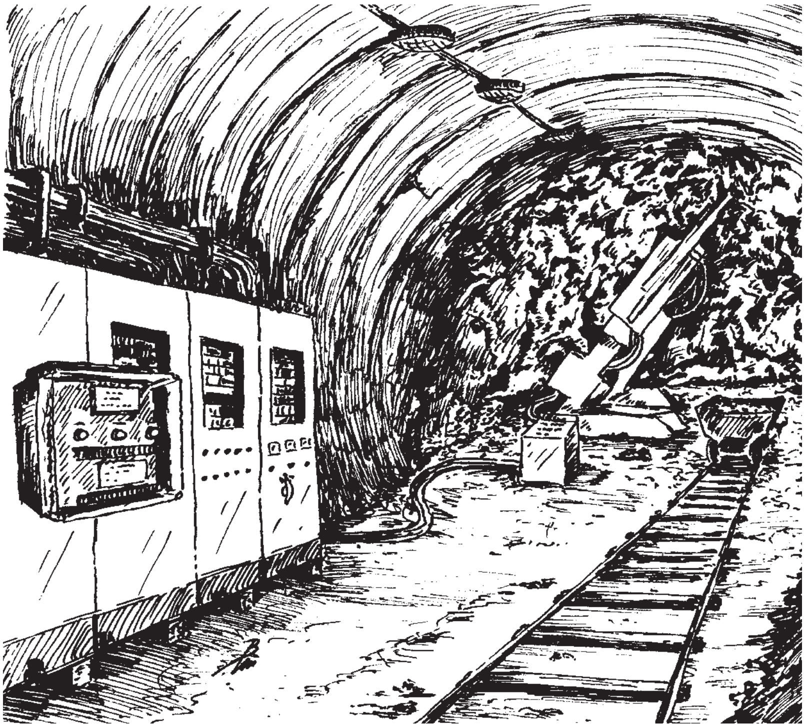
Operating Manual



HW135

High voltage cable monitor

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1. Intended use and safety information

1.1 About the operating manual

This manual has been compiled with great care. Nevertheless, errors and omissions cannot be entirely excluded. The BENDER companies do not accept any liability for injury to persons or damage to equipment due to errors or omissions in this manual.

Note: In this manual and on the nameplate of the HW135 the abbreviation SL is used for the protective earth conductor (PE).

1.2 Technical support

BENDER provides customers with technical support and answers to questions regarding the respective devices. Please contact technical sales or product management
(Tel. +496401-807-0).

1.3 Delivery

Please check the goods received for damage and compare these with the delivery notes. In the case of damage in transit please inform BENDER immediately.
The devices must only be stored in areas protected from dust, damp, spray and dripping water and in which the specified storage temperature ranges are maintained.
In general, our “General conditions of sale and supply“ shall apply. These are available to the user when the contract is concluded at the latest.

1.4 Intended use

This manual describes the high voltage cable monitor HW135 which is referred to below as the HV monitor or HW135.

The task of the HW135 is to monitor cables for earth faults and to issue a switch-off command if a conducting object penetrates the cable or if the PE conductor becomes open circuit. Precondition is that both the protective earth conductor (SL) and a monitoring conductor (ÜL) are led through the cable. Any other use beyond this is deemed to be use other than for the intended purpose. BENDER shall not be liable for any damage arising there from.

Use in accordance with the intended purpose also includes:

- Observing of all instructions in this manual
- Observing the test intervals

1.5 Personnel

Only suitably qualified personnel may work on the high voltage cable monitor HW135. Qualified means familiar with the installation, commissioning and operation of the devices and with training appropriate to the work.
Personnel must have read and understood the safety section and warning information in this operating manual.

1.6 Hazards when handling the system

The high voltage cable monitor HW135 is built in accordance with the state of the art and the recognized technical safety regulations. Nevertheless, danger to the life and limb of the user or third persons or damage to the HW135 or other property may occur during its use. The HW135 must only be used:

- For the purpose for which it is intended
- When it is in perfect technical condition as far as safety is concerned

Faults which may impair safety must be eliminated immediately. Impermissible modifications and the use of spare parts and additional equipment not sold or recommended by the manufacturer of the equipment may cause fires, electric shock and injuries
Warning signs must always be easily readable. Damaged or illegible signs must be replaced immediately.

1.7 Explanation of symbols and warnings

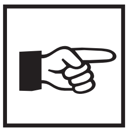
The following designations and symbols are used in BENDER documentation for hazards and warnings:

This symbol means an immediate threat of danger to the life and health of human beings.
Failure to comply with these warnings means that death, serious physical injury or substantial damage to property ***will*** *ensue if the relevant precautions are not taken.*

This symbol means a possible threat of danger to the life and health of human beings.
Failure to comply with these warnings means that death, serious physical injury or substantial damage to property ***may*** *ensue if the relevant precautions are not taken.*

This symbol means a possibly dangerous situation.
Failure to comply with these warnings means that slight physical injury or damage to property may ensue if the relevant precautions are not taken.

This symbol gives important information about the correct handling of the devices.
Failure to comply with this information can result in faults in the devices or in their environment.



Where you see this symbol, you will find application tips and other particularly useful information. These help you to make optimum use of the control module.

1.8 Warranty statement

Bender warrants the high voltage cable monitor HW135 to be free from defects in material and workmanship under normal use and service for a period of 24 months from the date of delivery.
This warranty does not extend to any kind of maintenance work and shall only be valid for the first purchaser and shall not extend to products or individual parts thereof which have not been correctly used, or which have undergone modifications. Any warranty shall lapse if the device is used other than for the intended purpose.
The warranty obligation is limited to the repair or the exchange of a product which has been sent to Bender within the warranty period.
The qualifying conditions are that Bender shall recognize this product as being faulty, and that the fault cannot be attributed to improper handling or modification of the device, nor to abnormal operating conditions.
Any warranty obligation shall lapse if repairs are undertaken by persons who are not authorized by BENDER.
The foregoing warranty provisions apply exclusively and instead of all other contractual or legal warranty obligations including, but not restricted to, the legal warranty of marketability, suitability for use or expediency for a specified use.
BENDER shall not assume any liability for direct or indirect concomitant or subsequent damage regardless of whether these are attributable to legal, illegal or other actions.

1.9 Warranty and liability

Warranty and liability claims in cases of personal injury or damage to property are excluded if they are attributable to one or more of the following causes:

- Use other than for the intended purpose
- Incorrect installation, commissioning, operation and maintenance
- Operation with defective safety equipment or incorrectly fitted or non-functional safety or protection equipment
- Non-observance of information in the operating manual regarding transport, storage, installation, commissioning, operation and maintenance
- Unauthorized structural modifications
- Non-observance of technical data
- Incorrectly executed repairs and the use of spare parts or accessories which are not recommended by the manufacturer
- Catastrophes
- Uncontrollable external factors and force majeure.

2. System description

High voltage cable monitors (HV monitors) are compulsorily required by the mining authorities for underground high voltage systems where cables are installed without special mechanical protection in panel entries and in specially ventilated mine-workings.
Besides being used in mining HV monitors have become more and more widespread in tunneling. The task of these HV monitors are defined in the standard DIN VDE 0118:2001-11. According to the requirements of part 1, section 19.1, high voltage cable monitors shall monitor the cable for:

- short circuit ÜL/SL (pilot wire/PE conductor)
- open circuit of the monitoring circuit for the PE conductor
- earth fault, short circuit phase conductor/PE conductor
- short circuit phase conductor/pilot wire

In case of a fault the HV monitor has to give status indication and to initiate the disconnection of the concerned conductor.

The introduction in section 19.1 specifies:

Electrical protective equipment are only allowed to be used if their effectiveness with regard to the conductor system and conductor faults is verified by a test protocol of the TÜV (Technical Inspectorate).

2.1 Preconditions for use

*In order to use the HV monitor as an electrical protective device in accordance with DIN VDE 0118 part 1:2001-11, section 19.1, **all** preconditions below must be fulfilled:*

- Use in an IT system (protective system) with a clearly defined direction of energy flow, thus a system with branches radiating outwards or a branch line.
- A sufficiently large system upstream the residual current transformer providing a capacitance of at least 0.6 µF at 5 kV, 0.3 µF at 10 kV and 0.15 µF at 20 kV against earth. If this capacitance does not exist, the HV monitor will not be able to function properly. Install this capacitance by means of a discrete capacitor or a cable at each of the three phase conductors.
- Voltage level of the system 5, 6, 10 or 20 kV.
- The cable to be monitored is a cable according to DIN VDE 0118 part 2:2001-11, sections 21.1.1 and 21.1.2.
- A maximum capacitance of 20 µF (50 µF when block Ü102 is used) between the pilot wire (ÜL) and PE conductor (SL). Instructions of the conductor manufacturer are to be taken into consideration when defining the maximum cable length.

2.2 Characteristics

The high voltage cable monitor HW135 is a protective device intended to be used in mining and tunnelling. According to DIN VDE 0118 part 1, section 19.1, the cable to be protected is monitored for:

- short circuit ÜL/SL pilot wire/PE conductor
- open circuit of the monitoring circuit for the PE conductor
- earth fault in the conductor being monitored.

In all the cases above, the cable or the cable section will be switched off immediately. The switch off is carried out by external switching devices being not a component of the HW135. A reclosing directly after an earth fault switch-off is prevented.

In order to fulfil the requirements of DIN VDE 0118 part 1, section 19.1.3.1, the monitoring circuit for the protective conductor is designed so that in case of a disconnected system the highest possible voltage occurring in the monitoring circuit at the given system line capacitance is lower than the minimum igniting voltage according to EN 50 020.

The effectiveness of the monitoring circuit for the protective conductor is guaranteed by a cable end unit for the entire cable length. This is an imperative requirement stipulated in DIN VDE 0118 part 1, section 19.1.3.2.

Caution

The protection of cables against hazards caused by mechanical influences is required by DIN VDE 0118 part 1, section 18.1. Reference is made to the corresponding protective device in section 19.
The structure of the cable being protected is explained in section 19.2.
Following this, cables have to comply with DIN VDE 0118 part 2:2001-11, section 21.1.1 and 21.1.2.

2.3 Cable design

For systems with nominal voltages over 1 kV, only cable types complying with the requirements of DIN VDE 0118 part 1:2001-11, section 19.2.2.1 are allowed. These are cables with single concentric protective conductor. In this case, the PE conductor (SL) either is:

- evenly distributed as non-insulated concentric conductor above the insulating cover of the line conductors
  or
- evenly distributed as non-insulated conductor in the gaps if the insulating cover of the line conductors are covered with non-metal conductive material (conductive rubber).

The monitoring conductor (ÜL) either is:

- placed concentrically to the conductor axis as a metallic non-insulated or non-metallic conductive cover between inside and outside sheath (see illustration 2.1 on the following page)
  or
- a single conductor.

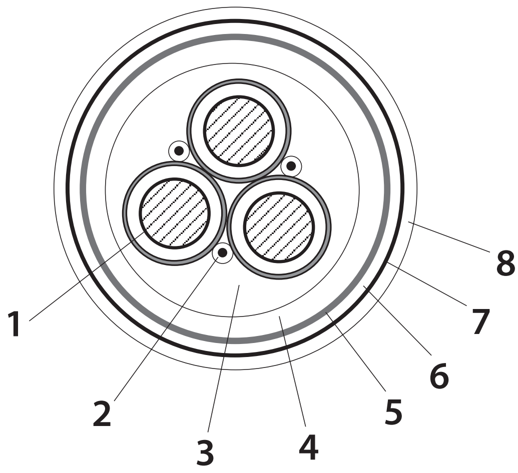


Fig. 2.1: Structure of the cable

Legend to the illustration above:

1 Three energy wires

- Conductors made of pure copper wires
- Inner conductor coat
- Insulation
- Outer conductor coat
- PE conductor (SL) evenly distributed as non-insulated concentric conductor above the insulating cover of the energy cores

2 Control wire

3 Gap filling

4 Inside sheath

5 Pilot wire (ÜL) concentrically to the conductor axis

6 Intermediate sheath

7 Armouring as braiding

8 Outside sheath

A present-day high voltage underground systems is assumed to be a compensated one. According to DIN VDE 0118 part 1, section 13.1.4, the earth fault current flowing through the point of fault must not exceed 10 A if a disconnecting time of 6 seconds is to be achieved. In a 6 kV system, this value is already achieved when using a cable with a length 0f 6 - 12 km. In extensive systems capacitive earth fault currents of more than 100 A can occur.

In order to reduce fire risk and to prevent arcing backs from arcing faults, it is necessary to limit the earth fault current flowing through the point of fault to a maximum of 10 A.

2.4 System with Petersen coil

In a system with a Petersen coil, i.e. with an earth fault compensation circuit, an inductance coil (Petersen coil) is located between the star point of the system and the PE conductor (SL).

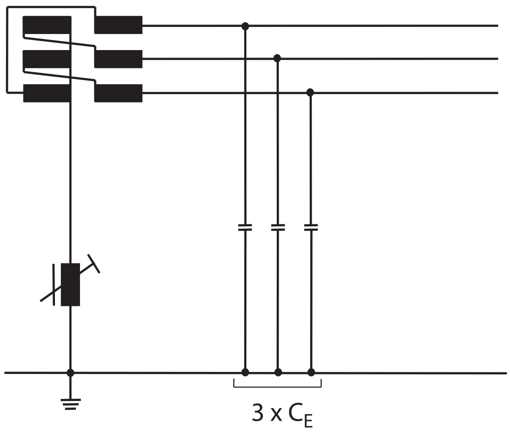


Fig. 2.2: System with earth fault compensation circuit

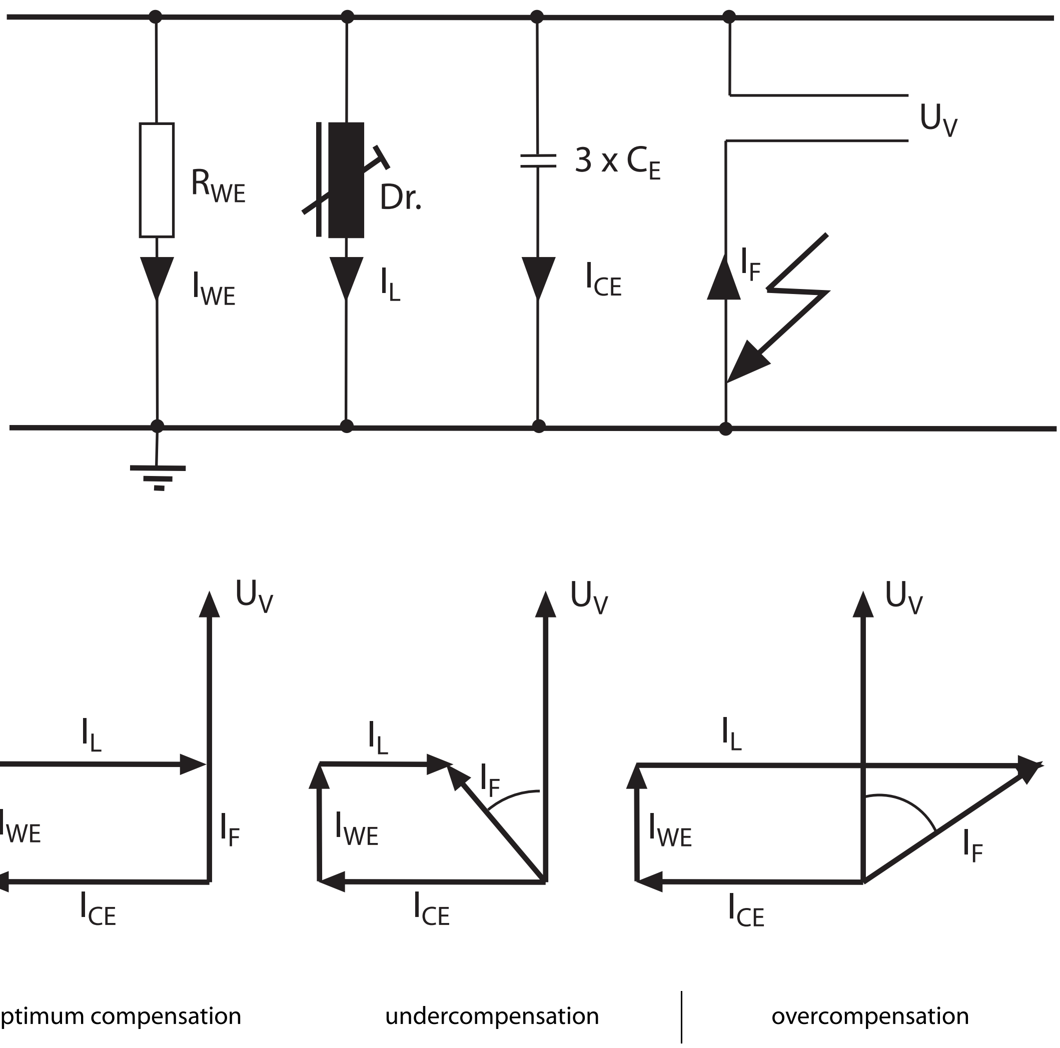
In a “healthy“ system with completely symmetrical external conductors against earth, the coil is not live, and thus has no effect. In practice, however, there are always slight differences present resulting from asymmetries of the system. This asymmetry is necessary to adjust the current of the choke to the magnitude of the capacitive earth fault current needed for compensation. The setting can only be carried out in a system when there is no fault.

In case of a dead short circuit the faulty phase conductor is connected to earth. In this case the displacement voltage is applied to the choke. The transformer leakage inductance is taken as a part of the choke inductance.

In case of optimum compensation, the inductive and the capacitive reactive current are of equal magnitude. The choke current and the current of the conductor capacitances, however, contain always smaller resistive current parts which cannot be compensated. This resistive current therefore is the smallest possible current across the point of fault.

2.4.1 Compensation

When the choke current gets greater or smaller than the capacitive current (over or undercompensation), the current across the point of fault increases and its phase position changes. The harmonic content in the fault current, however, will stay the same, since the compensation is adapted to the 50 Hz fundamental wave.



R_{WE}: Equivalent resistance for all resistive-power losses in the system, choke and capacitances CE in case of an earth fault.

I_{WE}: resulting resistive current

Fig. 2.3: Fault currents in case of an earth fault in a compensated system with different compensation degrees

2.4.2 Transients in the system in case of an earth fault

At the instant of a short circuit between line and earth, the entire capacitive charge present on the faulty conductor discharges through the point of fault. This high-frequency transient wave dies away relatively quickly. Since the transformers and converters have a large “magnetic inertia“, they do not participate in this process.
Simultaneously, the voltage of the “healthy“ phase conductors has to increase from $U/\sqrt{3}$ to voltage U. The necessary charges have to flow from the power transformer to the conductor capacitances. The inductances and capacitances existing in the system are simulated to dampened oscillations. The frequency of this medium-frequency compensatory process is several hundred Hz depending on the form and type of the system. The occurring large currents are transferred by the current transformers and can thus cause (RCD) protective devices to cause false alarm response unless appropriate countermeasures are taken.

Once the transients have died away, all that remains is the steady-state earth fault current at a fundamental frequency of 50 Hz accompanied by a greater or lesser proportion of harmonics.

The limiting of the fault current to 10 A flowing through the earth fault required by the mining authorities is intended to reduce the fire risk and the risk of arcing back from arcing faults.

Any arc at the point of fault extinguishes at the instant when the current passes through zero. The capacitive nature of the circuit means that this is the peak value of the voltage. If the previously conducting path has not yet attained sufficient insulating strength, arcing back occurs again and again. Such intermittent earth faults generate overvoltages which can penetrate into the system and cause faults. If the fault current is 10 A or less, re-ignition is extremely unlikely.

In case of optimum compensation, the only current to flow is the uncompensated resistive residual current which can be 5 - 8 % of the magnitude of the capacitive earth fault current.

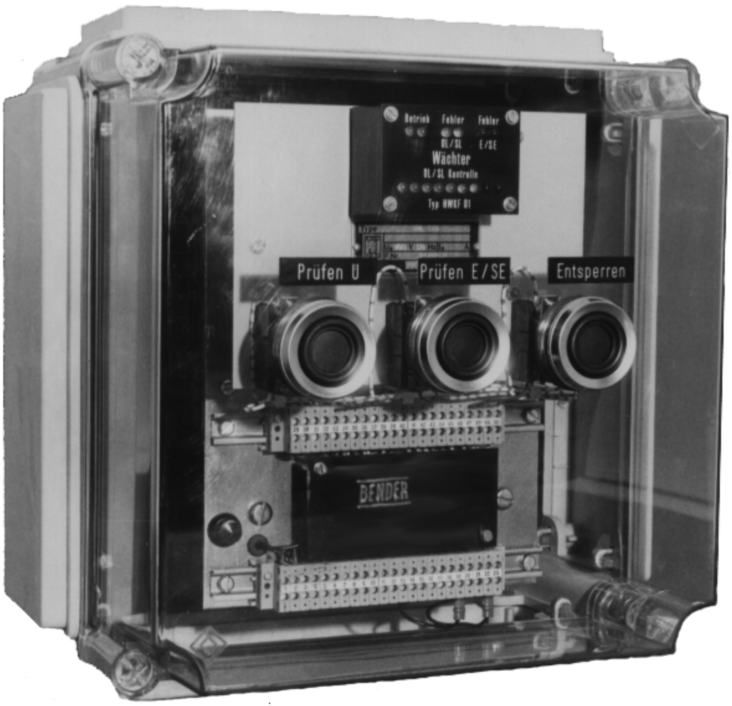
Thus, the criteria for the maximum response setting of an earth fault switch off device is the magnitude of the resistive residual current which depends on the size of the system. In a large system with a capacitive earth fault current of 100 A, for example, a response level of up to 5 A (5 %) is appropriate, in a small system with a capacitive current of 30 A, only a response level of up to 1.5 A is acceptable. In small and medium-sized systems, therefore, a device increasing the resistive residual current can be useful.
If an earth fault occurs in the upstream section of the system, i.e. before the residual current transformer, the protective devices may not respond. The desired selectivity can only be achieved if the magnitude of the earth fault current in the conductor being monitored is lower than the response value set for the protective device. Depending on the design of the conductors being monitored underground, earth fault currents of more than 1.5 A/km are provided. That points out the significance of high response values.

2.5 System components

2.5.1 Function blocks

The HW135 is a modular system consisting of different blocks. In combination with external components it forms a functional unit.

The base unit, the HW135, is incorporated into an insulating casing IV43. It contains the individual function blocks a display block, display and test elements as well as terminals for connecting the HW135.



The individual blocks are:

Block V	with power supply unit, input voltage AC 100 V
Block R	with switching relays, including self-monitoring facility
Block Ü101 and 102	for the monitoring circuit ÜL/SL Ü101 for limited cable routes, the maximum capacitance between monitoring conductor (ÜL) and PE conductor (SL): 20 µF Ü102 for longer cable routes, the maximum capacitance between the monitoring conductor ÜL and the PE conductor (SL): 50 µF
Block E	for earth fault monitoring solely by amplitude sensing, adjustable response value 1 - 2 - 3 - 4 or 5 A.

The display block HWKF01/HWKF02 which is also incorporated in the casing, contains the Power On indicator, the “Fehler E“ indicator (earth fault), the “Fehler E/SE“ indicator (fault monitoring conductor/PE conductor) as well as a status indicator for the ÜL (monitoring circuit)/SL (PE circuit). The status indicator consists of five green, two yellow and one red LED(s). They allow ÜL/SL faults to be detected at an early stage.

All aforementioned blocks are completely resin encapsulated and thus provide adequate protection against mechanical stress.

Three push buttons are integrated into the cover of the insulated casing IV 43. These are intended for testing the earth fault monitoring circuit, to check the ÜL/SL monitoring circuit and to reset the HV monitor after clearing the fault.

Two common terminal strips within the insulating casing are intended for connecting the HW135 to the external components and the supply voltage.

2.5.2 Residual current transformer and cable end unit

A functional unit consists of an HW135 combined with the following external components:

- the residual current transformer HWW-11 intended for the detection of the earth fault current. The HWW-11 operates with a transmission ratio of 1:1000. That means that one thousandth of the primary residual current existing in the system runs through the load winding of the transformer.
  The test winding of the transformer has 100 windings and is connected to one end of the load winding. The terminal designations are:
  1 = load winding
  2 = common connection
  3 = test winding.
  The windings are accessible via sealed nuts, the screws can be removed witch a slotted screwdriver.
- the cable end unit EV22S. It is intended to be fitted inside flame-proof connecting boxes or casings and should be connected to the end of the conductor to be monitored.

2.6 Function

2.6.1 Block E - earth fault monitoring module

The function of earth fault monitoring module is based on the residual current measurement principle. The evaluation of the earth fault current is indirectly carried out via the residual-residual current transformer current transformer HWW-11 in Block E of the HW135. Response levels of 1 - 2 - 3 - 4 or 5 A can be set, to suit the conductors and/or cables being monitored.
This matching process is carried out by bridging a switchable load resistor on the load winding of the residual current transformer by laying a bridging link for the ranges 2 to 5 A. The response time for a fault level only slightly above the response level is about 300 ms.
This time is reduced to approximately 100 ms for higher fault currents.
When a certain fault voltage is present on the voltage circuit of Block E, a suitably biassed operation amplifier triggers and a release command is given to the relays in Block R. The message will be stored by a memory relay and remains stored even in case of failure of the supply voltage and will be reset by pressing the button “ENTSPERREN“.
The function of Block E can be checked via a contact of the testing switch. For that purpose an auxiliary voltage of AC 8 V is applied to the test winding of the residual current transformer via matching resistors. This simulates a fault current causing the device to open.

Please note that for settings between 1 A and 3 A the test current should be set to 3.5 A and for settings of 4 or 5 A, the test current should be set to 6 A.

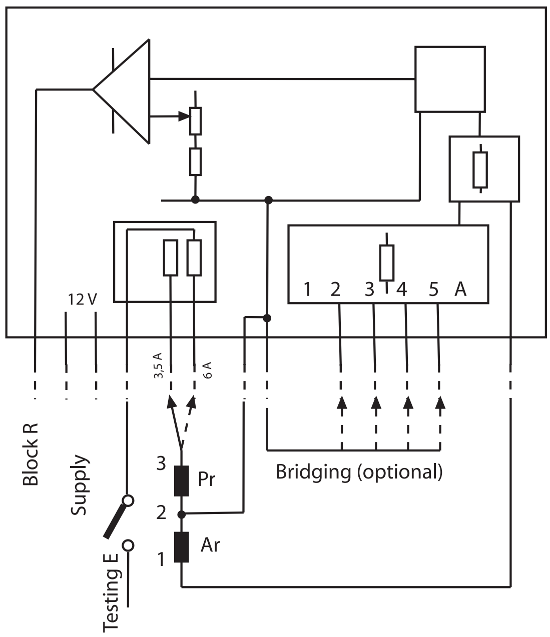


Fig. 2.4: Block E
Pr - test winding of the residual current transformer
Ar - load winding of the residual current transformer

2.6.2 The ÜL/SL circuit

The ÜL/SL monitoring circuit works on the half-wave principle with a diode at the end of the conductor being monitored.
The monitoring circuit is connected through a voltage divider to the AC voltage (30 V) supplied from Block V. At the tap point of the voltage divider, and thus at the conductor being monitored, there is a no-load voltage of approximately 19 V relative to the earth conductor SL. A resistor limits the current in this monitoring circuit to approximately 38 mA if the ÜL/SL loop presents a short circuit. The cable end unit at the end of the conductor being monitored is practically short-circuited during the negative half-cycle of voltage from the tap of the voltage divider, i.e. it is practically at the potential of SL.
If no fault is present, the positive half-cycle produces a DC component. If the voltage drops below a reference comparison voltage, an operational amplifier triggers and gives a switch-off command to the relay in Block R.
The message will be stored by a memory relay and remains stored even in case of failure of the supply voltage and will be reset by pressing the button “ENTSPERREN“.
This condition occurs when the ÜL/SL circuit is interrupted or closed. In the case of interruption, the voltage at the tap point on the voltage divider is an AC voltage, while in the case of closed circuit, the voltage tap point is practically at the potential of the earth conductor (SL), so that no DC component can form.
The time delay between the occurrence of the ÜL/SL fault and the closing of the tripping contact of the relays in Block R is a maximum of 80 ms.
The function of the ÜL/SL circuit can be checked by pressing the test button “Prüfen“ which causes one contact of the test button to bridge ÜL to SL, i.e. the tap point on the voltage divider is connected via a low resistance to SL potential, which causes a switch-off command to be given.

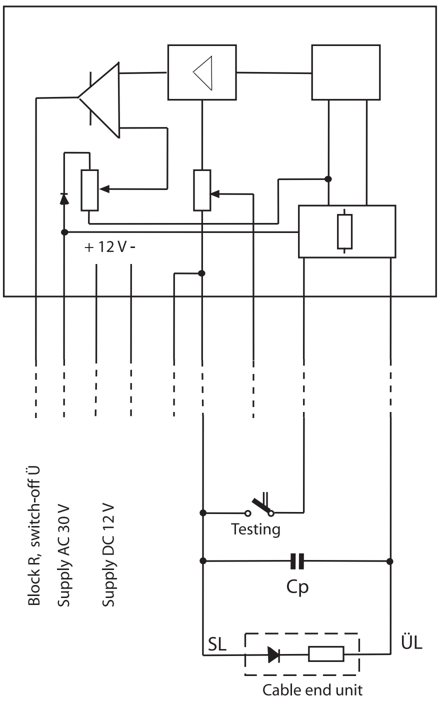


Fig. 2.5: Block Ü

Indicators of the ÜL/SL monitoring circuit

The magnitude of the DC voltage component in the Ü module, which is a measure of the condition of the circuit, can be read off on a chain of LEDs in the indicating block HWKF01. The display consists of five green, two yellow and one red LED. If the circuit is functioning properly, a green LED lights. If, for example, the insulation level between ÜL and SL drops, the illuminated point moves through the yellow LEDs into the red LED area. An opening operation follows at the transition from the yellow to the red areas. The insulation level can also decrease due to rising parallel capacitances between ÜL and SL and the conductor series resistances.

2.6.3 Blocking circuit and release circuit

The HW135 contains a blocking circuit and a release circuit. The blocking circuit prevents that the device is unintentionally switched on when the HW135 is not connected to the supply voltage. That prevents that a device is energized without this protective measure. Connection is carried out via terminal 4 to the locking coil.
The release circuit is intended for connection to external contactors signalling via a flashing output (terminal 6) when the HW135 is not connected to supply voltage and therefore cannot be operated.

3. Mounting and connection

3.1 Mounting

The HV monitor and the associated components may only be installed by a qualified electrician.

Please check correct mains voltage. Prior to installations and before work activities are carried out on the connecting cables, make sure that the mains power is disconnected.
Failure to comply with this safety information may cause electric shock to personnel. Furthermore substantial damage to the electrical installation and destruction of the device can occur.

Installation is carried out according to the following steps:

- Installation of the residual current transformer HWW-11 near the incoming supply. The active conductors L1, L2 and L3 have to be passed through the current transformer. The residual current transformer has to be built into a suitable outlet box or into a connecting box.
- Installation of the cable end unit EV22S connected to the end of the conductor being monitored. The cable end unit is intended to be fitted inside a suitable flameproof connecting box or casing.
- Installation of the connecting leads between the test winding of the HV monitor HW135 and the load winding of the residual current transformer HWW-11 and the ÜL and SL terminals of the cable end unit EV22S. The residual current transformer is to be connected to the PE conductor.

3.2 Connection HW135

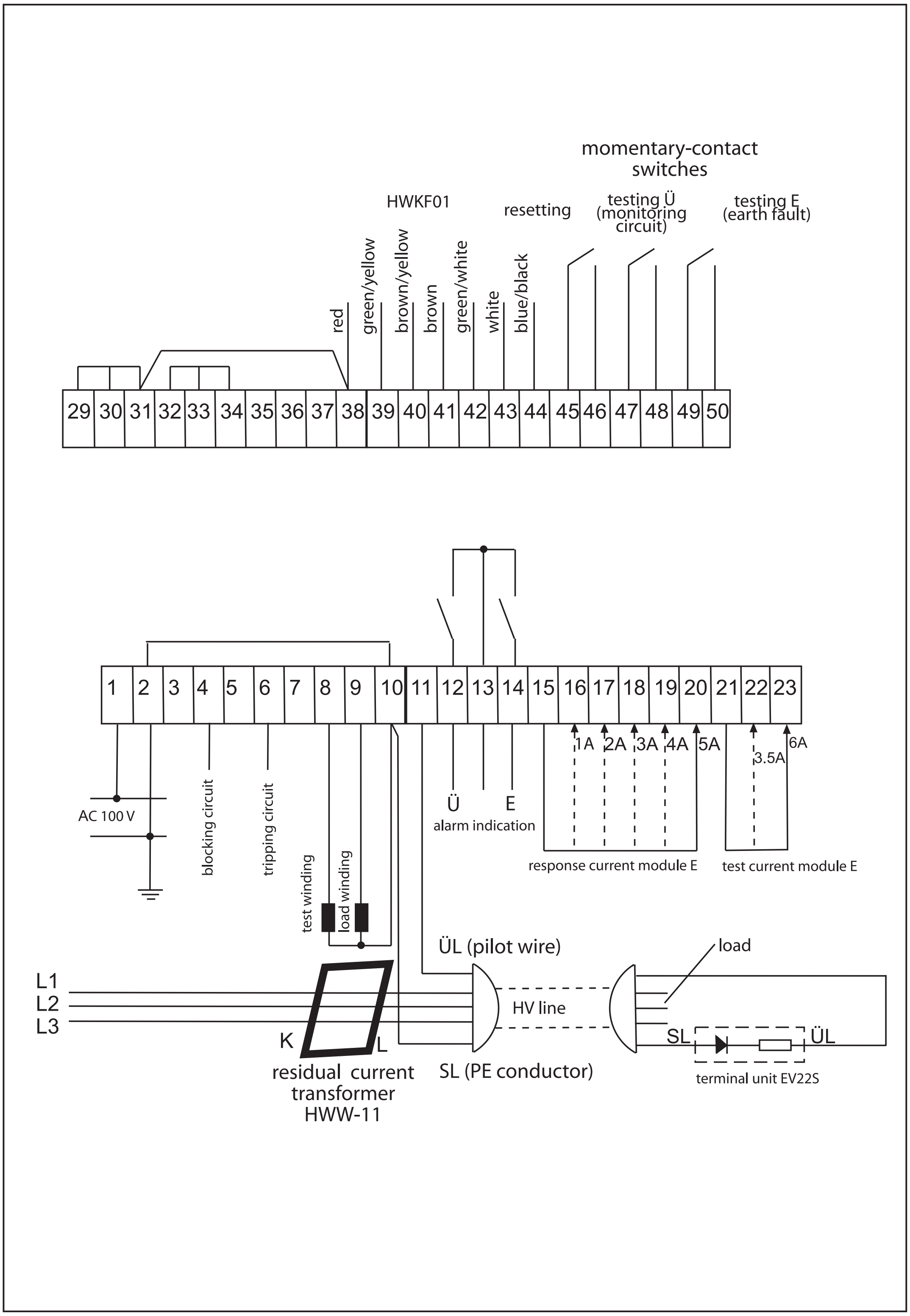


Fig. 3.1: Connection diagram HW135

3.3 Block diagram and schematic connection diagram

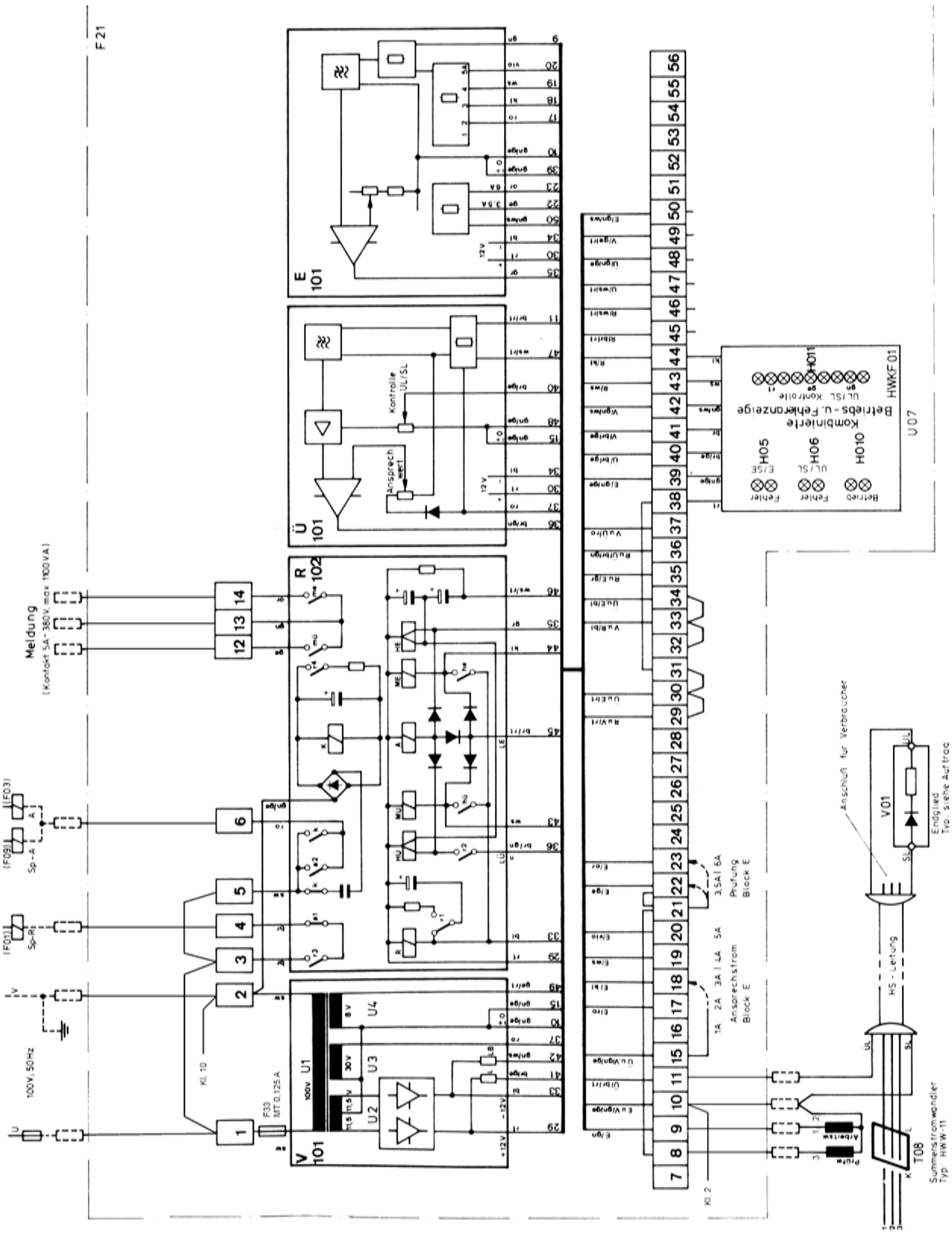


Fig. 3.2: Block diagram with schematic connection diagram HW135

4. Commissioning

4.1 Steps to be taken before switching on

Before operation of the HW135, check that the supply voltage is correct: it should be AC 100 V, 50 Hz for all the modules. The supply is usually taken from the existing voltage transformers.

Switch the external test switches to the “Betrieb“ position.
Check that the residual current transformer HWW-11 and the cable end unit EV22S at the end of the conductor being monitored are properly fitted and properly connected.

Check whether the capacitance upstream the residual current transformer is sufficiently great to guarantee safe operation of the HV monitor. This capacitance must be installed on all three phase conductors and can be set up in the form of a high voltage cable or a discrete capacitor. Since the operating voltage usually is between 5 and 20 kV, the following minimum phase conductor capacitances are provided:

for 5 kV	=>	0.6 µF	=>	ICE=1.67 A
for 10 kV	=>	0.3 µF	=>	ICE=1.67 A
for 20 kV	=>	0.15 µF	=>	ICE=1.67 A

In case of these minimum phase conductor capacitances, a response value not exceeding 1 A is to be set for the protective device.

Installation, connection and operation of the HW135 in combination with high voltage switches shall only be carried out under consideration of:

- the basic conditions mentioned in this chapter and
- the relevant standards, regulations and directives that apply to this system
- as well as the operating instructions of the associated devices in the system (e.g. high voltage switch)

4.2 Functional test and resetting

In order to be able to check the function of the HV monitor HW135, test buttons are incorporated in the lid of the casing. The test buttons are labelled according to their function: Prüfen E (testing), Prüfen Ü (testing), Entsperren (reset).

a) Testing Block E
By pressing this button, a test voltage of 8 V is applied to the test winding of the residual current transformer via a series resistor. The evaluation electronics issues a switch-off command for the respective relays in Block R.

b) Testing Block Ü
A low-resistance connection is established in the device between the protective conductor and the monitoring conductor via the associated contact of the test button Ü. In this way, the DC component for the reference voltage is suppressed and the switch-off command for the relays in Block R is given.

c) Resetting
A reclosing lockout is required for HV monitors by the mining authorities. For reclosing respectively resetting, the respective latching or memory relays have to be reset to their position of rest.
This is effected by a short current impulse which is given via the lockout contact to the reset operation of the relays.

4.3 Maintenance

The HV monitor HW135 and all the associated components require practically no maintenance, since there are no wearing parts and the encapsulation in cast resin practically prevents any adverse effect from the surrounding environment.
All that is necessary is to carry out test switching function at intervals as officially laid down or as suitable to local conditions.

4.4 Calibration

During operation, transportation and storage, HV monitors are subject to harsh environmental conditions.

A calibration interval of 5 years is recommended for HV monitors HW135. An additional calibration is recommended prior to each reinstallation.

Please contact our Technical Sales Department to determine a date for calibration.

5. Setting requirements for HV monitors

5.1 Tunnel drilling machine

When planing earth fault protection it is assumed that an earth fault can occur in the system section being monitored. However, you can learn by the last setting requirement below that also an earth fault in the upstream section of the system can be detected.

- Precondition for proper setting of the protective device HV monitor is the calculation of the earth fault current.
- The earth fault current resulting from the capacitances upstream the conductor being monitored (upstream the residual current transformer) triggers the protective device in case of fault.
- The HV system must be designed so that a minimum capacity is available upstream the conductor being monitored (upstream the residual current transformer). This capacitance should be at least 0.3 µF (ICE=1.67 A) at 10 kV, resp. 0.15 µF (ICE=1.67 A) at 20 kV.
- The earth fault current resulting from the capacitances upstream the conductor being monitored (upstream the residual current transformer) should at least exceed the setting of the HV monitor by 0.5 A.
- At a minimum capacitance, the response value for the HV monitor must be set to 1 A.
- In case of "one" tunnel drilling machine, the length of the cable being monitored is not relevant (but should have a minimum length). Only the pre-capacitance should be considered when setting the HV monitor.
- An earth fault should also be detected in the upstream section of the system and result in a disconnection of the system. Therefore the earth fault current of the cable being monitored (please observe the minimum capacitance) must always be greater than the setting value of the HV monitor.

5.2 Two or more tunnel drilling machines

When planning earth fault protection it is assumed that an earth fault can occur at any point of the system.

- Precondition for proper setting of the protective device HV monitor is the calculation of the earth fault current.
- The earth fault current resulting from the capacitances upstream the cable being monitored (upstream the residual current transformer = the complete galvanically connected system) activates a protective device in case of an earth fault.
- The HV system must be designed so that a minimum capacity is available upstream the conductor being monitored (upstream the residual current transformer). This capacitance should be at least 0.3µF (ICE=1.67 A) at 10 kV, resp. 0.15 µF (ICE=1.67 A) at 20 kV.
- In case of monitoring two or more tunnel drilling machines, the length of the cable being monitored is to be observed for the setting.
- The response value for the HW135 is to be selected so that it always exceeds the capacitive earth fault current of that section in the system that is to be monitored, but should not exceed the capacitive earth fault current of the rest of the system. If this condition cannot be met, a selective monitor (up to 10 kV only) is to be used.
- If the earth fault current resulting from the capacitances of the cable being monitored (downstream the residual current transformer) is greater than 5 A, a selective HV monitor which can operate up to 20 A is to be used (up to 10 kV only).

6. Technical data and dimensions

6.1 Technical data

Supply voltage

Supply voltage .... AC 50Hz, 100 V
Power consumption .... max. 16 VA

Response values (earth fault)

Response current .... 1, 2, 3, 4 or 5 A
Response time .... at 1.05 x Ian : 300 ms
.... > 2 x Ian : 100 ms

Block Ü101

for ÜL/SL circuit/parallel resistor .... 430 Ω at approx. 0 µF
.... 1.2 kΩ at approx.19 µF
ÜL/SL series resistance .... 710 Ω at 0 µF
.... 80 Ω at 19 µF

Block Ü102

for ÜL/SL circuit/parallel resistor .... 150 Ω at approx. 0 µF
.... 1 kΩ at approx. 50 µF
ÜL/SL series resistance .... 2 kΩ at 0 µF
.... 50 Ω at 50 µF
ÜL/SL circuit no-load voltage .... approx. 19 V
ÜL/SL circuit short circuit current .... max. 38 mA
LED .... 5 green, 2 yellow and 1 red LED
Operation and fault indications .... green - Power On
.... red - earth fault
.... yellow - ÜL fault

Fault memory

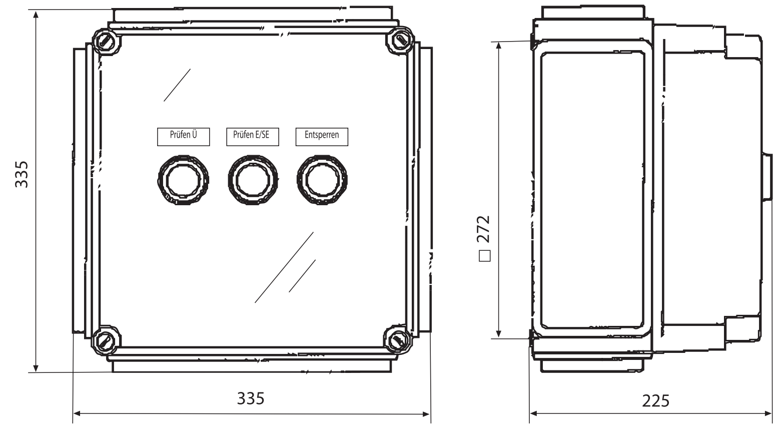
Fault memory .... by latching relays DC 24 V

Output contacts

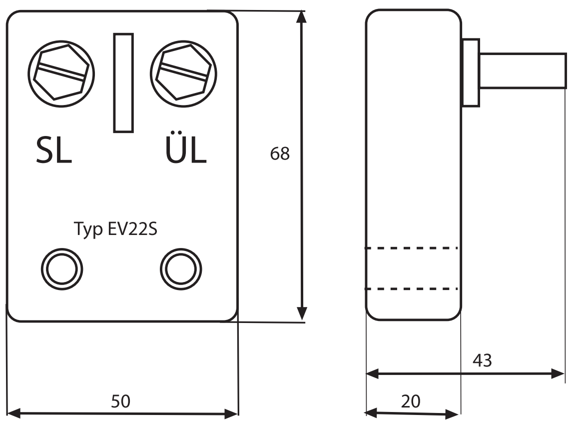
for releasing circuit .... 2 NO contacts, parallel, potential free
.... switching capacity 250 V/4 A /500 VA
for the lockout circuit .... 1 NO contact, 1 NC contact, series-connected, potential free
.... switching capacity 250 V/4 A/ 500 VA
for alarm outputs .... 2 NO contacts, potential free
.... switching capacity 400 V/ 5 A /1100 VA

6.2 Dimensions

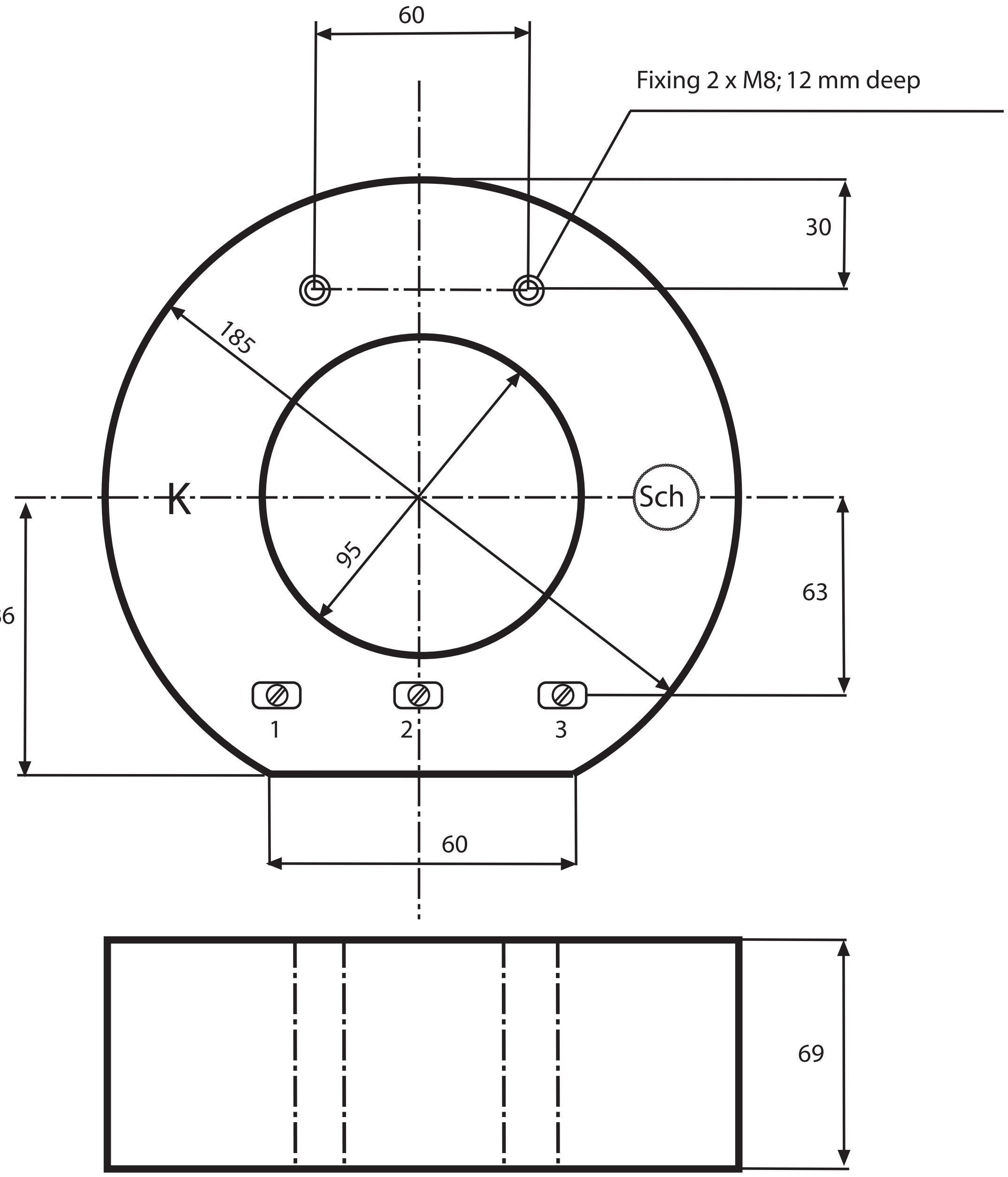
6.2.1 Dimension diagram HW135 casing

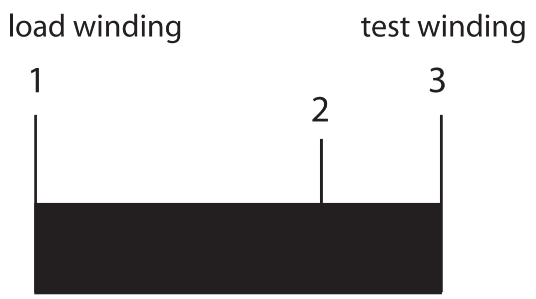


6.2.2 Dimension diagram cable end unit EV22S



6.2.3 Dimension diagram residual current transformer HWW-11





6.3 Ordering details

Type	Description	Art. No.
HW135	High voltage cable monitor in insulating casing IV43GTH HV with Block Ü101	B984620
HW135-1	High voltage cable monitor in insulating casing IV43GTH HV with Block Ü102	B984597
HWW-11	residual current transformer for HV monitors Internal diameter 95mm	B984760
EV22S	Cable end unit for ÜL/SL circuit	B984800

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