History memory error	—	An error is present in the operating data history memory
Memory card error	—	An error is present in the operating data history on the memory card

Message contents	Extra argument	Meaning
Ethernet error	—	An Ethernet communication error is active
Signature error	—	Device signature error
Device startup	—	The device power-on event saved whenever the event occurs
ADC error	—	The analogue/digital converter is in a fault state
Relay error	error code	Operating error of actuator relays
Relays lockout	—	The operation of actuator relays is disabled
Measurement module error	error code	An error has occurred in the measurement modules of the device
Fuse error	error code	Internal fuse error

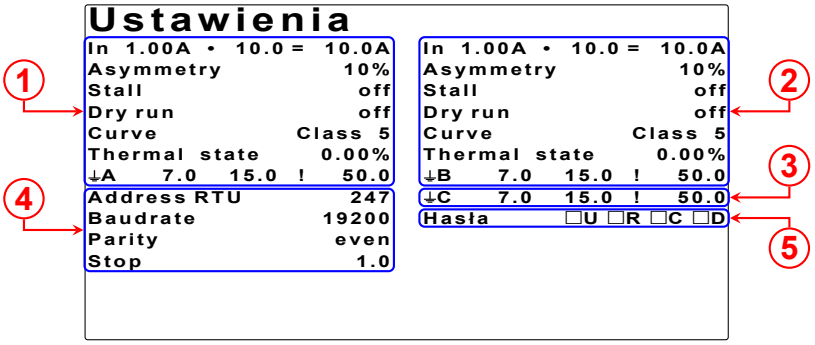
13.1.2 Device „About" menu screen

The figure below shows the menu screen with the 'About' data of the product. You can display it by pressing ⊕ with the main menu screen on the display. The on-screen items are explained below:

- Device type.
- Serial number.
- CPU temperature.
- Firmware version.
- Hardware version.
- Modbus protocol data version.
- Date of manufacture.
- Operating time since the last power-on.
- Total operating time.
- Manufacturer's data.



13.1.3 Configuration settings menu screen



The figure above shows the configuration settings menu screen. You can display it by pressing ⊖ with the main menu screen on the display. The on-screen items are explained below:

(1) – Outlet A settings, with the following displayed (from top to bottom):

- Rated current • short-circuit rate = short-circuit current
- Phase current asymmetry
- Stall rate
- Dry run rate
- Overload response curve

- Earth leakage trip: [central stage] [interlocking stage] **!** [warning signal level] (all values are expressed in kΩ)

(2) – Outlet B settings (ref. to the outlet A setting items)

(3) – Outlet C settings (leakage module only)

(4) – Modbus RTU:
- Device address
- Baud rate
- Parity bit
- Number of stop bits

(5) – Active passwords:
- U – user password
- R – reset command password
- S – remote settings password (over the communication protocol)
- D – remote control password (over the communication protocol)

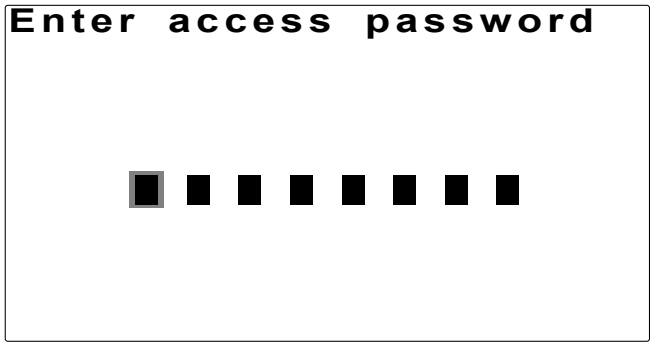
13.1.4 Resetting the displayed messages

The messages and errors can be reset (deleted) by pressing while the main menu screen is displayed. If the message reset command password has been enabled, the menu screen illustrated to the right will be displayed. The active segment of the password input string is highlighted. To reset (delete) the messages, fill out the password input field and press . To cancel, press .

The messages can also be reset with a command sent to the binary input designated „RST”. If the password prompt is displayed, follow this procedure:
- Press the „Reset” button briefly to increase the character value by one
- Pressing and holding the „Reset” button for 2 or more seconds will jump to the next segment in the password input string.
- If the „Reset” button is held after the character changes, the system will attempt to execute the reset command. If the entered password is correct, the errors and messages will be reset. Otherwise, this menu screen will be closed without any reset.

13.1.5 Opening the menu structure

The display menu is entered by pressing while the main menu screen is displayed. A password prompt screen will be displayed, as illustrated to the right. The active segment of the password input string is highlighted. To enter the display menu, fill out the password input field and press . Press to cancel.



WARNING: The user has no possibility to recover a lost access password. In case when the user forgot the access password it can be changed only by the manufacturer, after delivering the device to manufacturer's premises.

13.1.6 Saving the configuration settings

This screen allows to decide what to do with changes introduced during configuration. The „Exit without saving" option causes that the introduced changes will be forgotten. The „Test" option will cause that the changes will be applied without their saving (e.g. after re-start the previous settings will be read in). The „Restore" option will cause that the stored settings will be read in and applied. The „Save" option will cause saving and applying of new settings. The last option „Factory" will cause that the factory settings will be read in and applied.Press to execute the command allowed on the menu screen. Press to go back to the last menu.

13.2 Outlet configuration

13.2.1 Outlet designation

- Name ▦ 🌲 – The outlet designation displayed in the message area and on the main menu screen. The name can be up to 4 characters long[11].

13.2.2 Current trips

- Rated ▦ 🌲 – This is the configurable setting of the rated current value. In two-speed control, this will be the current value of the 2nd speed.
- Transducer ▦ 🌲 – this is the setting value of the current transformer ratio.
- DC Filter ▦ 🌲 – This option allows filtering a constant component from the measured signal.
- Overload – the configuration settings of the overload stage:
  - Lockout ▦ 🌲 – If this option is enabled, all overload module tripping messages will have to be reset manually. If the option is disabled, the overload module trip status will be reset automatically when the motor temperature drops below the trip threshold (which is 70% for classes and 0% for types) which will restarting the controlled motor.
  - Curve ▦ 🌲 – Selects the response curves and the overload stage.
  - TMS ▦ 🌲, k ▦ 🌲, t_r ▦ 🌲, c ▦ 🌲, a ▦ 🌲 – The configuration parameters of the reponse curve types (see Section 15.2).
- Short circuit – the configuration settings of the short-circuit stage:
  - Multiplier ▦ 🌲 – This is the multiplier of the rated current value at which the phase current will be qualified as a short-circuit event.
  - Delay ▦ 🌲 – This is the detection response time. If in every period of 5 ms the RMS current value is detected above the trip threshold, the module will be triggered to trip.

[11] The valid characters are as specified in the ASCII code table and the language options available in the device menu. The additional characters available include: ¶, „, ”, ±, °, α, δ, φ, Ω. The range of valid characters can be reduced with the Character Limit option (see Section 13.5, page 43). The range of supported characters can be changed in future versions of the product.

- Asymmetry – The configuration settings of the phase current asymmetry stage:
  - Threshold ▦ 🌲 – This is the trip threshold setting of the phase current asymmetry stage. Phase current asymmetry is defined as $\frac{I_{L_{max}} - I_{L_x}}{I_{L_{max}}} \cdot 100\%$, with: $I_{L_{max}}$ – highest phase current value, I_{L_x} – actual phase current value, with: $L_x \in \{L_1, L_2, L_3\}$.
  - Delay ▦ 🌲 – This is the detection response time. If in every period of 0.1 ms a phase current asymmetry is detected to be above the trip threshold, the stage will be triggered to trip.
- Stall – The configuration settings of the overcurrent trip module[12]:
  - Multiplier ▦ 🌲 – This is the multiplier of the rated current value at which the phase current will be qualified as a stall event.
  - Delay ▦ 🌲 – This is the detection response time. If in every period of 0.1s the RMS current value is detected above the trip threshold, the module will be triggered to trip.
- Dry Run – The configuration settings of the undercurrent trip module[12]:
  - Threshold ▦ 🌲 – This is the trip threshold value at which the phase current will be qualified as a dry run event.
  - Delay ▦ 🌲 – This is the detection response time. If in every period of 0.1s the RMS current value is detected above the trip threshold, the module will be triggered to trip.

13.2.3 Control

- Signal ▦ 🌲 – The duration of the warning signal before the contactor make operation.
- Acknowledgement ▦ 🌲 – The timeout for the input of the contactor make acknowledgement.
- Reset as Stop ▦ 🌲 – If this option is enabled, the „Reset” command input to the active outlet will disable that outlet.
- Start as Reset ▦ 🌲 – If this option is enabled, the „Start” command at the input will reset the errors indicated. If this operation is completed and allows enabling an outlet, that outlet will be enabled.
- 2-speed operation – The configuration settings of the 2-speed operation:
  - Mode ▦ 🌲 – This option enables / disables the 2-speed operating mode[13]
    * None – Disables the 2-speed operation.
    * 1st speed – The outlet will act as the 1st speed in the 2-speed operation[14].
    * 2nd speed – The outlet will act as the 2nd speed in the 2-speed operation[14].
    * 1st + 2nd speed – The outlet controls the 1st and 2nd speed operation[15].

[12] The module is activated in this operating status: RUNNING.

[13] If the 2-speed operating mode is enabled with the reverse option, the effect of the reverse mode for the 1st and 2nd speeds will depend on the configuration settings of individual outlets. For the „1st + 2nd Speed” mode, the reverse contactor will be made and broken independent of the main contactor, and the prevention of simultaneous make operation of the actuator contactors shall be applied with a solution peripheral to this device. In this 2-speed operating mode, the „Mode 2” reverse operation will act like „Mode 0”

[14] These options apply to two-speed motors where each features two separate winding packs. Here, one of the outlets shall be configured to work as the 1st speed and the other outlet shall be configured to work as the 2nd speed. In this configuration, each of the speeds uses a separate set of protection features and their settings for each of the outlets. The configuration of the outlet in the 1st Speed mode is significant for the control and time dependencies. The 1st Speed will internally control the operation of the outlet in the 2nd Speed mode.

[15] This option applies to two-speed motors with galvanically bonded winding packs, like in the Danhlander system. In this configuration, the current trips are operated by a single set of current transformers in both speeds and a single earth leakage trip, overtemperature trip, etc…

- Manual control – If this checkbox is ticked, the 2nd speed will be switched to by an external input signal connected to the PMB-2. In this case the user must control the delay time after the 1st speed is enabled or acknowdledged as enabled and the maximum current threshold which triggers the 2nd speed. Failure to comply with the configuration settings saved in the product will return an error message. If the checkbox is unticked, the 2nd speed will be switched to automatically when the criteria dependent on the configuration settings are met.
- 1st speed current – This is the rated current setting for the 1st speed, expressed as the percentage of the 2nd speed current setting. This setting applies only in the „1st + 2nd Speed'' mode.
- 1st speed treshold – This is the maximum current setting of the 1st speed at which the 2nd speed can be switched to.
- Delay – This setting specifies the delay to switch to the 2nd speed since the command to switch is input or the 1st speed switch-on is acknowledged sucessfully. The time remaining to the switching to the 2nd speeed is counted down on the display.
- Switch off 1st speed – Breaks the main contactor (of the 1st speed) before the 2nd speed is switched to.
- Switchover – This setting defines the time interval between the moment the 1st speed is switched off and the 2nd speed is switched on.

• Control selection – This setting defines the control source:
  * Local – Local control will be used only.
  * Remote – Remote control will be used only.
  * Local Selection – The control source is selected via the binary input.
  * Remote Selection – The control source is selected via the control line input.
  * Stop + Q – The control source (Remote / Local) is selectable with the „Stop" local control button and disconnector Q. Pressing and holding the „Stop" button while switching over disconnector Q (in either direction, from 0 to 1 or from 1 to 0) will switch the active control source to its opposite (e.g. Local will be switched to Remote or vice versa)[16].
  * Start + Stop – Pressing and holding the „Start" and „Stop" local control buttons for approx. 5 seconds will switch the active control source to its opposite (e.g. Local will be switched to Remote or vice versa)[16].
  * Data port – The control source is changed with the respective command input via the selected communication port[16].
• Advanced – The configuration settings of the advanced control options:
  - Local – Selects the local control type:
    * None – The outlet is disabled.
    * Sync – If this option is enable, the main contactor control relay remains permanently made (the SYNC operating status is displayed instead of READY or RUNNING). The relay will only operate to break when a lockout is activated or a failure status is enabled which affects the main contactor.
    * Start + Stop – The control is operated with two buttons, each with a single steady state: „Start" and „Stop".
    * Start – The control is operated with one button which has two steady states or with a Start/Stop command contact.

[16])This change is not permanently saved. The next power cycle will restore the settings saved in the „Default".

    * Reverse + Start + Stop – The control is operated with two buttons, each with a single steady state, Start and Stop, and another button with two steady states, „Reverse”.
    * Reverse + Start – The control is operated with one button which has two steady states or a Start/Start/ Stop command contact and another button which has two steady states, „Reverse”.
- Remote ▦ 🌲 – wybór typu sterowania zdalnego:
    * None – The outlet is disabled.
    * Sync – If this option is enable, the main contactor control relay remains permanently made (the SYNC operating status is displayed instead of READY or RUNNING). The relay will only operate to break when a lockout is activated or a failure status is enabled which affects the main contactor.
    * Start + Stop – The control is operated with two buttons, each with a single steady state: „Start” and „Stop”.
    * Start – The control is operated with one button which has two steady states or with a Start/Stop command contact.
    * Reverse + Start + Stop – The control is operated with two buttons, each with a single steady state, Start and Stop, and another button with two steady states, „Reverse”.
    * Reverse + Start – The control is operated with one button which has two steady states or a Start/Start/ Stop command contact and another button which has two steady states, „Reverse”.
    * Pumps – This setting is used when several breakers (or outlets) are used at the same time to power pumps or fans which are run alternately in normal operating conditions or simultaneously if a single pump or fan capacity becomes insufficient.
    * Diode – A temporary reversal of the diode direction of operation is equivalent to the Start command.
    * Data port – Remote control via the communication port.
- Default ▦ 🌲 – The default and initial status of control (immediately after powering on the product) for these control switchover modes: „Stop + Q’’, „Start and Stop’’, and „Data Port’’.
    * Local – Local control.
    * Remote – Remote control.
- Control switchover as Stop ▦ 🌲 – If this option is enabled, the Remote/Local control source switchover disables the outlet.
- Reverse ▦ 🌲 – The reverse operating mode[13]:
    * Mode 0 – The main contactor is operated to make with the Start button. The reverse contactor is operated to make with the Reverse button. When the control is online, the Reverse input selects the active contactor and the switchover is made instantly[17].
    * Mode 1 – The main contactor is operated to make with the Start button. The reverse contactor is operated to make with the Reverse button. The control direction can only be selected before the control is activated[17].
    * Mode 2 – The main contactor is operated to make with the Start button. The reverse contactor is operated to make with the Reverse button. To change the

[17] If the control does not use the „Stop” button, at least one of the „Start” or „Reverse” command inputs must remain active to maintain the control in operation.

direction of operation, the command signal must be applied again to the selected input[17].

* Diode – The operating direction of the remote Start command diode selects the contactor to be made. In local control, the operating logic is the same as in Mode 1.

◦ Current-Time ▦ 🌲 – This setting provides the selection of the time vs. current functions[18]:

* None – The option is disabled.
* Function 1 – The operation continues for a limited time without additional triggers. Once made, the contactor will remain made for the duration specified in the Run Time setting. Once this duration is expired, the contactor will operate to break. The duration countdown is shown on the display[19].
* Function 2 – The operation continues for a limited time with additional triggers. The operating logic is the same as in the previous function, but each time the „Start" command is input, the duration countdown is reset to the value specified in the „Run Time" setting. Function 2 requires control with the „Start" and „Stop" buttons.
* Function 3 – Automatic cyclic operation with current level control. When the product is powered on, the contactor will be automatically made. Once the main contactor is in the made position, the PMB-2 will control the current level. If the current trip modules are triggered, the Stop command is input or another module or lockout is activated, the contactor will be operated to break. Once the main contactor is in break, the PMB-2 will count down the duration specified in the „Stop Time" setting. Once the duration expires, the device will attempt to reset the control errors, make operation acknowledgement, and the phase asymmetry, stall and dry run modules. The overload module reset operation depends on the „Lockout" setting in the „Overload" settings group of the outlet. All other failures must be reset manually. Once the errors have been reset, the main contactor has to be operated to make again. The duration countdown is shown on the display[19].
  This function can automatically start a pump at predefined (and programmable) intervals and verify that the pump is running with water by monitoring the pump motor load current. The pump is stopped if the load current value is close to the idle run value specified in the Dry Run setting.
  This function is also operated with the stall module settings which can reduce the sensitivity of the current load measurement to transient states which may occur during starting or operation of the pump.
  It is possible to stop automatic operation with a „Stop" command input. This will start counting down the duration specified in the „Stop Time" setting. Once the countdown ends and the „Stop" command is not present at the input, the pump will restart. If the „Stop" command remains active at the input, however, the „Stop Time" duration countdown will begin anew.

◦ Run Time ▦ 🌲 – The time for which the main contactor remains made with the time vs. current function enabled.

[18] Selecting a time vs. current function forces two-wire control with the Start and Stop buttons.

[19] In the case of two-speed operation, the time remaining to engage the second gear is presented first. Only after its expiry is the remaining working time presented.

- Stop Time – The delay after which the main contactor is operated to make with the time vs. current function enabled[20].
- Pump number – This setting specifies the sequential number of the pump when multiple pumps or fans are controlled by synchronized switches / outlets and operate alternately.
- Data port – The data port for remote control is specified here.
  * Modbus RTU – The control input is the RS-485 serial port.

13.2.4 Leakage protection

- Warning – The earth leakage resistance threshold at which the insulation resistance loss is indicated (with a flashing yellow LED).
- Hysteresis – The hysteresis for the insulation resistance loss indication reset.
- Lockout – The lockout applied when the protection trip is triggered. This will require a manual reset.
- Central-Interlocking – The trip operates like a central and interlocking module.
- Interlocking – The interlocking module settings:
  - Resistance – The resistance threshold at which the trip is triggered.
  - Injected –The resistance of additional components (like chokes, resistors, etc.) connected to the measurement line.
  - Hysteresis – The hysteresis for the triggered state reset.
  - Delay – The time of delay for the trip to be triggered.
- Central – The central module settings:
  - Resistance – The resistance threshold at which the trip is triggered.
  - Injected – The resistance of additional components (like chokes, resistors, etc.) connected to the measurement line.
  - Hysteresis – The hysteresis for the triggered state reset.
  - Delay – The time of delay for the trip to be triggered.

13.2.5 Temperature protection

- Lockout – The lockout applied when the protection trip is triggered. This will require a manual reset.
- Min. threshold – the lower resistance threshold of the measurement element below which the trip is triggered.
- Min. hysteresis – The lower trip threshold hysteresis of the trip reset.
- Max. threshold – the upper resistance threshold of the measurement element above which the trip is triggered.
- Max. hysteresis – The upper trip threshold hysteresis of the trip reset.
- Delay – The time of delay for the trip to be triggered.

13.2.6 PE wire discontinuity monitoring

- Lockout – The lockout applied when the protection trip is triggered. This will require a manual reset.
- Resistance – The maximum resistance allowed for the monitored line.

[20] The time set using the „Stop Time" setting also includes any duration of the warning signal. Thanks to this, the total downtime is equal to the value of the „Stop Time" setting. On the other hand, the countdown on the display is reduced by the duration of the warning signal.

13.2.7 Lockouts

The possible lockout command sources for the outlets:
- Internal lockouts ▦ 🌲 – I1 ÷ I16.
- External lockouts ▦ 🌲 – D1 ÷ D6.

13.3 IO signals (inputs/outputs)

13.3.1 Binary and control inputs

The trip module features 16 non-intrinsically safe binary inputs, designated from I1 to I16. Each input is switched over by applying voltage within the product's supply voltage range (ref. Table 3)There are also 6 intrinsically-safe control inputs designated D1 to D6. Each control input is switched over by connecting a type 1N4007 rectifier diode. The diode can be spliced in in any orientation; however, the direction of connection is differentiated which can be used to select the direction of operation in the reverse mode.

- Input I*n*/D*n*[21]
  - Outlet selection ▦ 🌲:
    * A – Selects function for outlet A.
    * B – Selects function for outlet B.
  - Function ▦ 🌲 – This specifies the the input function selection:
    * None – Input disabled.
    * Start – The Start command.
    * Stop – The Stop command.
    * Start 2nd Speed – Engages the 2nd speed of the controlled load.
    * Reverse – Specifies the direction of motor rotation.
    * Message – Displays the message configured in the „Text" setting (this message can be reset manually).
    * Message + Auto Reset – Displays the message configured in the „Text" setting (which is automatically reset).
    * Lockout – The input works in the lockout command mode (and the lockout can be lifted manually).
    * Lockout + Autoreset – The input works in the lockout command mode (and the lockout is reset automatically).
    * Control selection – Selects the local or remote control source.
    * Acknowledgement – Acknowledgement of the main contactor make or the 1st speed activation[22].
    * Reverse acknowledgement – Acknowledgement of the reverse contactor make[22].
    * 2nd speed acknowledgement – Acknowledgement of the 2nd speed contactor make[22].
    * Disconnector Q – Displays the disconnector status[22,23].
    * Auxiliary Outlet C – Indicates that the auxiliary outlet contactor C is operated to make[22,23].
    * Escape button – The external Escape button [22,23].
    * Enter button – The external Enter button [22,23].
    * Up button – The external Up button [22,23].

[21] *n* – input/relay sequential number
[22] This option is available for binary inputs only.
[23] The „Outlet selection" setting has no effect on this feature.

Input status	Reverse action	Logical state
0	no	0
1	no	1
0	yes	1
1	yes	0

(a) Binary inputs

Input status	Reverse action	Logical state	Control status
	no	0	
	no	0	
	no	1	
	no	1	
	yes	1	
	yes	1	
	yes	0	
	yes	0	

(b) Control lines

Table 6: Reversal of the input action

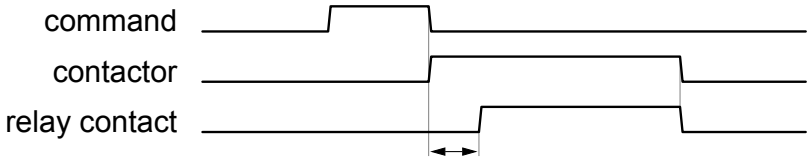
  * Down button – The external Down button [22,23].
  * Plus button – The external Plus button [22,23].
  * Minus button – The external Minus button [22,23].
- Delay – An additional delay time after which the product can detect the change of the input status. The time setting made here will directly affect the functions of the PMB-2which are input-dependent.
- Reverse action –- Reverses the logical state of the input detected by the product. If the direction / sense of operation is controlled by a diode, the setting will reverse the direction / sense (ref. Table 6). This setting affects all input functions.
- Text – The message which is displayed in the message area or the lockout name, depending on the input function enabled. The text can be up to 24 characters long[11].

13.3.2 Relays

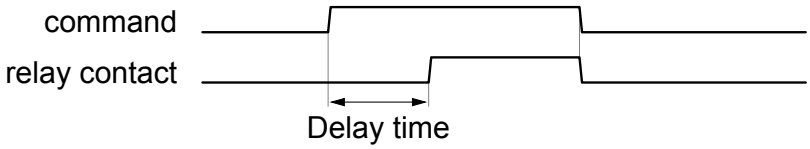
The product features 10 relays designated K1 to K10 and four more relays, designated IK1 to IK4, the actuator contacts of which can be wired to intrinsically-safe lines.

- Relay K*n*/IK*n*[21]
  - Outlet selection :
    * A – Selects function for outlet A.
    * B – Selects function for outlet B.
  - Function – This specifies the the relay function selection:
    * None – Relay disabled.
    * Sum of signals – The response to the command signals specified in the „Outlet Signals” and „Common Signals” settings.
    * Start – Response to the „Start” command active at the input.
    * Stop – Response to the „Stop” command active at the input.
    * Start 2nd speed – Response to the „Start 2nd speed” command active at the input.
    * Reverse – Response to the „Reverse” command active at the input.
    * Hold up – A command signal which can maintain the activation / make command signal if a monostable „Start'' button is wired and used.
      This function switches over the relay contacts if the outlet has the RUNNING status active. The contacts can only maintain the signal outlet from a monostable „Start'' button with single-wire control.
    * Remote Control – This setting makes the contact when remote control is enabled.

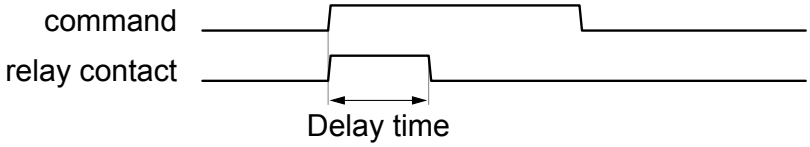
* Acknowledgement – Response to the „Acknowledgement" command active at the input.
* Reverse scknowledgement – Response to the „Reverse acknowledgement" command active at the input.
* 2nd speed acknowledgement – Response to the „2nd speed acknowledgement" command active at the input.
* Signal – The warning signal activated prior to the contactor make operation.
* Main contactor – Control of the main contactor for the outlet.
* Contactor reverse – Control of the reverse contactor for the outlet.
* Contactor 2nd speed – Control of the 2nd speed contactor for the outlet.
* Data port – The contact is operated to make with a remote command at the active data port input.
* Zwalniak – Control over the break release. Once the main contactor has been operated to make, this contactor will be operated to make after the delay specified in the „Delay" setting expires:



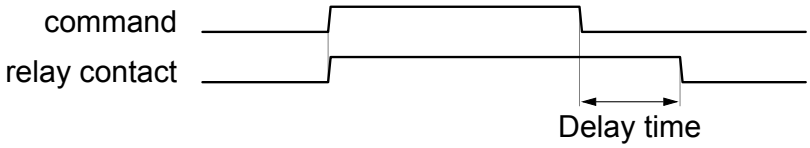
* Pumps – This setting is used to operate the switch / outlet when several breakers (or outlets) are used at the same time to power pumps or fans which are run alternately in normal operating conditions or simultaneously if a single pump or fan capacity becomes insufficient.
* Function 1 – Delayed power-on:



* Function 2 – Power-on for a limited time:

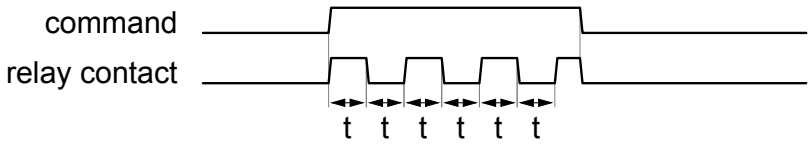


* Function 3 – Delayed power-off:



* Function 4 – Power-on for a limited time after the control is off:

* Function 5 – Cyclic duty[24]:



- Outlet Signals ▦ 🌲 – It>, I>>, AS, I>, I<, PTC, PE, !⏚, ⏚, B, ACK, AER, ERR[25].
- Common Signals ▦ 🌲 – I1, I2, I3, I4, I5, I6, I7, I8, I9, I10, I11, I12, I13, I14, I15, I16, D1, D2, D3, D4, D5, D6, ES, Q, RST, C, !⏚C, ⏚C[25].
- Trigger source ▦ 🌲 – Selects the signal to control the operation of the time-limited functions „Function 1” ÷ „Function 5”:
  * None – No trigger signal.
  * Input I1 – Triggered by input I1.
  * Input I2 – Triggered by input I2.
  * Input I3 – Triggered by input I3.
  * Input I4 – Triggered by input I4.
  * Input I5 – Triggered by input I5.
  * Input I6 – Triggered by input I6.
  * Input I7 – Triggered by input I7.
  * Input I8 – Triggered by input I8.
  * Input I9 – Triggered by input I9.
  * Input I10 – Triggered by input I10.
  * Input I11 – Triggered by input I11.
  * Input I12 – Triggered by input I12.
  * Input I13 – Triggered by input I13.
  * Input I14 – Triggered by input I14.
  * Input I15 – Triggered by input I15.
  * Input I16 – Triggered by input I16.
  * Input D1 – Triggered by input D1.
  * Input D2 – Triggered by input D2.
  * Input D3 – Triggered by input D3.
  * Input D4 – Triggered by input D4.
  * Input D5 – Triggered by input D5.
  * Input D6 – Triggered by input D6.
  * Signal – Triggered by the warning signal.
  * Contatcor – Triggered when the contactor operates to make.
- Delay ▦ 🌲 – Specifies the time of delay for the time-limited functions „Function 1” ÷ „Function 5”.
- Reverse action ▦ 🌲 – Reverses the operation of the relay contacts[26].

13.3.3 Analogue output

The product features a single non-intrinsically safe, active analogue output which can operate in one of the following modes:

- Mode ▦ 🌲 – Specifies the operating mode of the analogue output:

[24] Extreme caution is advised when setting this function. Frequent switchover of the relay status will reduce the switching capacity, or the relay life.

[25] Ref. Table 4; this setting is only applicable to the „Sum of Signals” setting.

[26] This setting does not affect the relay contact status if the product is powered-off.

  - 0V–10V – Voltage output.
  - 0V–5V – Voltage output.
  - 0mA–20mA – Current output.
  - 4mA–20mA – Current output.
- Source ▦ 🌲 – The control signal which defines the analogue output value:
    * None – brak sygnału sterującego.
    * Current A – Outlet A current value.
    * Current B – Outlet B current value.
    * Overload A – Thermal state of outlet A.
    * Overload B – Thermal state of outlet B.
    * Asymmetry A – Phase current asymmetry of outlet A.
    * Asymmetry B – Phase current asymmetry of outlet B.
    * Temperature A – Resistance of the outlet A PTC element.
    * Temperature B – Resistance of the outlet B PTC element.
    * Leakage A – Earth leakage resistance of outlet A.
    * Leakage B – Earth leakage resistance of outlet B.
    * Leakage C – Earth leakage resistance of outlet C.
- Minimum ▦ 🌲 – The control quantity value which corresponds to the minimum value of the analogue output.
- Maximum ▦ 🌲 – The control quantity value which corresponds to the maximum value of the analogue output.
    * The setting is specified by selecting the minimum and maximum values from the setting range of the control signal to reflect the full analogue output range in the selected operating mode.
      The detailed settings for the individual source signal types are listed with a selection of examples in Table 11 on page 51.

13.3.4 Emergency stop

The product features a dedicated intrinsically-safe control line monitoring input which is intended for wiring with an emergency stop button. The emergency stop contact shall be wired in series with a type 1N4007 rectifier diode and the correct diode polarity in the serial connection is important. The emergency stop will be executed if the control line resistance threshold is exceeded or the control line is shorted and without the rectifier diode. This line works independently from the CPU control. Still, the CPU processes the line status in real time and may lockout the outlet in the event of a failure or an error.

Only one setting option can be selected:

- Lockout ▦ 🌲 – Enables the lockout when the emergency stop is triggered. This will require a manual reset.

13.4 Communication

- Modbus RTU – The configuration settings of the RS-485 network Modbus protocol:
  - Address ▦ 🌲 – The slave device address in the network.
  - Baudrate ▦ 🌲 – The baud rate for data exchange.
  - Parity ▦ 🌲 – This setting allows selecting whether the transmitted data parity should be checked or not.
  - Stop ▦ 🌲 – Specifies the number of stop bits.

13.5 Interface

The configuration of the display. Each change made in this menu will be applied instantly; however, all changes to the settings must be saved on the menu exit screen (ref. Section 13.1.6), otherwise they will be discarded and lost.

- Language ▦ 🌲 – Specifies the language of the display menu.
- Menu exit timeout ▦ 🌲 – Specifies the timeout during which no interaction with the menu on the display after which the menu is closed.
- Backlight ▦ 🌲 – The display backlight brightness can be adjusted here.
- Time ▦ 🌲 – The time settings.
- Date ▦ 🌲 – The date (calendar) settings.
- Flip screen ▦ 🌲 – Rotates the display contents by 180°. This also rotates the assignment of the ▲ and ▼ buttons on the front panel.
- Negative ▦ 🌲 – Switches the display colours to their negative.
- Character limit ▦ 🌲 – Enables the limit of the characters available for the user-configurable message contents[11]. For the outlet names: the capital letters A-Z, digits, and the characters [+−,.:;~] will only be available. For the input/lockout names: the ASCII characters, the alphabet characters of the current language version and the characters: ¶, „, ”, ±, °, α, δ, φ, Ω will only be available.
- Enable IR Remote ▦ 🌲 – If this checkbox is ticked, the settings can be entered with the IR remote control.

13.6 Passwords

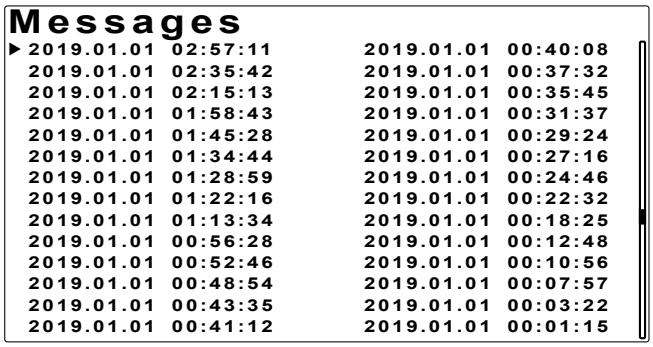
▦ 🌲The product can support several access password types. The passwords can be enabled to prevent unauthorized access to certain configuration settings and commands. Any password can be modified by entering the valid full access password in the Main field and other password fields. Each password you enter must fill out all segment in its string. You will have to confirm each password modification by ticking the „Modify” checkbox[27]. Any password can be disabled by filling out its field with the full access password. The full access password cannot be disabled.

- Master ▦ 🌲 – The full access password which provides unrestricted access to the entire configuration of the product.
- New Master ▦ 🌲 – Specify the new full access password.
- User access ▦ 🌲 – The user access password which provides read-only access to the menus and display of the settings. The user access password does not authorize modification of any parameters directly affecting the protection or control features of the product.
- Reset ▦ 🌲 – the error message reset password (ref. Section 13.1.4).
- Remote config ▦ 🌲 – This password enables remote configuration of the settings over the communication protocol. If it is not defined here, the remote access is only allowed if the full access password is entered.
- Remote control ▦ 🌲 – This password enables remote control of the product over the communication protocol. If it is not defined here, the remote access is only allowed if the full access password is entered.
- Modify ▦ – If this checkbox is ticked, all modifications made to the access passwords will be applied and saved.

[27] Each password modification will only be applied when saved in the menu exit screen (ref. Section 13.1.6). If you leave the password change menu screen and re-open it, all changes unsaved before exiting will be discarded.

13.7 History

When you select „History” in the main menu screen, follow to „Messages” and confirm the command by pressing the following screen will be displayed. The active entry is marked with ▶. You can navigate the entries with the and buttons. The and buttons can skip the whole current screen contents up and down, respectively. The right-hand side of the screen shows the scroll bar.



The button opens the selected entry to display the device events saved in the history. The and buttons navigate the entries one by one without having to return to the list of entries displayed to the side of the screen. The meaning of the messages is listed in Table 5 on page 28.

You can review the history of starting current values and trigger current values of each current trip.

13.8 LED indicators

The assignment of the LED indicators on the front panel and the meaning of their colours and work modes are listed in Table 7. The left-hand LED indicators (see Fig. 4) are arranged in two columns assigned to outlets A and B, respectively.

Table 7: LED indicator assignment

Symbol	Description	Status
I	Outlet current trips	green – OK (no error active) yellow – the overload module can be reset if no other current trip has been triggered czerwony – a trip has been triggered
AS	Phase current asymmetry	green – OK (no error active) red – the phase current asymmetry module has been tripped
PE	PE wire discontinuity monitoring	green – OK (no error active) yellow – PE wire continuity is OK, but an error must be reset red – PE wire discontinuity is detected
PTC	Motor temperature	green – OK (no error active) yellow – the temperature is OK, but an error must be reset red – overtemperature is active
GND	Earth leakage	green – OK (no error active) yellow – the earth leakage status is OK, but an error must be reset flashing yellow – earth leakage warning red – earth leakage fault
ERR	Outlet error	green – OK (no error active) flashing yellow – the outlet settings are incorrect red – the outlet has an active error flashing red-yellow – both of the above statuses are active
BL	Outlet lockout status	green – lockout inactive red – lockout active

Symbol	Description	Status
ACT	Device operating status	flashing green – running OK flashing yellow – update mode enabled
KA	Outlet A contactor status	off – ready for operation or the outlet is disabled flashing green – warning signal green – running red – a control or outlet error is active
KB	Outlet B contactor status	off – ready for operation or the outlet is disabled flashing green – warning signal green – running red – a control or outlet error is active
ES	Emergency stop	green – released for operation yellow – input the Reset command to release for operation red – lockout active
LINK	Communication status	green pulse – serial port data frame processing yellow pulse – USB port data frame processing
ERROR	Device error status	green – OK (no error active) flashing yellow – the settings are incorrect red – an internal error (fault) has occurred flashing red-yellow – both of the above statuses are active

14 Default configuration

The default (factory) configuration settings and valid setting ranges are specified in Table 8. The configuration settings of the inputs and actuator relays are specified in Tables 9 and 10. The detailed settings of the analogue output are specified in Table 11. If the product's default configuration settings are restored, their values are as follows.

Table 8: Default configuration

Setting	Setting range		Default
Outlet name	4 znaki (4 characters (see note[11] on page 32		outlet A: „A” outlet B: „B” outlet C: „C”
Rated current / 2nd speed rated current	0.10…2A 2.0…10A 10…25A 25…100A 100…250A 250…1000A 1000…2500A	0.01A increments 0.05A increments 0.1A increments 0.5A increments 1A increments 5A increments 10A increments	1A
Current ratio	0.1…250mV/A		5mV/A
DC Filter	on/off		on
Lockout if Overload Module is Tripped	on/off		off

Setting	Setting range	Default
Overload Response Curve Types	Classes 2, 3, 5, 10A, 10, 15, 20, 25, 30, 35, 40, Type A (Inverted), Type B (Very Inverted), Type C (Extremely Inverted), Type D (IEEE Moderately Inverted), Type E (IEEE Very Inverted), Type F (IEEE Extremely Inverted), User-defined	Class 5
Coefficient „TMS”	0.01…50	1
Coefficient „k”	0.01…100	1
Coefficient „t_r”	0.01…250	1
Coefficient „c”	0.00…2	0
Coefficient „a”	0.01…2.5	1
Short-circuit current rate (multiplier)	version **O** – 2.0…12.0 or off version **E** – 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5, 8, 9, 10, 11, 12 or off	10.0
Short-circuit module detection time	20…1000ms, 5ms increments	40ms
Max. permitted current asymmetry	10…60% or off	10%
Phase current asymmetry module detection time	0.1…60.0s	4.0s
Stall current rate (multiplier)	1.5…6.0, 0.1 increments or off	off
Stall module detection time	0.1…60.0s	10.0s
Dry run current rate (multiplier)	10…90% or off	off
Dry run module detection time	0.1…60.0s	10.0s
Control warning signal duration	0.1…240.0s lub off	5.0s
Make operation acknowledgement timeout	0.1…2.5s lub off	1.5s
External Reset as Stop	on/off	off
Start Resets Errors	on/off	off
2nd speed control mode	None, 1st speed, 2nd speed, 1st + 2nd speed	None
2nd speed external control	on/off	off
1st speed rated current	1…100%	50%
1st speed threshold to switch to 2nd speed	20…150% lub off	110%
2nd speed switch-on delay	1.0…60.0s	5.0s
Main contactor (1st speed) break operation before switching to the 2nd speed	on/off	off
Speed switchover delay	0.1…10.0s or off	0.5s
Control selection	Local, Remote, Local selection, Remote selection, Stop + Q, Start + Stop, Data port	Local
Local control	None, Sync, Start + Stop, Start, Reverse + Start + Stop, Reverse + Start	Start + Stop

Setting	Setting range	Default
Remote control	None, Sync, Start + Stop, Start, Reverse + Start + Stop, Reverse + Start, Pumps, Diode, Data Port	Start + Stop
Default control	Local, Remote	Local
Control change like Stop	on/off	on
Reverse operating mode	Mode 0, Mode 1, Mode 2, Diode	Tryb 1
Current-Time Function	None, Function 1, Function 2, Function 3	None
Run time	1…240min	5min
Stop time	1…240min	5min
Pump number	2…10	2
Outlet control data port	Modbus RTU	Modbus RTU
Earth leakage trip warning	10.0…300.0kΩ or off	50.0kΩ
Hysteresis of earth leakage warning trip reset	1.0…50.0kΩ	10.0kΩ
Lockout if Earth Leakage Trip is Triggered	on/off	off
Earth leakage trip in central-interlocking module mode	on/off	off
Earth leakage interlocking trip resistance	1.0…150.0kΩ or off	15.0kΩ
Earth leakage interlocking trip injected resistance	0.0…20.0kΩ or off	7.0kΩ
Hysteresis of earth leakage interlocking trip reset	1.0…50.0kΩ or off	4.5kΩ
Earth leakage interlocking trip delay	0.01…15.00s or off	off
Earth leakage central trip resistance	1.0…150.0kΩ or off	7.0kΩ
Earth leakage central trip injected resistance	0.0…20.0kΩ or off	3.3kΩ
Hysteresis of earth leakage central trip reset	1.0…50.0kΩ or off	5.0kΩ
Earth leakage central trip delay	0.01…15.00s or off	off
Lockout if overtemperature module trip is triggered	on/off	off
Min. Threshold of overtemperature module trip	10…500Ω	30Ω
Min. Hysteresis of overtemperature module reset	10…200Ω	30Ω
Max. Threshold of overtemperature module trip	1000…5000Ω	3500Ω
Max. Hysteresis of overtemperature module trip reset	100…1000Ω	500Ω
Overtemperature module trip delay	0.01…10.00s or off	off

Setting	Setting range	Default
Lockout if the PE wire discontinuity monitoring is tripped	on/off	off
Resistance of the PE wire discontinuity monitoring trip	50Ω, 100Ω	50Ω
Outlet active internal lockouts	I1 ÷ I16	(none active)
Outlet active external lockouts	D1 ÷ D6	(none active)
Input – Outlet selection	A or B	(ref. Table 9)
Input – Function	None, Start, Stop, Start 2nd speed, Reverse, Message, Message + Auto Reset, Lockout, Lockout + Auto Reset, Control selection, Acknowledgement[28], Reverse acknowledgement[28], 2nd speed acknowledgement[28], Auxiliary Outlet C[28], Disconnector Q[28], „Escape" button[28], „Enter" button[28], „Up" button[28], „Down" button[28], „Plus" button[28], „Minus" button[28]	(ref. Table 9)
Input – Delay	0.1…25.0s or off	(ref. Table 9)
Input – Reverse action	on/off	(ref. Table 9)
Input – Message or lockout text	24 characters (see note[11] on page 32	(ref. Table 9)
Relay – Outlet selection	A or B	(ref. Table 10)
Relay – Function	None, Sum od signals, Start, Stop, Start 2nd speed, Reverse, Hold, Remote control, Acknowledgement, Reverse acknowledgement, 2nd speed acknowledgement, Signal, Main contactor, Contactor reverse, Contactor 2nd speed, Data port, Release, Function 1, Function 2, Function 3, Function 4, Function 5	(ref. Table 10)
Relay – Outlet signals	It>, I>>, AS, I>, I<, PTC, PE, !⏚, ⏚, B, ACK, AER, ERR	(ref. Table 10)
Relay – Common signals	I1 ÷ I16, D1 ÷ D6, ES, Q, RST, C, !⏚C, ⏚C	(ref. Table 10)
Relay – Trigger Source	None, Inputs I1 ÷ I16, Inputs D1 ÷ D6, Signal, Contactor	(ref. Table 10)
Relay – Delay	0.1…320.0s or off	(ref. Table 10)
Relay – Reverse action	on/off	(ref. Table 10)
Analogue output operating mode	0…10V, 0…5V, 0…20mA, 4…20mA	0…10V
Analogue output signal source	None, Current A, Current B, Overload A, Overload B, Asymmetry A, Asymmetry B, Temperature A, Temperature B, Outlet A, Outlet B, Outlet C	None
Minimum control quantity value of the analogue output	0…10000[29].	0

[28] Applies to binary inputs only.

[29] The resolution of the specified quantity with the minimum ay 0 and the maximum at 10000. See details in Section 14.3

Setting	Setting range	Default
Maximum control quantity value of the analogue output	0…10000[29]	10000
Lockout if the emergency stop is triggered	on/off	on
Modbus RTU – Address	1…247	247
Modbus RTU – Baud Rate	300, 600, 1200, 1800, 2400, 3600, 4800, 7200, 9600, 14400, 19200, 28800, 38400, 57600, 115200, 128000, 256000	19600
Modbus RTU – Parity	even, odd, zero, one, none	even
Modbus RTU – No. of Stop Bits	1.0, 1.5, 2.0	1.0
Language	Polish, English, German, Spanish, Czech, Russian, Turkish	Polish
Menu exit timeout	1…10min	2min
Display backlight	10…100%	100%
Backlight	00:00:00…23:59:59	00:00:00
Date	01.01.2000…31.12.2099	01.01.2000
Screen Flip by 180°	on/off	off
Display Negative Colours	on/off	off
Character limit	on/off	on
Enable IR Remote	on/off	włączone
Access passwords	00000000…99999999	00000000

14.1 Input settings

Table 9: Input settings

Input	Outlet selection	Function	Delay	Text	reverse action
I1	A	Start	off	I1	off
I2	B	Start	off	I2	off
I3	A	Stop	off	I3	off
I4	B	Stop	off	I4	off
I5	A	Acknowledgement	off	I5	off
I6	B	Acknowledgement	off	I6	off
I7	A	Start 2nd speed	off	I7	off
I8	B	Start 2nd speed	off	I8	off
I9	A	2nd speed acknowledgement	off	I9	off
I10	B	2nd speed acknowledgement	off	I10	off
I11	A	Reverse	off	I11	off
I12	B	Reverse	off	I12	off
I13	A	Reverse acknowledgement	off	I13	off

Input	Outlet selection	Function	Delay	Text	reverse action
I14	B	Reverse acknowledgement	off	I14	off
I15	A	Auxiliary Outlet C	off	I15	off
I16	A	Disconnector Q	off	I16	off
D1	A	Start	off	D1	off
D2	B	Start	off	D2	off
D3	A	Reverse	off	D3	off
D4	B	Reverse	off	D4	off
D5	A	Control selection	off	D5	off
D6	B	Control selection	off	D6	off

14.2 Relay settings

Table 10: Relay settings

Relay	Outlet selection	Function	Outlet signals	Common signals	Trigger source	Delay	Reverse action
K1	A	Main Contactor	—	—	None	off	off
K2	B	Main Contactor	—	—	None	off	off
K3	A	Signal	—	—	None	off	off
K4	B	Signal	—	—	None	off	off
K5	A	Contactor 2nd speed	—	—	None	off	off
K6	B	Contactor 2nd speed	—	—	None	off	off
K7	A	Reverse	—	—	None	off	off
K8	B	Reverse	—	—	None	off	off
K9	A	Sum of signals	It>, I>>, AS, I>, I<, PTC, PE, ⏚, ACK, AER, OER	—	None	off	off
K10	B	Sum of signals	It>, I>>, AS, I>, I<, PTC, PE, ⏚, ACK, AER, OER	—	None	off	off
IK1	A	Hold up	—	—	None	off	off
IK2	B	Hold up	—	—	None	off	off
IK3	A	None	—	—	None	off	off
IK4	B	None	—	—	None	off	off

14.3 Analogue output settings

Table 11: Analogue output settings

Signal source	Patameter	Setting range	Default
Current A, Current B	Minimum	0.000…10.000I_n	0.000I_n
	Maximum		10.000I_n
Overload A, Overload B, Asymmetry A, Asymmetry B	Minimum	0.00…100.00%	0.00%
	Maximum		100.00%
Temperature A, Temperature B	Minimum	0…10000Ω	0Ω
	Maximum		10000Ω
Leakage A, Leakage B, Leakage C	Minimum	0.0…1000.0kΩ	0.0kΩ
	Maximum		1000.0kΩ

Caution: If the setting is „Minimum" < „Maximum", the analogue output change will be proportional to the source signal change. If the setting is „Minimum" > „Maximum", the analogue output change will be inversely proportional to the source signal change.

Example 1: The thermal state (overload) can ranges within 0…100%. The setting value of 10% means that the temperature status of 10% has the analogue output value at 0V within 0…10V or 4mA within 4…20mA. Likewise, the setting value of 85% means that the thermal state of 85% has the analogue output value at 10V within 0…10V or 20mA within 4…20mA.

Example 2: The nominal current settings are somewhat different. Here, the „Minimum" and „Maximum" settings correspond to the rates or multipliers of nominal current, I_n. A reading within 0-10V,which corresponds to the current value range of 0-2I_n set the „Minimum" to 0.00I_n and the „Maximum" to 2.00I_n. The setting will correspond to the default control logic of the analogue output for the OSC-3/ELBA100Am protection devices.

15 Overload characteristics

15.1 Standards EN 60255-149 and EN 60947-4-1

The class of characteristics, meeting the conditions specified in the table 12 are implemented in the overload stage of the protection. Response time curves for cold and hot states are presented in figures 6 and 7. In the case of testing response times from cold state, the initial thermal state should not exceed 1%. Then, its effect on time measurement can be considered negligible. When testing response times from hot state, the initial thermal state shall be equal to 70.6%, which corresponds to the value determined for current flow equal I_n. A reset of overload element is possible, when thermal state drops below 70%.

The run of presented characteristics is guaranteed up to the preset short-circuit multiplication of the short-circuit stage. If the short-circuit stage is switched off then the presented runs of characteristics are guaranteed up to the rated current multiplication amounting to 12. The conditions specified in: EN 60255-149 and EN 60947-4-1 standards are fulfilled.

HINT: If the power supply voltage of the PMB-2 relay is turned off during the motor cool-down time which corresponds to the selected response curve (which is after the overload module was tripped), the countdown continues from the value at the power-off when the supply voltage is reconnected.

Table 12: Overload characteristic classes

Trigger-ing class	Triggering time T_p at the multiplication of the control circuit (for cold state)				Approximate time to switching on after the overload stage triggering in case of no flow of phase currents
	1,05	1,2	1,5	7,2	
2			$T_p \leq 48$ s	$0,5 < T_p \leq 2$ s	1:11
3			$T_p \leq 1{:}12$ min	$1 < T_p \leq 3$ s	1:47
5			$T_p \leq 2$ min	$2 < T_p \leq 5$ s	2:59
10A			$T_p \leq 2{:}48$ min	$3 < T_p \leq 7$ s	4:10
10			$T_p \leq 4$ min	$4 < T_p \leq 10$ s	5:58
15	$T_p \geq 2$ h	$T_p < 2$ h	$T_p \leq 6$ min	$5 < T_p \leq 15$ s	8:56
20			$T_p \leq 8$ min	$6 < T_p \leq 20$ s	11:55
25			$T_p \leq 10$ min	$7,5 < T_p \leq 25$ s	14:54
30			$T_p \leq 12$ min	$9 < T_p \leq 30$ s	17:53
35			$T_p \leq 14$ min	$11 < T_p \leq 35$ s	20:51
40			$T_p \leq 16$ min	$13 < T_p \leq 40$ s	23:50

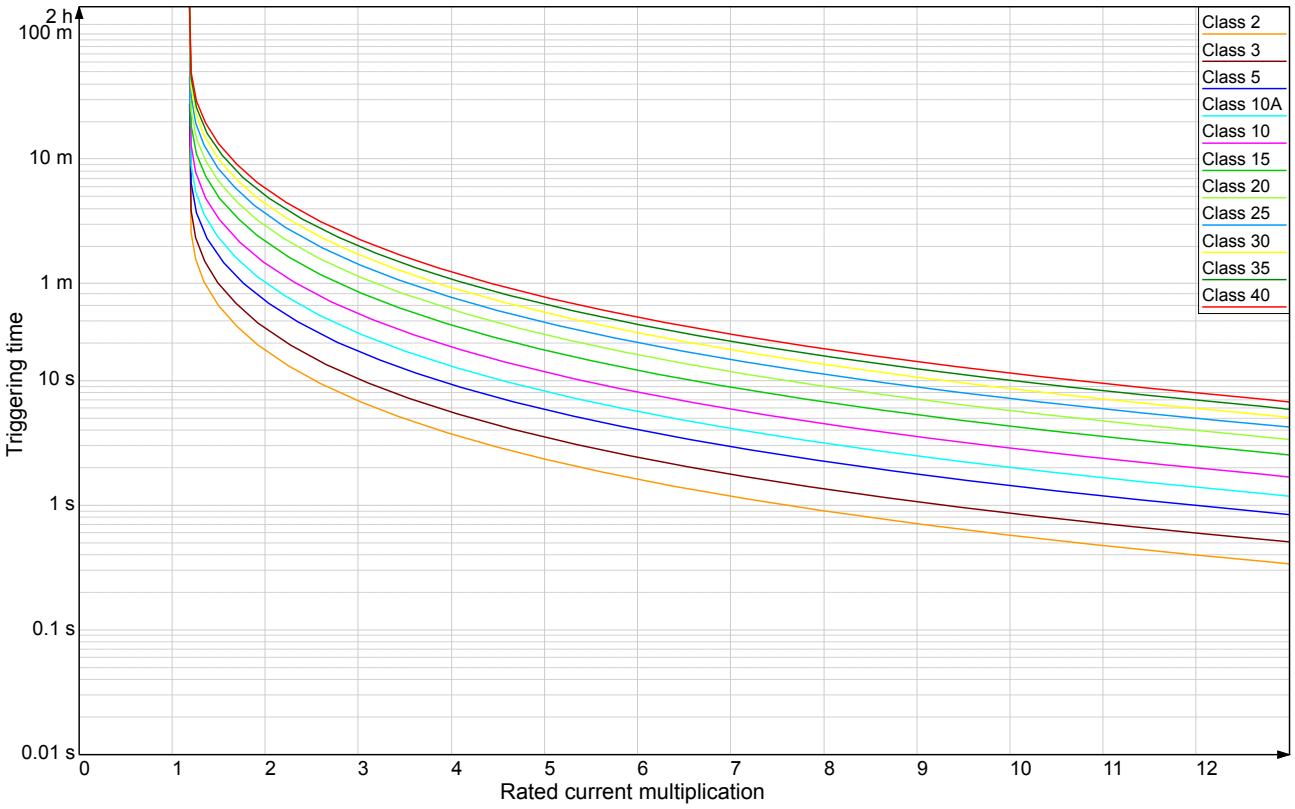


Figure 6: Class curves for cold state

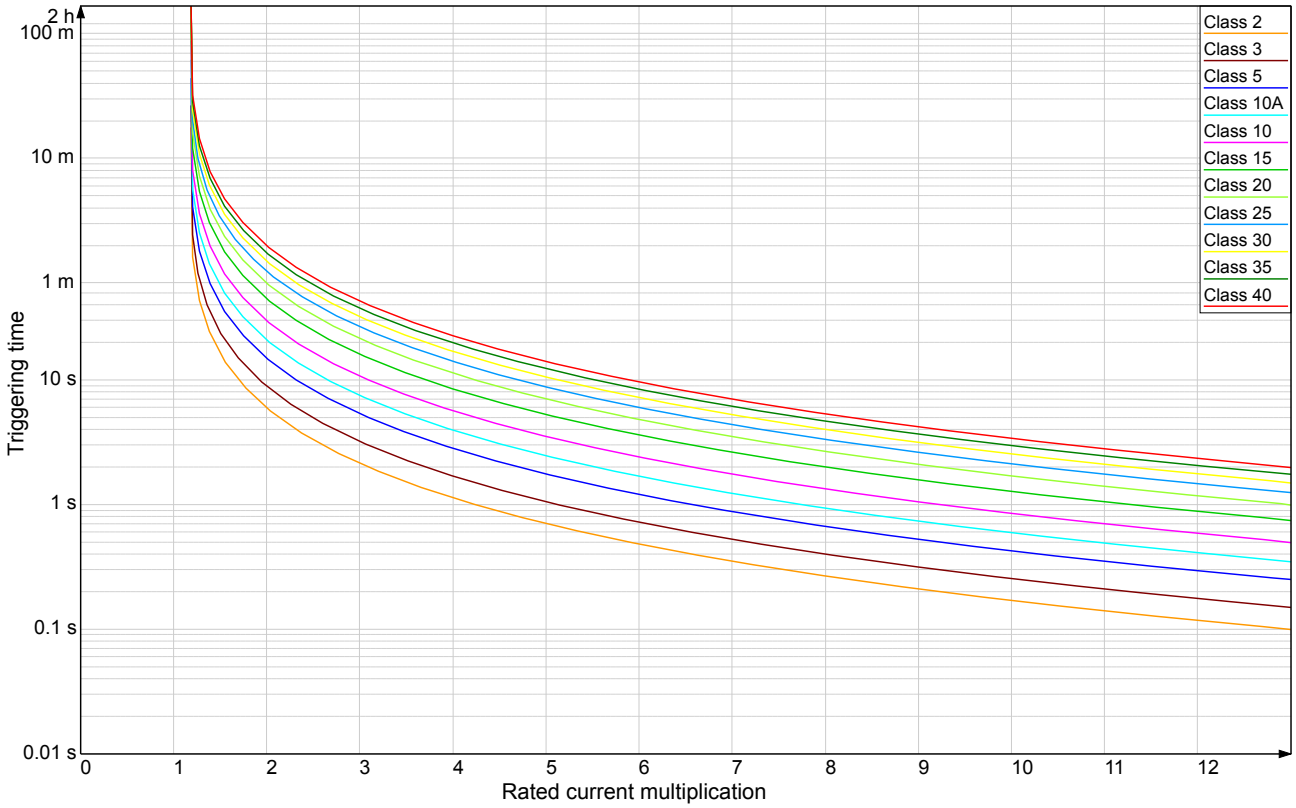


Figure 7: Class curves for hot state

15.2 Standard EN 60255-151

In overload element of the protection, also characteristics conforming EN 60255-151 standard have been implemented. Response and unlocking times are specified below. The given characteristics are marked in options acc. To the standard names specified in the standard. User can specify time constant for each curve. Its influence on characteristics is presented on figures from 8 to 13. Furthermore, user can specify own parameters of the user curve.

Response time:

$$t(I) = TMS\left(\frac{k}{\left(\frac{I}{I_n}\right)^{a}-1}+c\right)$$

Unlocking time:

$$t(I) = TMS\left(\frac{t_r}{1-\left(\frac{I}{I_n}\right)^{2}}\right)$$

where:

I – forced current,
I_n – rated current,
t_r – unlocking time for $I = 0$ and $TMS = 1$,
TMS, k, a, c – parameters defined by standard.

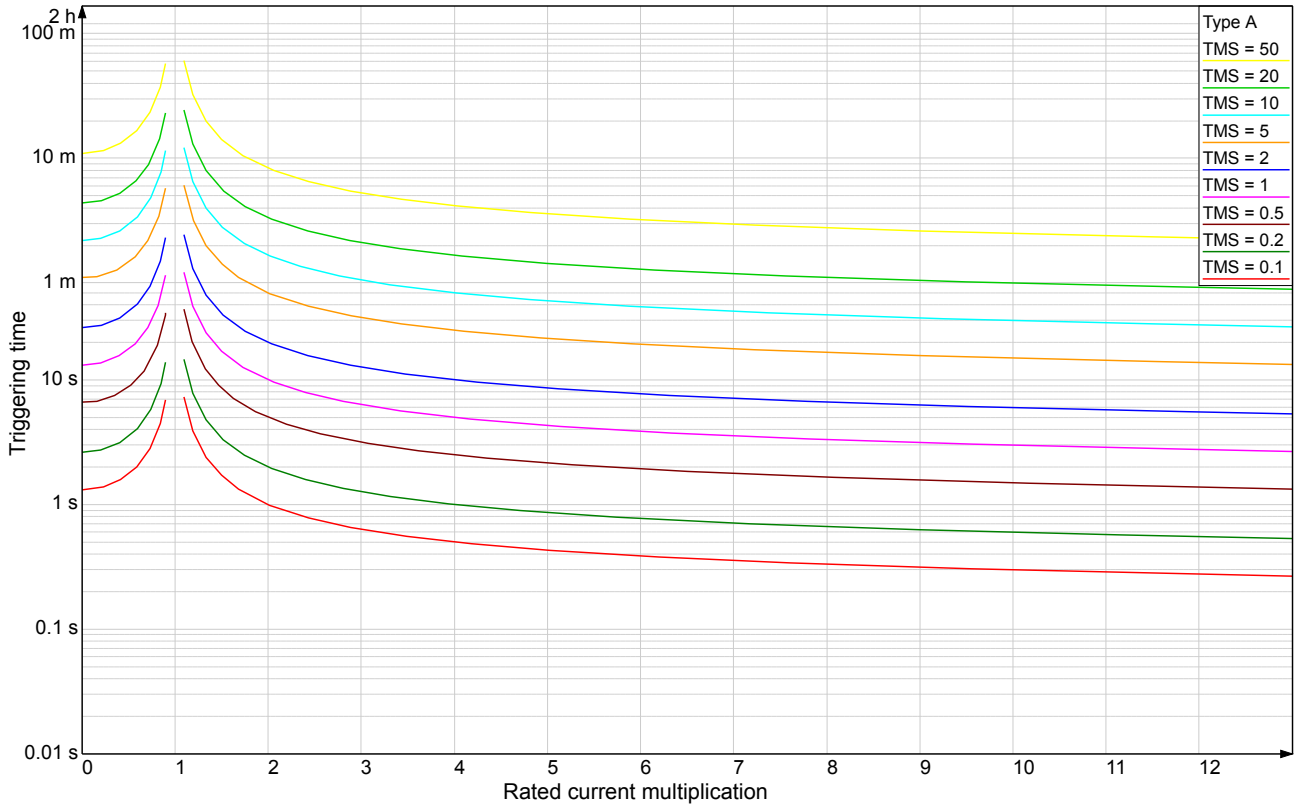


Figure 8: Characteristics type A (Inverse)

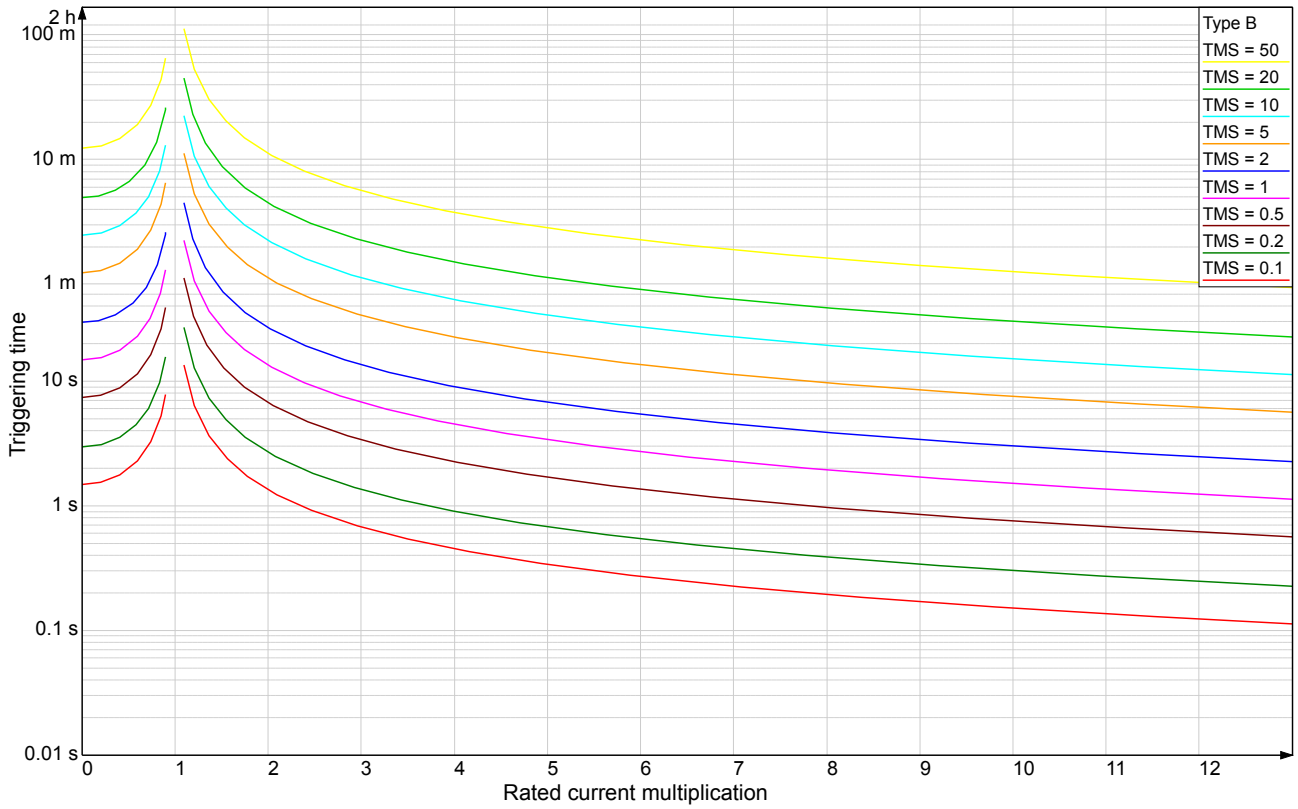


Figure 9: Characteristics type B (Very inverse)

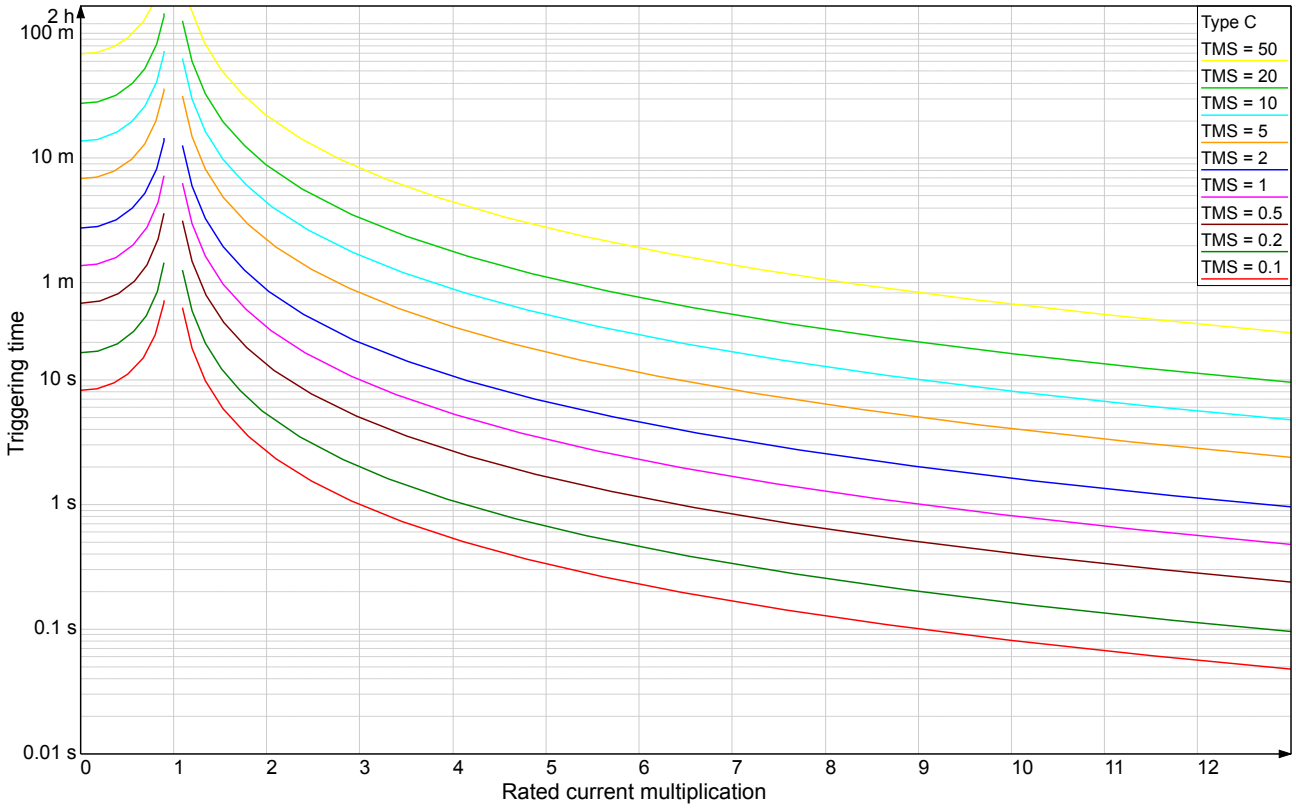


Figure 10: Characteristics type C (Extremely inverse)

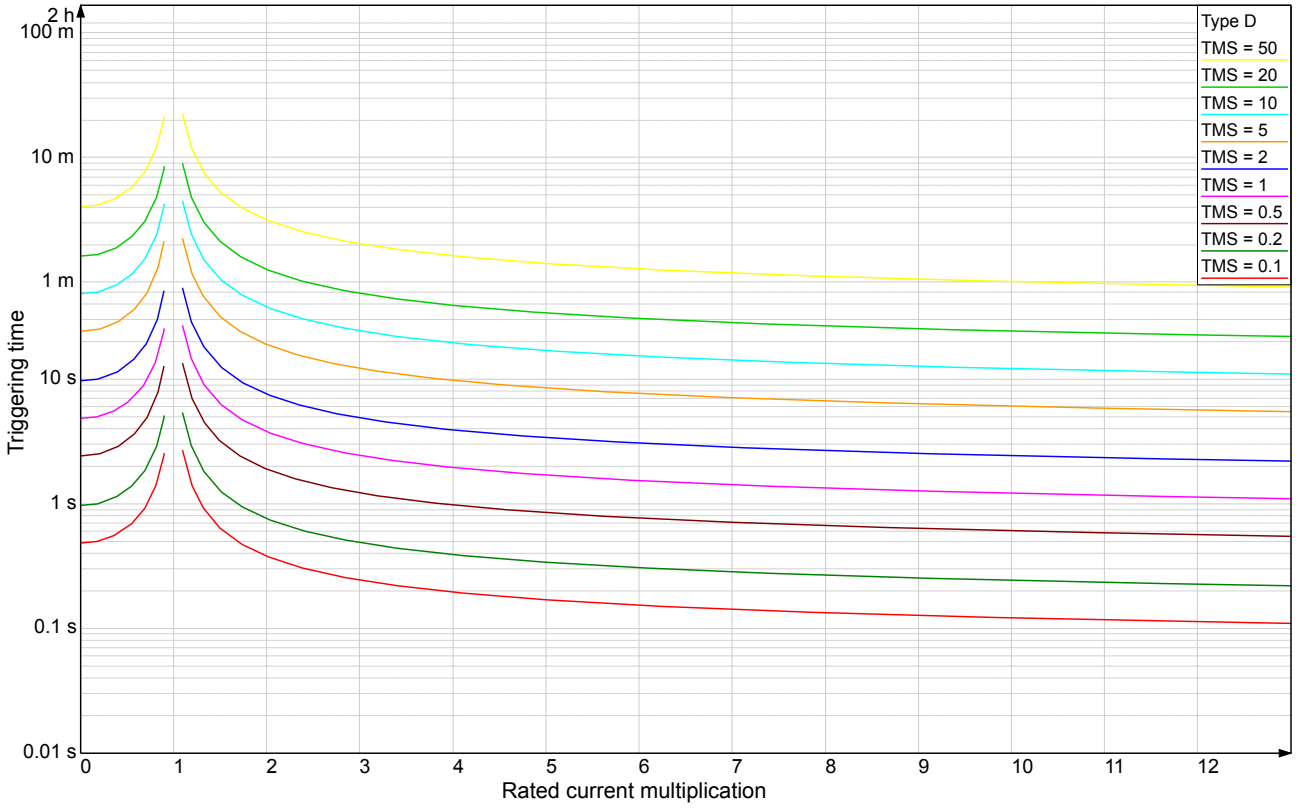


Figure 11: Characteristics type D (IEEE Moderately inverse))

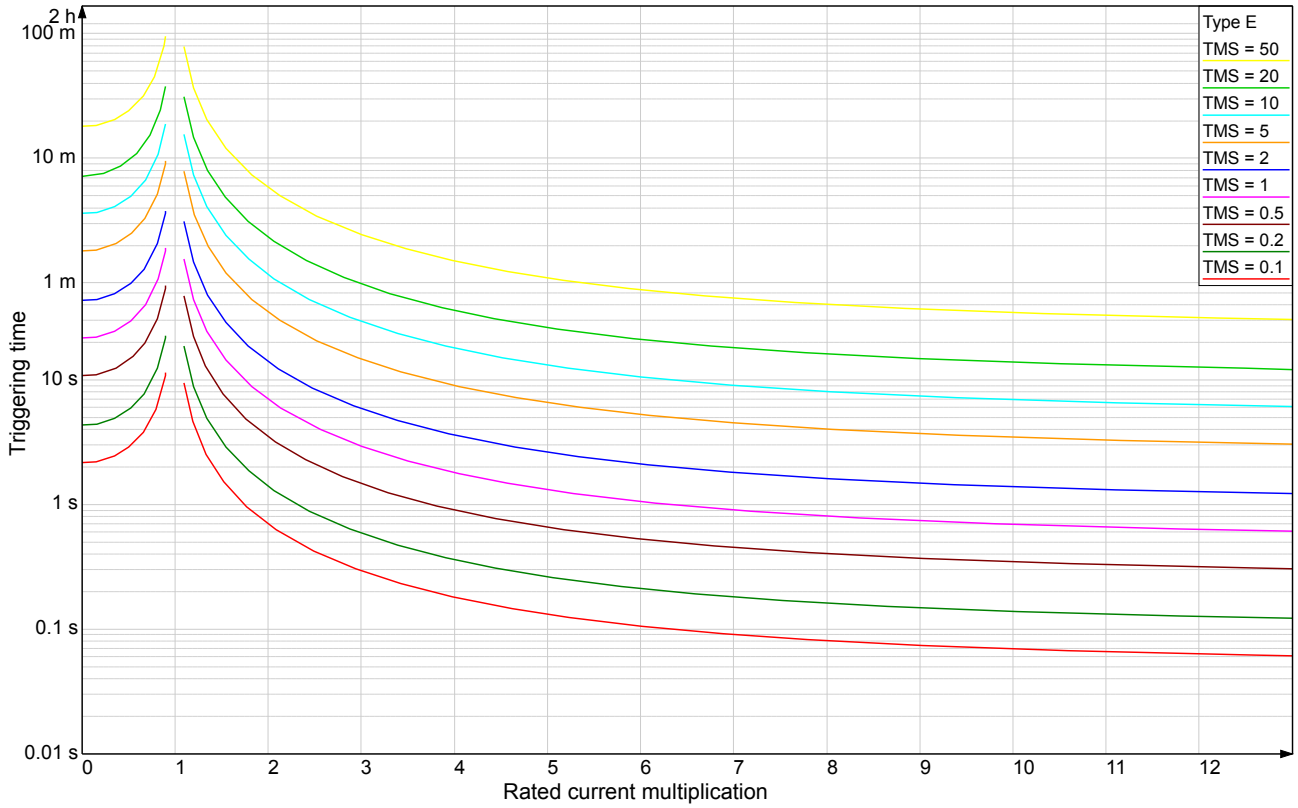


Figure 12: Characteristics type E (IEEE Very inverse)

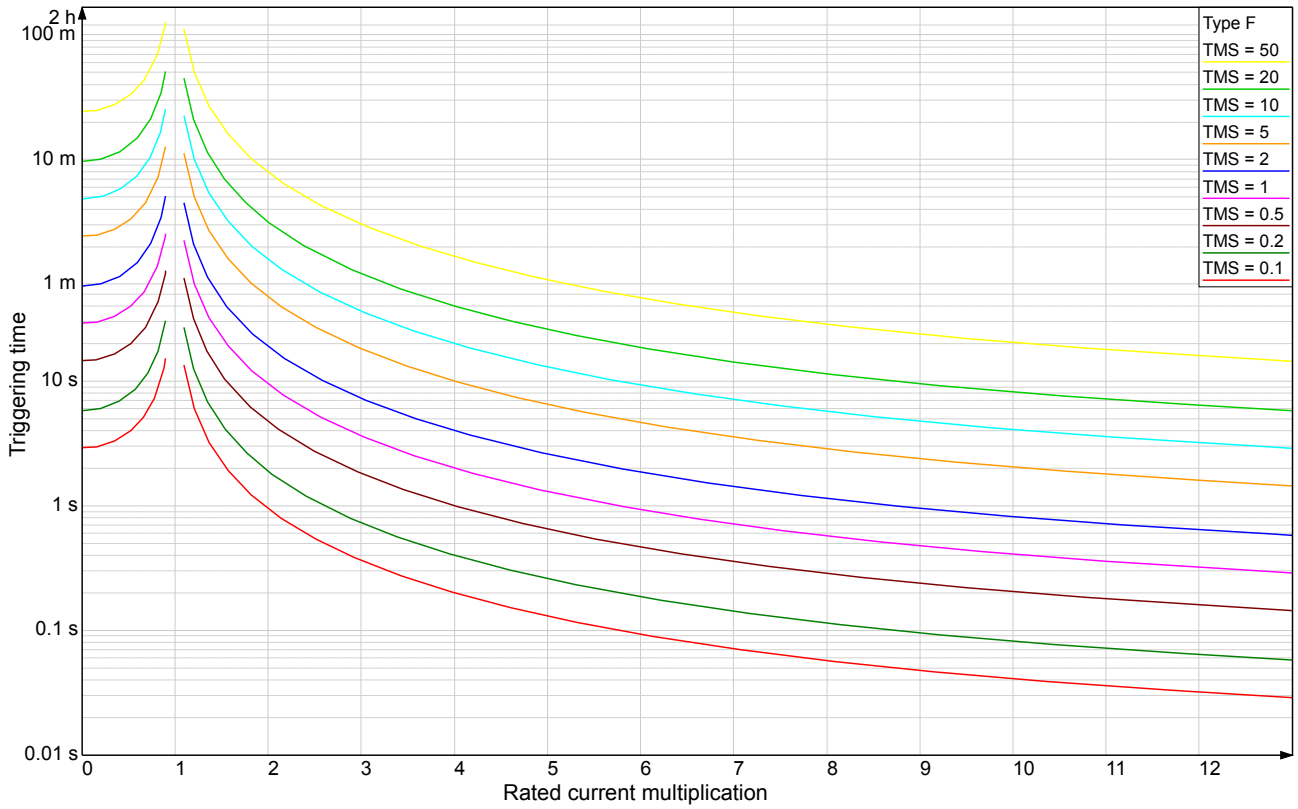


Figure 13: Characteristics type F (IEEE Extremely inverse)

15.3 Selecting of protection settings for motors with reinforced construction

A correct protection of a motor with reinforced construction „e" requires that the triggering time of the overload stage is shorter than t_E time of the protected motor. A class for which the overload stage triggering time is shorter than t_E motor time at motor starting current multiplication I_r/I_n should be selected from the overload and short-circuit characteristics.

A correct protection of a motor with reinforced construction „e" requires also that the time of switching off in case of short-circuit is shorter than 100ms. Taking into consideration the switch-off time of an average contact it is not recommended to set the short-circuit stage detection time to the value higher than 50ms.

16 Earth leakage protection

16.1 Installation

The measurement system is connected to the monitored mains via terminals *x*LP and *x*LN (*x* – outlet A, B, C). To synchronise the protection device over 1 or 3 phases with the mains, 1, 2 or 3 failsafe coupling chokes of type ED 100i or ED 100 are required. Wired resistors can replace the chokes when connecting to a mains rated at $\leq$230V AC.

When in the interlocking trip mode, the earth leakage monitoring module must be isolated from the outlet being protected when the outlet voltage is turned on. When the outlet voltage is turned off, the earth leakage monitoring module must be reconnected to the protected outlet.

16.2 PN-G-42040 setting resistance

The earth leakage central trip shall feature a system for testing its operating performance and connection to the operating earth. This is done by simulating a single-line insulation failure of the mains with a breakdown resistance equal to 0.8 times the setting resistance and a tolerance of −20%. The setting resistance values are listed in Tables 13a and 13b.

16.3 Central/interlocking trip settings

Wire the measuring leads of the trip module to the monitored mains in one of the configurations shown in Fig.14 and 15. The alternative wiring configuration of the central trip will extend the trip trigger delay.

When configuring the earth leakage central trip settings (Fig. 14)), remember that alternative (injected) resistance of the wired chokes or resistors. The value of this resistance depends on the wiring configuration of the monitored mains. The resistance of a single ED 100i choke is 7,1-7,5 kΩ ± 20%. Example: the wiring configuration shown in Fig. 14e features a parallel connection of three resistors (and where constant component transformer provides the short-circuit); the wiring configuration shown in Fig. 14g provides a single functional choke (the mains phases are not interconnected).

For a interlocking trip (see Fig. 15), two scenarios can exist. First, no load is connected, as shown in Fig. 15a and 15b. In this scenario the mains phases are not interconnected and the injected resistance is equal to the resistance of a single choke. Second, a load is connected to the outlet line, as shown in Fig 15c and 15d. Here, the phases are shorted (via a motor for the

Table 13: PN-G-42040 setting resistance of the earth leakage trip

(a) Central trip

Mains / wiring system rated voltage (U) [V AC]	Resistance value [kΩ]	
	Three-phase mains	Single-phase mains
U ≤ 127 (133)	4	4
127 (133) < U ≤ 220 (230)	7	7
220 (230) < U ≤ 500	15	15
500 < U ≤ 1000	30	30
1140	60	60

(b) Interlocking trip

Mains / wiring system rated voltage (U) [V AC]	Resistance value [kΩ]
U ≤ 42	7
42 < U ≤ 220 (230)	15
220 (230) < U ≤ 500	25
500 < U ≤ 1000	50
1140	100

constant component) and the injected resistance is equal to the resistance of the chokes wired in parallel.

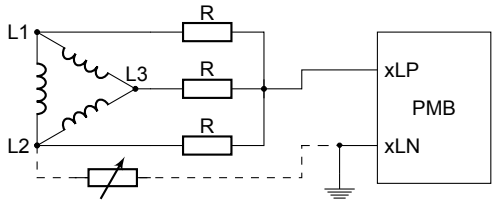
To determine the injection resistance for the central and earth leakage trip with loads other than an electric motors, each case must be considered individually.

WARNING: Only one earth leakage trip can be operated in the given section of the supply mains. The interlocking trips must be isolated from the monitored mains when the outlet is online – the interlocking trips must not be online with the supply voltage connected to the load.

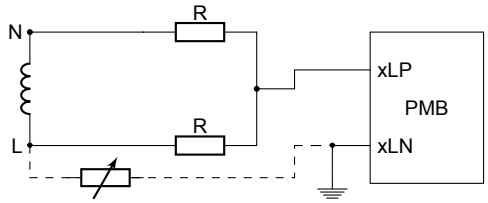
RESTRICTION: The earth leakage trip is intended for operation in 50Hz AC mains. Due to its operating principle (DC-based measurement), the earth leakage trip SHALL NOT be applied in any mains which feature loads that directly transform AC power to DC power without an additional insulating transformer. This largely applies to rectifiers and the loads which feature indirect DC lines for frequency converters powered directly by the monitored mains.

17 Communication

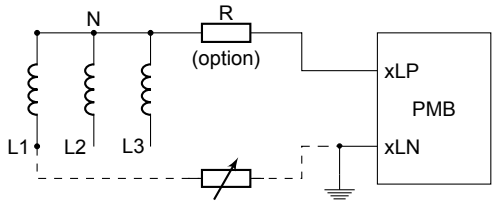
The PMB-2 multifunctional relay is designed for interfacing with external control and monitoring systems via RS-485 and Ethernet via Modbus. This feature enables reading the operating status, the actual measured current and resistance, the failure statuses, and the active lockouts. The feature also enables remote control of the PMB-2, including control source switchover (between Local and Remote), inputting Start and Stop commands, or control over the operation of internal relays. The product can also have the settings remotely configured.



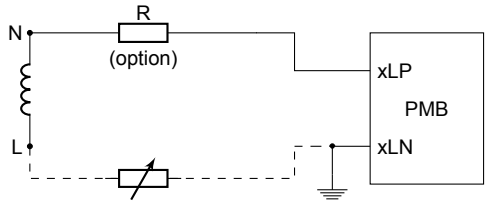
(a) Central protection for 3-phase mains
(preferred connection layout no. 1, ≤ 230V)



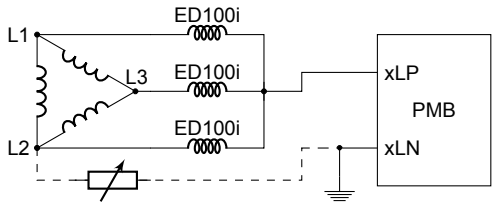
(b) Central protection for 1-phase mains
(preferred connection layout no. 1, ≤ 230V)



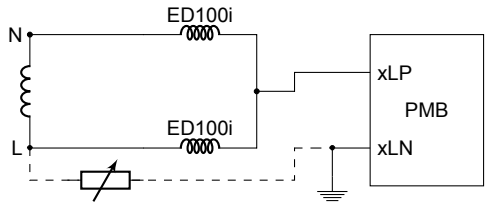
(c) Central protection for 3-phase mains
(preferred connection layout no. 2, ≤ 230V)



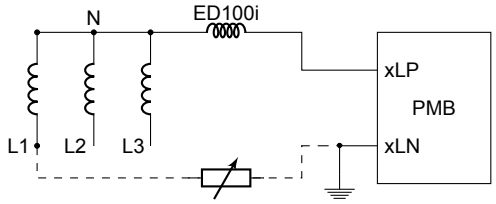
(d) Central protection for 1-phase mains
(preferred connection layout no. 2, ≤ 230V)



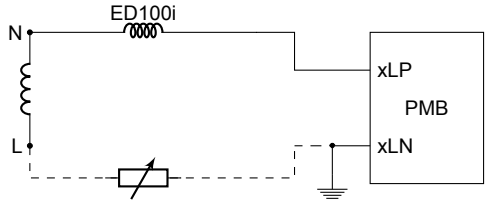
(e) Central protection for 3-phase mains
(alternative connection layout no. 1)



(f) Central protection for 1-phase mains
(alternative connection layout no. 1)



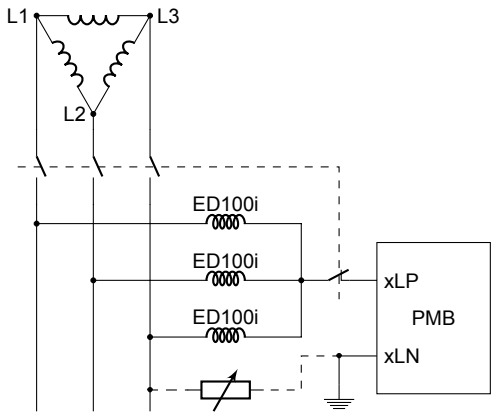
(g) Central protection for 3-phase mains
(alternative connection layout no. 2)



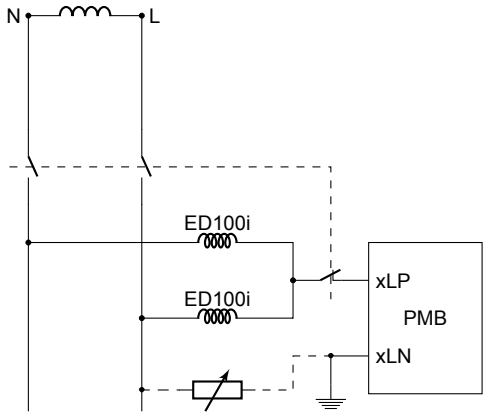
(h) Central protection for 1-phase mains
(alternative connection layout no. 2)

Figure 14: Wiring connection layout of the earth leakage central trip
(the broken line shows the wiring of a decade resistance box during the configuration of the settings; for a-d systems, wire resistors of suitable ratings shall be applied)

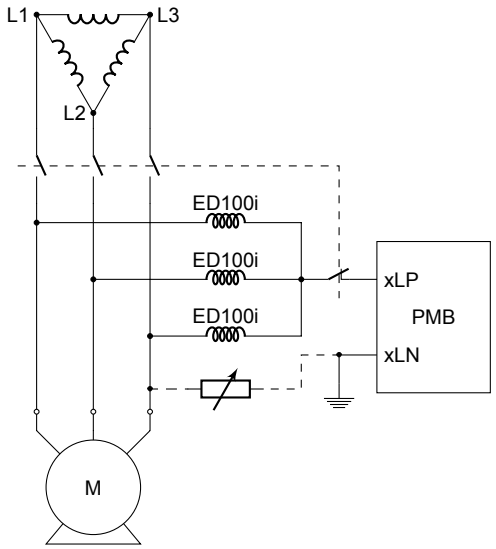
The communication method and the specification of the Modbus protocol functions for the PMB-2 are shown in a separate document titled „Type PMB-2 Multifunctional Relay. Modbus communication protocol", no. BP/IOM/01/16.



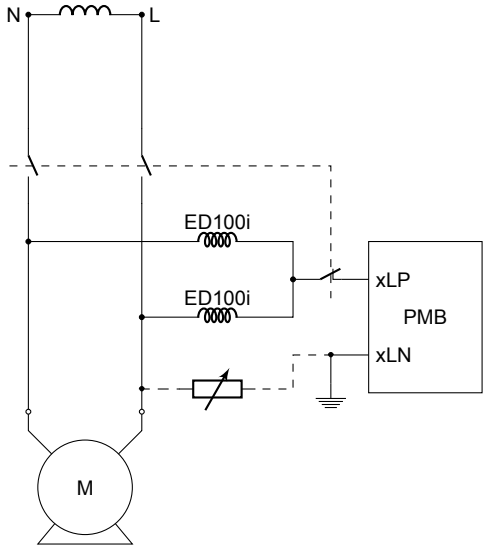
(a) Interlocking trip for a 3-phase outlet *(no load)*



(b) Interlocking trip for a 1-phase outlet *(no load)*



(c) Interlocking trip for a 3-phase outlet *(loaded)*



(d) Interlocking trip for a 1-phase outlet *(loaded)*

Figure 15: Wiring connection layout of an earth leakage interlocking trip
(the broken line shows the wiring of a decade resistance box during the configuration of the settings)

18 Reference standards

The design engineering of this product was based on the standards listed in Table 14:
Table 14: Reference standards

Standardization document	**Description**
Directive 2014/34/EU	**Equipment and protective systems intended for use in potentially explosive atmospheres (ATEX)**
PN-EN IEC 60079-0:2018-09 *(EN IEC 60079-0:2018)*	Explosive atmospheres. Part 0: Equipment. General requirements.
PN-EN 60079-11:2012 *(EN 60079-11:2012)*	Explosive atmospheres. Part 11: Equipment protection by intrinsic safety „i”.
PN-EN 60529:2003/A2:2014-07 *(EN 60529:1991/A2:2013)*	Degrees of protection provided by enclosures (IP Code).

Standardization document	Description
PN-EN 50303:2004 *(EN 50303:2000)*	Group I, Category M1 equipment intended to remain functional in atmospheres endangered by firedamp and/or coal dust.
Directive 2014/30/EU	**Electromagnetic Compatibility (EMC)**
PN-EN IEC 61000-6-2:2019-04 *(EN IEC 61000-6-2:2019)*	Electromagnetic compatibility (EMC). Part 6-2: Generic standards. Immunity for industrial environments.
PN-EN IEC 61000-6-4:2019-12 *(EN IEC 61000-6-4:2019)*	Electromagnetic compatibility (EMC). Part 6-4: Generic standards. Emission standard for industrial environments.
Other	
PN-G-50003:2003 *(Polish mining standard)*	Occupational protection in mining. Electrical mining equipment. Requirements and testing.
PN-G-42040:1996 *(Polish mining standard)*	Protection and safety measures in mining power engineering. Earth leakage protection. Requirements and testing.
PN-EN 50628:2016-10 *(EN 50628:2016)*	Erection of electrical installations in underground mines.
PN-EN 60255-149:2014-03 *(EN 60255-149:2013)*	Measuring relays and protection equipment. Part 149: Functional requirements for thermal electrical relays.
PN-EN 60255-151:2010 *(EN 60255-151:2009)*	Measuring relays and protection equipment. Part 151: Functional requirements for over/under current protection.
PN-EN IEC 60947-4-1:2019-05 *(EN IEC 60947-4-1:2019)*	Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters. Electromechanical contactors and motor-starters.

19 End notes

BARTEC is the manufacturer of this product and reserves the right to changes and modifications as a result of technical progress and to use equivalent replacement parts.

This product has been manufactured in compliance with good engineering practices.

20 Orders and service

The orders should be sent to the following address:

BARTEC POLSKA Sp. z o.o.
43-100 Tychy, ul. Graniczna 26A
Poland
Phone/fax:
+48 32 326 44 00
+48 32 326 44 03
Internet:
biuro@bartec.pl
www.bartec.pl

The housing components are replaced by the manufacturer or a company authorized by the manufacturer.

The manufacturer is not responsible for the device quality in case of repairs or components replacement made by the customer itself.

The manufacturer reserves the right to make changes in this specification in any time, without the necessity to inform about it.

BARTEC

BARTEC company protects people and environment by the safety of its components, systems and devices.

BARTEC company develops and produces the innovative components and systems which are controlled in accordance with international standards and are applied in areas endan-gered by explosion as well as in the field of environment pro-tection, radioactive protection and industry.

26 departments and over 40 agencies ensure that we are always close to our Customers. It allows us to communicate with the Customers immediately and directly and to develop the solutions suitable for them.

BARTEC Polska Sp. z o.o.