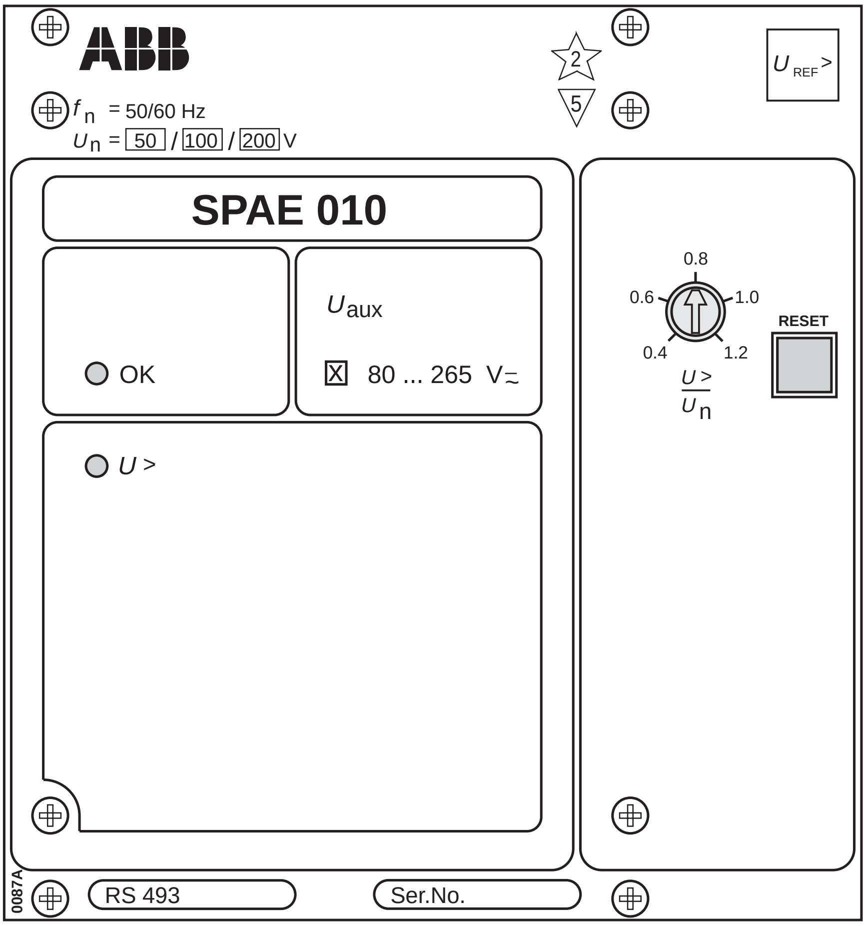
SPAE 010, 011
High Impedance Protection Relay

User´s manual and Technical description



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SPAE 010, 011
High Impedance Protection Relay

Contents

General features 2
Area of application. 2
Operation 3
Requirements on current transformers 4
Connection and block diagram 5
Connections 5
Settings and markings on the relay front plate 6
Technical data *(modified 2002-04)* 6
Operating time characteristics 8
Relay applications 8
Maintenance and repairs 10
Dimensions and instructions for mounting 11
Information required with order 11

General features

High impedance differential type earth-fault protection.

Applied for earth fault protection of transformers, motors and generators.

The relay includes the stabilising resistor.

Short total operating time together with high degree of stability.

High degree of immunity against all types of mechanical and electrical interference and tested according to the latest relevant IEC-standards.
High accuracy and long time stability features due to a digital and software based design.

Area of application

The protective relays type SPAE 010 and SPAE 011 form in their applications a differential protection of the high impedance type. The differential protection of the high impedance type is used as earth-fault protection for transformers, generators and motors. The difference between the two relays is the auxiliary supply voltage required. For SPAE 010 the auxiliary supply voltage is within the range 80. . .265 V ac or dc and for SPAE 01 1 the range is 18...80 V dc.

Operation

The high impedance type differential protection is stable for all types of faults outside the zone of protection. The stabilisation is obtained by a resistor in the differential circuit. In SPAE 010 and SPAE 011 the stabilizing resistor is included in the relay and is in series with the measuring transformer. This gives the name of the protection system, i.e. a high impedance type protection.

The stability of the protection is based on the circumstance that the impedance of a current transformer quickly decreases as the current transformer saturates. The reactance of the excitation circuit of a fully saturated current transformer goes to zero and the impedance is formed only of the resistance of the winding. By means of the resistor in the differential current circuit these condary current fed by a non-saturated current transformer is forced to flow through the secondary circuit of a saturated current transformer.

The operating level of the high impedance relay is to be set to a level not permitting a relay operation for any currents in the differential current circuit, caused by any fault currents arisen by faults outside the zone of protection of the high impedance protection.

When a fault arises within the zone of protection, both current transformers strive to feed current through the differential current circuit and the protection will operate.

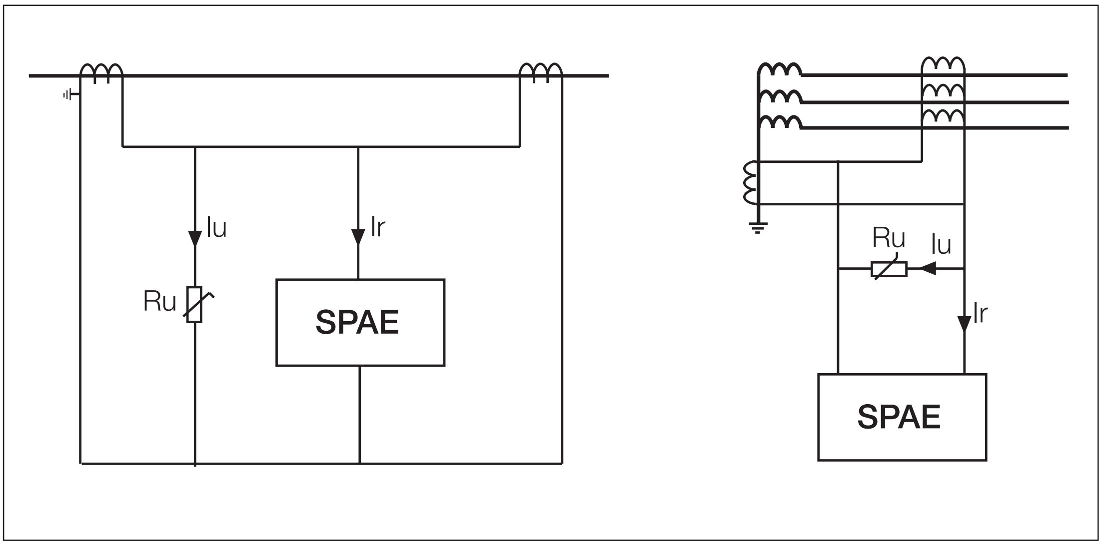


Fig. 1. The principle of the high impedance type differential protection

Requirements on current transformers

The sensitivity and reliability of the protection is much depending on the characteristics of the current transformers. The number of turns of the current transformers forming part of one and the same protection should be as equal as possible. In high impedance protections class x current transformers are to be used, the technical features of which are defined by the knee-point voltage UK, excitation current Ie at the knee point and the secondary winding resistance Rin. The knee-point voltage is the excitation voltage value measured on the secondary side of the current transformer, which when increasing with 10 % causes an 50 % increase of the excitation current.

For the current transformers to be able to force a current enough to operate the relay through the differential circuit during a fault condition inside the zone of protection, the knee-point voltage Uk should be 2 times higher than the stabilising voltage Us required in through fault conditions:

$$Uk = 2 \times Us = 2 \times Ikmax / n (Rin + Rm) \qquad (1)$$

where
Uk = the knee point voltage
Us = he stabilizing voltage
Ikmax = the maximum through fault current
n = turns ratio of the current transformer
Rin = he internal resistance of the current transformer secondary winding
Rm = he total resistance of the longest measuring circuit loop

The factor two is used when no delay in the operating time of the protection in any situation is acceptable. In order to prevent the knee-point voltage from growing too high, it is advisable to use current transformers, the secondary winding resistance of which is of the same size as the resistance of the measuring loop.

The sensitivity requirements set up for the protection are endangered, if the excitation current of the current transformers, corresponding to the knee-point voltage is permitted to grow too high. The magnitude of the excitation current Ie can be calculated from the expression:

$$Ie = (Iprim/n-(Ir+Iu))/m \qquad (2)$$

where
Ie = the excitation current
Iprim = the primary current level, for which the protection is to operate
Ir = the current corresponding to the relay setting
Iu = the current flowing through the protective resistor
n = turns ratio of the current transformer
m = number of current transformers per phase belonging to the protection

To prevent the voltage of the secondary circuit from growing too high during faults within the zone of protection, a resistor is connected in parallel with the differential current circuit. The resistance of the resistor is dependent of the voltage; the higher the voltage is, the lower the resistance value becomes.

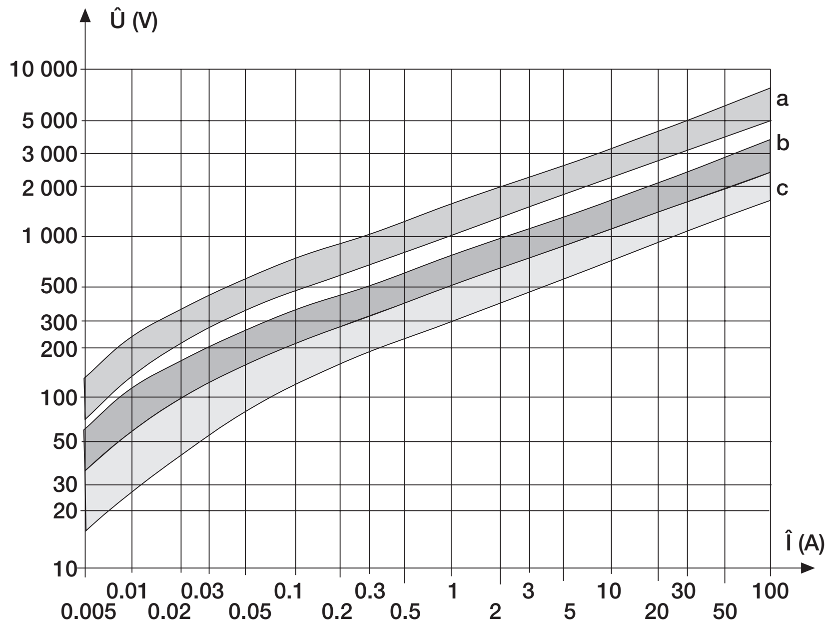


Fig. 2. Characteristics of the voltage dependent resistor
a = resistor 5248 831-D, b = resistor 5248 831-C, c = resistor 5248 831-B

Connection and block diagram

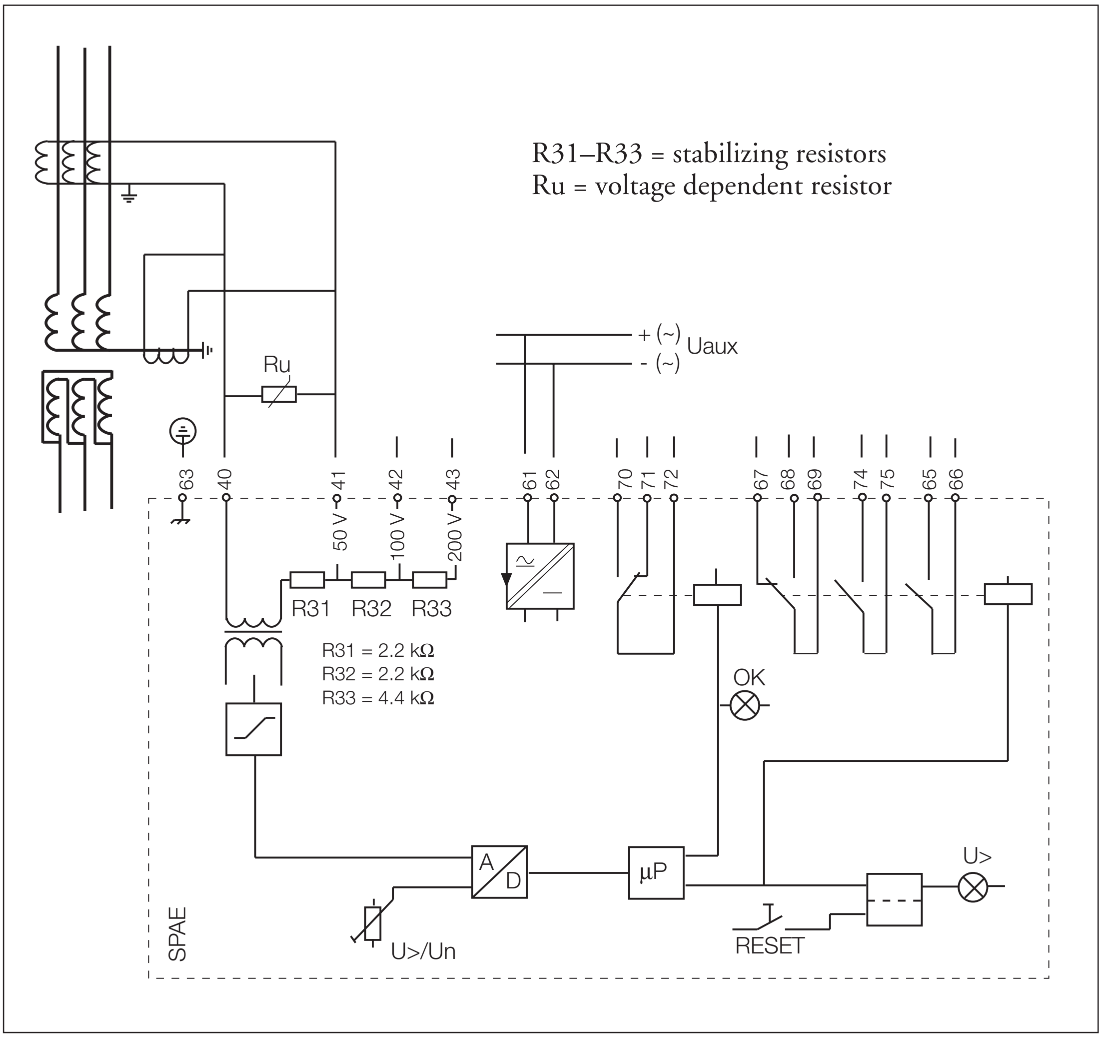


Fig. 3. Connection and block diagram of the high impedance relay type SPAE 010 or SPAE 011

Connections

The terminals of the relay have the following function:

Terminal	Function
40-41	Measured voltage when the setting range is 0.4...1.2 x 50 V
40-42	Measured voltage when the setting range is 0.4...1.2 x 100 V
40-43	Measured voltage when the setting range is 0.4...1.2 x 200 V
61-62	Auxiliary power supply. The positive pole of dc supply is connected to terminal 61
63	Protective ground
65-66	Trip contact 1
74-75	Trip contact 2
67-68-69	Alarm contact
70-71-72	Internal relay failure alarm contact. When the auxiliary power is connected and there is no internal failure contact 70-72 is closed

Settings and markings on the relay front plate

The front plate contains one setting knob, two LEDs, one green and one red and one push-button.

The operation voltage of the protection is set by means of the U/Un setting knob on the relay front panel and the setting range is 0.4...1.2 x Un.

The two LEDs on the front plate are used to indicate the relay status and the trip of the relay:

- The green LED (OK) is alight whenever the auxiliary voltage is connected, the relay is operating and there is no internal relay failure.
- The red LED (U>) lights up whenever the relay trips. The red LED remains glowing when the breaker is tripped and the relay drops off. RESET push-button is used to reset the red tripindicator.

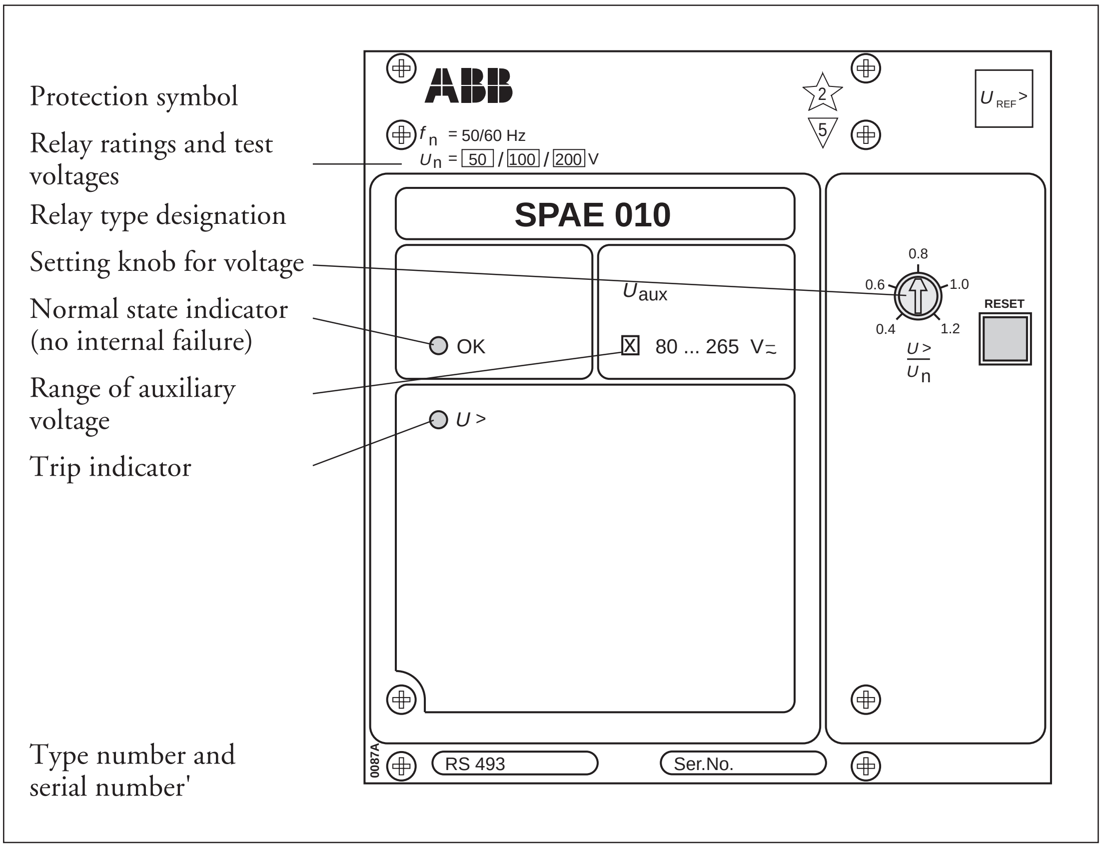


Fig. 4. Front panel of the relay SPAE 010 with setting elements

Technical data

(modified 2002-04)

Energizing inputs

Terminal numbers	40-41	40-42	40-43
Rated voltage, Un	50 V	100 V	200 V

Thermal withstand capability

- continuous	1.3 x Un
- for 1 s	10 x Un
Rated frequency, fn	50/60 Hz

Protection characteristics

Voltage setting range, U>/Un	0.4...1.2 x Un
Operating current	9...27 mA
Operating time	see fig. 5
Drop-off time	≤120 ms
Drop-off/pick-up ratio	0.8

Output contact ratings

Trip contacts, terminal numbers	65-66, 74 75
Rated voltage, make or break	250 Vac or dc
Make and carry for 0.5 s	30 A
Make and carry tor 3 s	15 A
Continuous carry	5 A
Breaking capacity for dc, when the control circuit time constant L/R£ 40 ms, at 48/110/220 V dc	5 A / 3A / 1 A
Contact material	gold plated AgNi
Signalling contacts, terminal numbers	67-68-69, 70-71-72
Rated voltage, make or break	250 Vac or dc
Make and carry for O.5 s	10 A
Make and carry for 3 s	8 A
Continuous carry	5 A
Breaking capacity for dc, when the control circuit time constant L/R ≤40 ms, at 48/110/220 V dc	1A / 0.25A / 0.15A
Contact material	gold plated AgNi

Auxiliary power supply

Supply voltage, SPAE 010	80...265 V ac or dc
Supply voltage, SPAE 011	18...80 Vdc
Power consumption	about 5 W

Insulation Tests

Dielectric test IEC 60255-5	2kV, 50Hz, 1min
Impulse voltage test IEC 60255-5	5kV, 1.2/50µs, 0.5J
Insulation resistance measurement IEC 60255-5	>100MΩ, 500Vdc

Electromagnetic Compatibility Tests

High-frequency (1MHz) burst disturbance test IEC 60255-22-1	
- common mode	2.5 kV
- differential mode	1.0 kV
Electrostatic discharge test IEC 60255-22-2 and IEC 61000-4-2	
- contact discharge	6 kV
- air discharge	8 kV
Fast transient disturbance test IEC 60255-22-4 and IEC 61000-4-4	
- All ports	2 kV
Spark interference test voltage, inputs and outputs as per SS 436 15 03, PL 4	4...8 kV

Environmental Conditions

Specified service temperature range	-10...+55°C
Transport and storage temperature range	-40...+70°C
Temperature influence on the operating values of the relay over the specified service temperature range	<0.2%/°C
Damp heat test, cyclic IEC 60068-2-30	+25...55°C, r.h. > 93%, 6 cycles
Degree of protection by enclosure of the relay case when panel mounted	IP 54
Weight of fully equipped relay	2 kg

Operating time characteristics

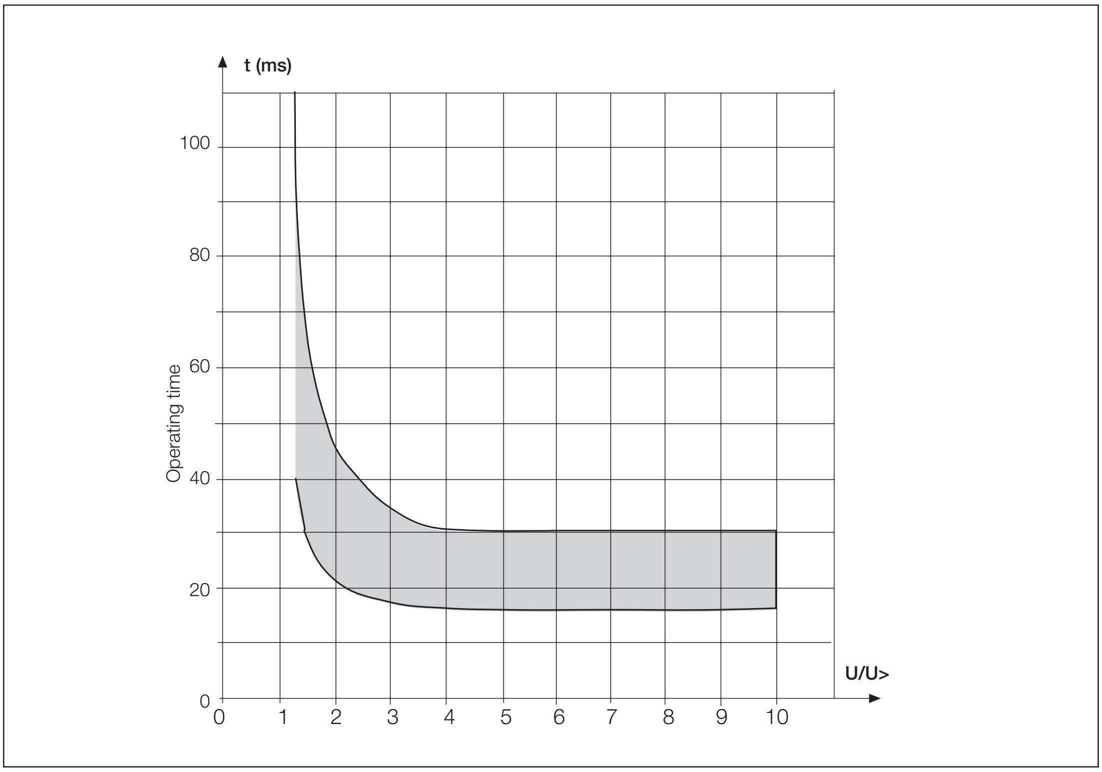


Fig. 5. Operating time characteristics of SPAE 010 and SPAE 011.

Relay applications

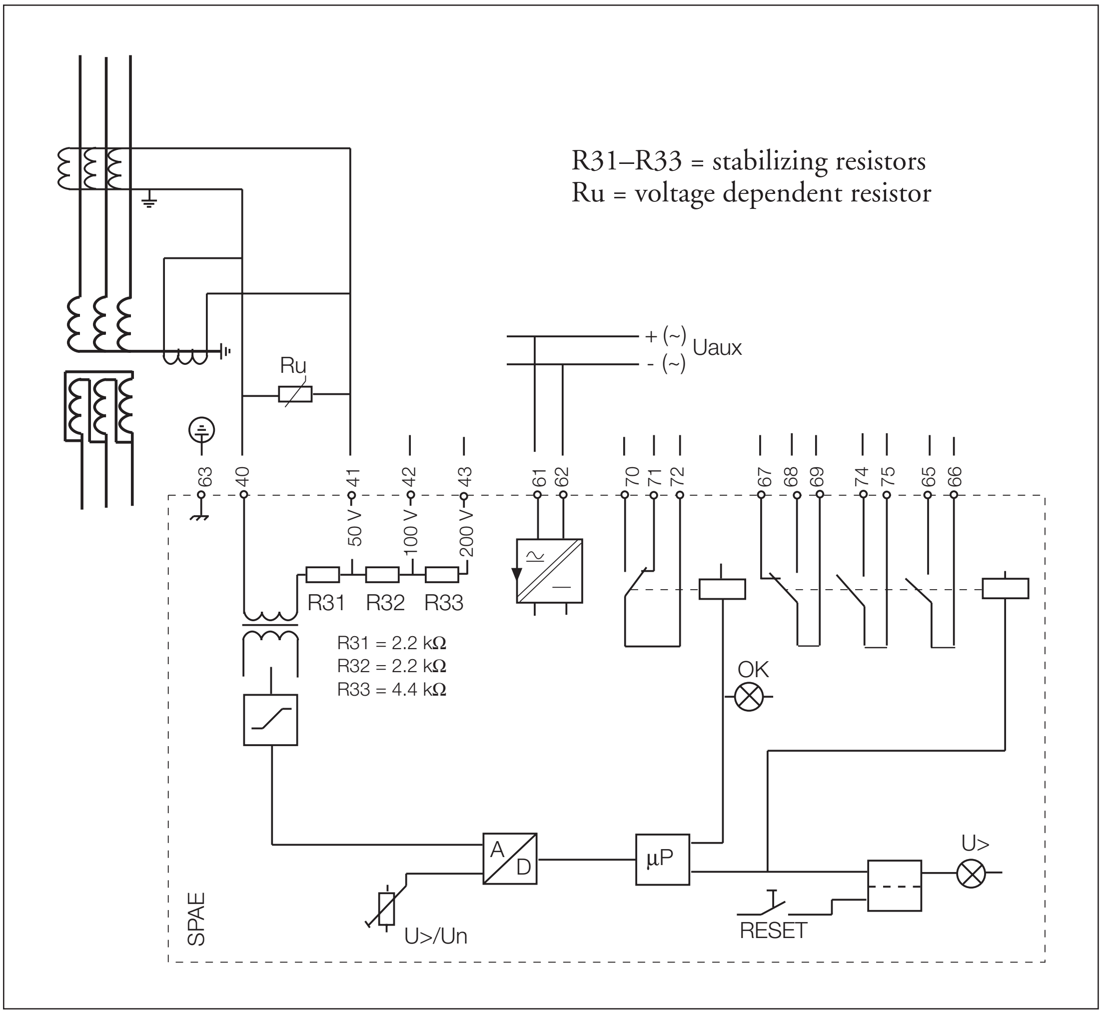


Fig. 6. Earth-fault protection of transformer using high impedance relay SPAE 010

In solidly earthed networks the Earth-fault currents reach very high magnitude. Therefore the earth-fault protection should be fast operating. In the application above the earth-fault protection of the high voltage side of the power transformer has been carried out with the high impedance relay SPAE 010 using the differential connection principle, i.e. so called restricted earth-fault protection.

The turns ratios of the current transformers are selected equal. The protection is to be stable both for earth-faults and short-circuits arising outside the zone of protection. In order to keep the secondary circuits as short as possible, the summation connections are performed at the terminals of the current transformers.

The setting value of the relay, U> can be calculated from the expressions:

U> ≥Us (3)
Us = Ikmax x (Rin + Rm)/n (4)

where
U> = setting value of the relay
U = stabilizingvoltage
Ikmax = the maximum through fault current, for which the protection is to be stable
Rin = the internal resistance of the current transformer secondary winding
Rm = the total resistance of the longest measuring circuit loop, i.e. the range from the relay terminals to the current transformer
n = turns ratio of the current transformer

The ratio of the stabilising voltage and the knee-point voltage has to be checked using the expression (1). The knee-point voltage has to be high enough to secure the operation of the protection in through fault situations.

The sensitivity of the protection can be calculated using the expression:

Iprim = n (Us /Rs +m x Ie+Iu) (5)

where
Iprim = the primary current level, for which the protection will operate
n = turns ratio of the current transformer
Us = the stabilising voltage
Rs = the value of the internal stabilising resistor
m = the number of current transformers per phase in the protection
Ie = the excitation current of the current transformer at the excitation voltage Us, when regarding the excitation curve of the C.T. as being linear
Iu = the current flowing through the protective resistor at the voltage level Us, see figure 2 on page 4.

Maintenance and repairs

When the protective relay is operating under the conditions specified in the section "Technical data", the relay is practically maintenance free. The relay modules include no parts or components subject to an abnormal physical or electrical wear under normal operating conditions.

If the environmental conditions at the relay operating site differ from those specified, as to temperature, humidity, or if the atmosphere around the relay contains chemically active gases or dust, the relay ought to be visually inspected in association with the relay secondary test being performed. At the visual inspection the following things should be noted:

- Check for signs of mechanical damage on relay case and terminals
- Accumulation of dust inside the relay cover or case; remove by blowing air carefully
- Rust spots or signs of eruginous metal on terminals, case or inside the relay

On request, the relay can be given a special treatment for protection of the printed circuit boards against stress on materials, caused by abnormal environmental conditions.

If the relay fails in operation or if the operating values remarkably differ from those of the relay specifications, the relay should be given a proper overhaul. Minor measures can be taken by personnel from the customer's company instrument workshop but all major measures involving overhaul of the electronics are to be taken by the manufacturer. Please contact the manufacturer or his nearest representative for further information about checking, overhaul and recalibration of the relay.

Note!
Static protective relays are measuring instruments and should be handled with care and protected against moisture and mechanical stress, especially during transport.

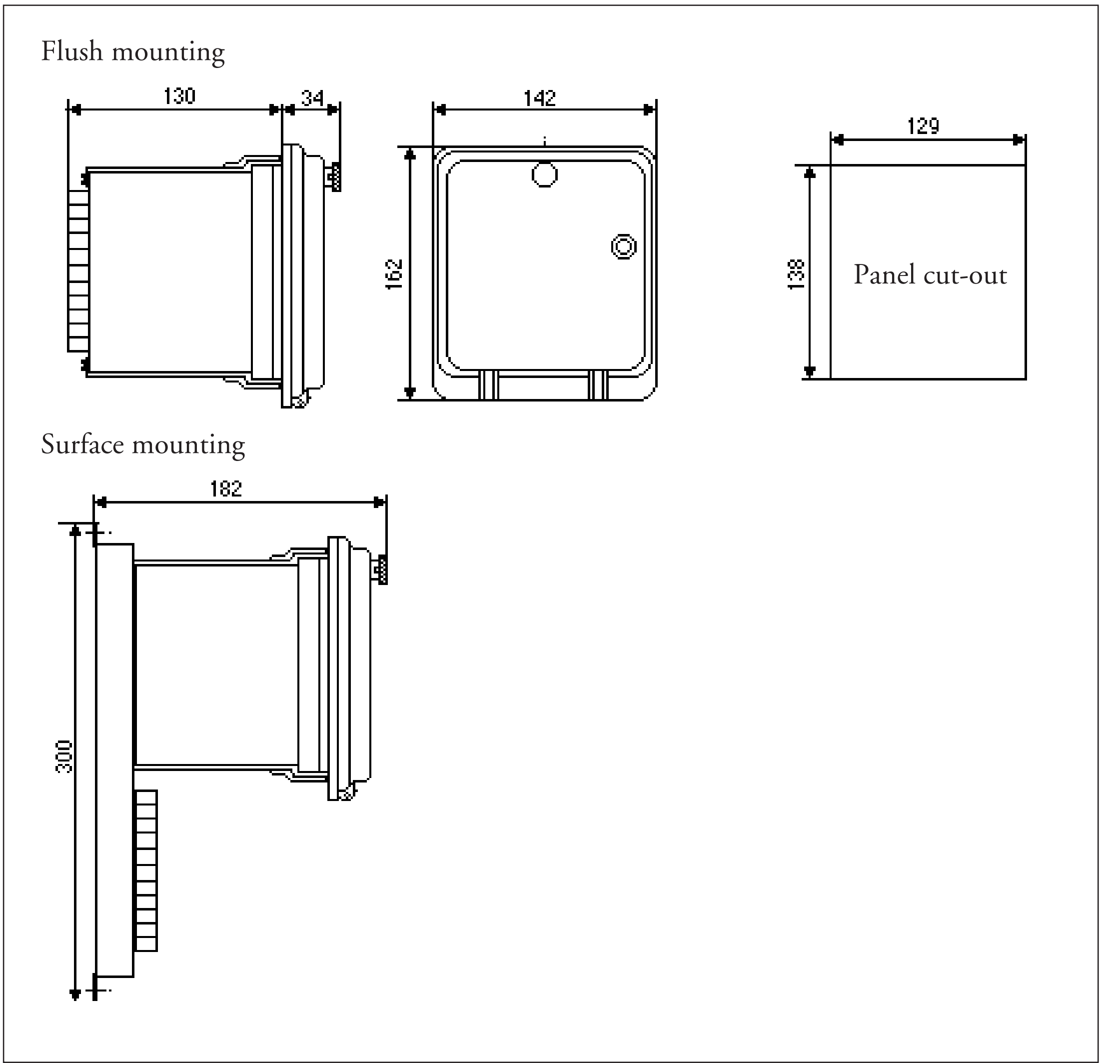
Dimensions for mounting

The relay is housed in a normally flush-mounted case. If needed, Fe can also be surface mounted. The relay case is made of a black anodized, extruded aluminium profile.

A cast aluminium Al by mounting frame with a rubber gasket provides a degree of protection by enclosure to IP 54 when the relay is panel mounted.

The relay case is complete with a hinged gasket, clear, UV- stabilized polycarbonate cover with a sealable fastening screw. The degree of protection by enclosure of the cover is also IP 54.

A terminal block is mounted on the back of the relay case to facilitate all input and output connections. A connection diagram is shown adjacent to the terminal block. To each terminal one or two 2.5 mm^2 wires can be connected. No terminal lugs are needed.



Information required with order

1. Number of and type of relay	2 off, SPAE 010
2. Auxiliary power supply voltage, U_{aux}	110 Vdc
3. Accessories	none
4. Special requirements	none

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