ABB Relays

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User's Guide
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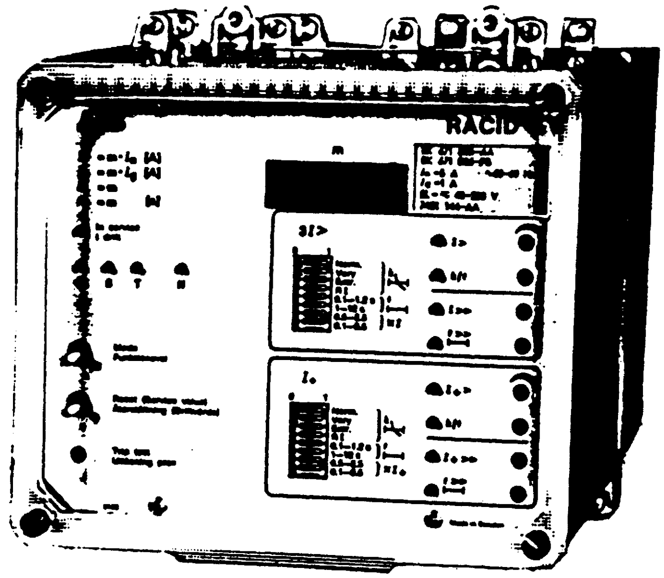
Type RACID Time-lag overcurrent and earth fault relay



(SE 900 662)

GENERAL

- Three-phase or two-phase overcurrent relay with start function, delayed and instantaneous functions
- Non-directional earth fault relay with start function, delayed and instantaneous functions
- Reconnectible time characteristic
  Definite time-lag
  Inverse time-lag
    normal inverse
    very inverse
    extremely inverse
    RI-curve
- Phase and start indication
- Low transient overreach
- High resetting ratio and short resetting time
- Wide range of settings
- Low burden on the measuring circuits
- The instantaneous function can be delayed to obtain selectivity in networks with fuses
- Easy to use. Numeric indication of set values, normal service currents and fault current when tripping occurs
- Continuous monitoring of internal circuits
- Indication of erroneous attendance
- Auxiliary voltage 48–220 V ±20%, dc or ac for the same relay
- Minimum of maintenance required
- COMBIFLEX or screw connections
- All normal methods of installation can be used

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DEFINITIONS

Start function I>, I⏚ > The instantaneous function which occurs when the current I has exceeded the set operating value for I> or I⏚ >.

Instantaneous function I>, I⏚ »

The instantaneous function which occurs when the current I has exceeded the operating value for I» or I⏚ ».

The instantaneous function can be delayed or blocked in order to achieve selectivity.

Delayed function The function which occurs a certain time after the actual current has exceeded the set operating value. The delay can be either of independent time or inverse time characteristic.

Independent time t, t» Delayed function where the delay is independent of the magnitude of the current when the set operating value for I>, I⏚ >, I» and I⏚ », is exceeded.

Inverse time k Delayed function where the delay is dependent on the magnitude of the current when the set value for I>, I⏚ > is exceeded. (Significant current = short delay, insignificant current = long delay.)

Accuracy limit factor n The accuracy limit factor n of a current transformer signifies the multiple of the rated current up to which the transformer's indicator error fulfils the accuracy class requirement. The accuracy limit factor is dependent on the magnitude of the burden and is calculated with the aid of the following formula:

$$n = \frac{a}{b + c}$$

where
a = constant (in ohms) which is determined on the basis of the transformer size and the network frequency
b = impedance (in ohms) of the secondary winding
z = impedance (in ohms) of the burden at which the accuracy limit factor is to be determined

At rated burden, the accuracy limit factor is identical to the rated accuracy limit factor of the transformer relay cores in accordance with SEN 27 08 11.

Transient overreach The influence of the dc component on the operating value. A portion of the dc component is transferred to the measuring circuits and results in the relay operating for a lower current (calculated on the stationary portion) than the set current. If, during a fully developed dc component, operation takes place for a stationary current that is 0.95 times the set value, the transient overreach of the relay is:

$$< \frac{1 - 0.95}{0.95} = 0.05, \textit{ i.e. } 5\%$$

I_n Rated current of time–overcurrent relay

I_g Rated current of earth fault relay

I_n and I_g are stated on the rating place located at the upper right–hand corner of the relay.

USE

The RACID is a flexible time-overcurrent and earth fault relay having high technical performance and thus a wide range of applications, e.g., as main and backup protection for distribution and industrial systems, transformers, capacitor banks, electric boilers, motors and small generators, or as backup protection for transmission lines, transformers and generators.

Due to accurate measuring, insignificant overreach, high reset ratio and short reset time, the RACID contributes to short time steps and low current settings in the selectivity plan.

RACID is available in different versions with respect to:

- method of connection and installation
- 2-phase or 3-phase time-overcurrent relay with or without earth fault relay
- with or without test switch

In addition to a trip relay and a signal relay for internal faults, always incorporated in RACID the version with 2 ranges of measurement have three extra programmable signal relays.
The function and setting of the overcurrent and earth fault relays in the protection are entirely individual. Both the relays have a start and instantaneous function. The instantaneous function can be delayed or blocked whenever necessary.

Three-phase or two-phase circuit protection

In a three-phase protective relay, both phase currents are always measured when a two-phase fault occurs. The relay operates, therefore, even if one of the measuring circuits should be faulty.
A three-phase relay is therefore more reliable than a two-phase relay. Compared to a summating type of protection, that has a common measuring circuit, considerably greater reliability is achieved.

If all the overcurrent relays in a network are located in the same phases, two-phase overcurrent relays are quite adequate.
A two-phase fault will then always influence at least one of the phases in a relay.

In networks with low short-circuit power, three-phase relays may, in some cases, be necessary. In the event of a two-phase short circuit on the Y-side of a D/Y-connected transformer, full short-circuit current will only flow in one of the phases. Approximately half the short-circuit current will flow in the other phases. If a two-phase short-circuit protection is used, the operation can therefore be unreliable.

Start function

The start function of RACID occurs instantaneously when the current exceeds the value set on $I>$ or $I_{\perp}>$.

In radially supplied networks, the function can be used for blocking a blockable busbar protection. In other cases, for starting printers, autoreclosing or signalling.

The current setting is determined by the loading capacity of the object and by the smallest fault current within the operating range. The delay of the trip signal is selected with consideration to the demand on selectivity and the thermal characteristics of the installation. Furthermore, the settings should always be chosen so that the overcurrent relay starts for at least two circuit–breakers in series in the event of a fault. In this manner, backup protection is obtained if the primary protection or the circuit–breaker should fail to operate.

Delayed function

With the aid of the selector switches, located on the front of RACID; a choice can be made between definite time delay or four different inverse time delays. As a rule, different time characteristics should not be used in one and the same system. An appropriate characteristic is therefore chose on the basis of previous practice.

The following rules of thumb can however facilitate the choice of characteristic when compiling a selectivity plan.

- Definite time delay is used in networks which have varying short–circuit power and when it is required to facilitate the compilation of the selectivity plan
- Normal inverse is used in networks which have varying short–circuit power and long "weak" lines
- Very inverse can facilitate the selectivity in networks which incorporate fuses and which have constant short–circuit power
- Extremely inverse is most appropriate when selectivity with fuses is required and where there is a risk of significant switching currents occurring, e.g., switching–in of heating or air–conditioning plants
- Inverse time tripping, in accordance with the RI–curve, is used in networks in which ABB's RI–type relay is already incorporated and determines the character of the selectivity plan

In systems which are supplied from several directions, the current sensed by the relays during a fault will vary considerably. Refer to Fig. 1 below.

In such cases, as a backup protection, use can often be made of inverse time overcurrent relays that all has the same setting. This provides good results since the fault current to the faulty item will always be higher than the fault current fed from the faultless items and therefore give rise to the shortest tripping time.

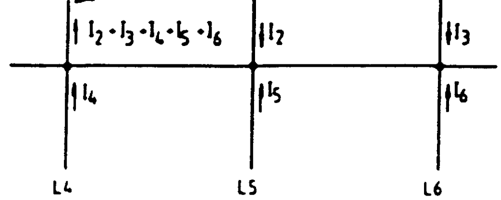

Fig. 1 System with several supply circuit

Instantaneous function

The instantaneous function is normally set to act for nearby faults. The reach is dependent on the variations in the short-circuit power and on the type of fault. Constant short-circuit power increases the possibility of using the instantaneous function also in networks which have moderate impedances.

In cases when the impedance of the system results in a well-defined fault current during through-flow fault currents, the variations in short-circuit power are of no significance.

In the case of a transformer, a fault on the low voltage side will never give rise to a fault current that has a magnitude greater than a given value. An instantaneous step, that has a higher operate value, has a well-defined reach towards but never through the transformer.

To prevent the relay from measuring through the transformer, consideration must be taken to the following:

- The relay's transient overreach due to a possible dc component in the fault current
- Variations in the short-circuit impedance of the transformer due to the positions of the tap changer
- The magnitude of switching-current surge

Normally, the impedance at the centre position of the tap changer is given with a few percents variation in the end positions. The instantaneous function is therefore set to approximately 120% of the maximum fault current. In certain cases, a little higher setting may be necessary.

In the case of protection located far out in a radial system, the instantaneous function is most appropriate. The adjustable independent time delay (0.1–1.2 seconds) enables selectivity towards fuses located farthest out in the system.

In those cases where selectivity with instantaneous function cannot be achieved, it is possible to block the function.

In the case of parallel lines supplied from several directions, directional overcurrent relays must be used. In radial systems which have two parallel lines, selective tripping can be achieved with four overcurrent relays, two of which are directional as shown in Fig. 2.

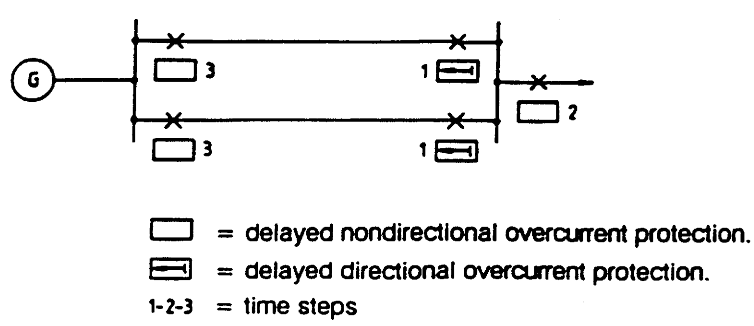

Fig. 2 Radially supplied system with parallel lines

By utilizing longitudinal differential protection on strategically selected cables and lines, instantaneous and selective tripping is achieved for these. One or more selective steps can therefore be omitted. Other cables and lines can be protected with normal overcurrent relays since these have shorter tripping times. This can be of special interest, for example in large industrial installations in which the short-circuit power has increased successively due to extension of the network as shown in Fig. 3.

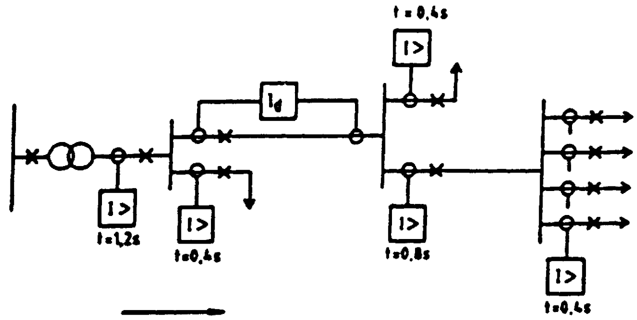

Fig. 3 Example showing how a longitudinal differential protection can reduce the number of selective steps

Earth fault relay

The demands imposed on the earth fault relay are dependent on how the neutral point of the system is arranged and on national requirements and previous practice.

Three different systems are in use: solidly earthed, low-impedance earthed an high-impedance earthed systems. This implies that the demands imposed on the earth fault relay vary considerably. The different versions of RACID; combined with their wide ranges of settings, fulfil these requirements more than well. The version which is intended for high-impedance earthed systems, consumes very little power. This implies that a high degree of sensitivity can be obtained in combination with cable current transformers. (Refer to Table 1.)

Solidly earthed systems

In solidly earthed systems, contributions are obtained from all neutral points in the systems. An earth fault current is not normally transferred from one voltage level to another, except when auto transformers are incorporated. In EHV or HV systems, a directional relay of type RAEPA is often required to constitute a primary earth fault relay. But it may also be possible to achieve selectivity with inverse time relays with the same settings on all relays. For voltages between 100 and 400 kV, it is often required to "disconnect" fault currents of magnitudes 100 to 400 A and, in the case of lower voltage levels, currents which are as low as 50–100 A. In systems where the lines are not transposed, the unbalance which arises can cause problems to a sensitive earth fault relay. The operate value should then be increased to approximately 30% of the maximum load.

Low-impedance earthed systems

In these systems, where the earth consists of a Z-O connected neutral-point transformer with or without resistor, or a separate resistor connected to the neutral point of the transformer, the fault current is generated from one point only. Selectivity is then achieved by time-grading the different earth fault relays.

Normally, a sensitivity of 10–30% of the maximum fault current is required and this applies to all relays. An earth fault relay can be included in the neutral point of the Z–O connected transformer to serve as a supplement and backup protection.

The current setting of the relay is often chosen to correspond with that which the neutral-point transformer can withstand continuously. It is also given a relatively long delay of between 10 and 30 seconds.

High-impedance earthed systems

These systems are earthed in the same manner as low-impedance earthed systems but with a high-impedance resistor in the neutral point. The resistor is chosen to provide a maximum fault current of 5–25 A. In certain cases, the resistor is omitted and the neutral point is connected to earth via a surge arrester and/or a voltage transformer. The system is then said to be isolated.

In these cases, the earth fault relay has an independent time delay and selectivity is obtained by time-grading the different relays. The current setting normally corresponds to 10–40% of the maximum fault current and is the same for all relays in the system.

Depending on the configuration of the system, the different capacitive currents of the objects and the required sensitivity, directional earth fault relays are sometimes required.

Directional relays are required for parallel lines and in cases when the capacitive current of the protected object is of great magnitude relative to the set operate value.

In the case of overhead lines, the capacitive current generated by them should not exceed 66% of the operate value set on the line protection. For cables, this value should not exceed 30% of the set value. Directional relays should be used for higher values.

Connection, earth fault relay

The earth fault relay can be fed in two different ways, by residual current connected line transformers or by using a separate open core current transformer.

In the case where the current transformers are residual current connected an unbalanced current can appear due to differences in the current transformers. In the event of a short circuit, the unbalanced current can be of such a magnitude as to cause the operation of the earth fault relay. This can be prevented if the operate time of the earth fault relay is extended in relation to that of the short-circuit protection or if an open core current transformer is allowed to feed the earth fault relay.

To reduce the unbalanced current in cases when the current transformers are residual current connected, the current summation must take place as near as possible to the current transformers. No other relays or instruments should be connected. If this cannot be avoided, the load should be symmetric and the burden low.

When transformers are residual current connected, certain magnetization losses arise and, in conjunction with the commissioning of an installation, the primary operate value should be checked to ensure that it is correct. Refer to Fig. 4.

Note that the internal resistance of the ammeter in the secondary circuit must be small in relation to that of the relay. If the ammeter has high internal resistance, the measured efficiency is reduced.

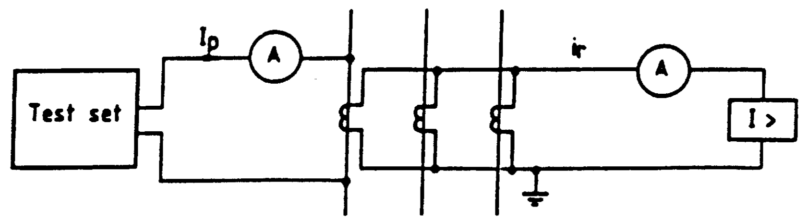

Fig. 4 Determining the efficiency

Directional protective relays require high efficiency in order to operate reliably. In the case of other protections, the efficiency is of less importance. However, it must not be so low as to influence the reliable operation of the relay in the event of a fault.

When supplied from open core current transformers of types IHKA, ILKB, KOLMA 06 D1 and KOLA 06 B2 the primary operate values according to Table 1 are obtained at different settings of RACID with rated current I_g = 30 mA.

Table 1	Relay setting	ABB's open core current transformer of type	Primary operate current	Efficiency factor
RACID	3 mA	ILKB 05 200/1	0.64 A	94%
I_g = 30 mA		IHKA 05 100/1	0.43 A	70%
		KOLMA 06 D1 50/1	0.27 A	56%
		KOLMA 06 D1 70/1	0.30 A	70%
		KOLMA 06 D1 100/1	0.38 A	80%
		KOLMA 06 D1 150/1	0.52 A	87%
		KOLA 06 B2 100/1	0.43 A	70%
	9 mA	ILKB 05 200/1	1.89 A	95%
		IHKA 05 100/1	1.12 A	80%
		KOLMA 06 D1 50/1	0.69 A	66%
		KOLMA 06 D1 70/1	0.80 A	79%
		KOLMA 06 D1 100/1	1.03 A	88%
		KOLMA 06 D1 150/1	1.45 A	93%
		KOLA 06 B2 100/1	1.15 A	78%
	15 mA	ILKB 05 200/1	3.13 A	96%
		IHKA 05 100/1	1.81 A	83%
		KOLMA 06 D1 50/1	1.09 A	69%
		KOLMA 06 D1 70/1	1.31 A	80%
		KOLMA 06 D1 100/1	1.68 A	89%
		KOLMA 06 D1 150/1	2.34 A	96%
		KOLA 06 B2 100/1	1.78 A	84%

Current transformers with moderate magnetizing characteristic were chosen when above primary operate currents were measured.

The resistance between the relay and the current transformer can be neglected in the above measurements.

If doubts arise regarding the primary operating value, it should be measured in conjunction with commissioning.

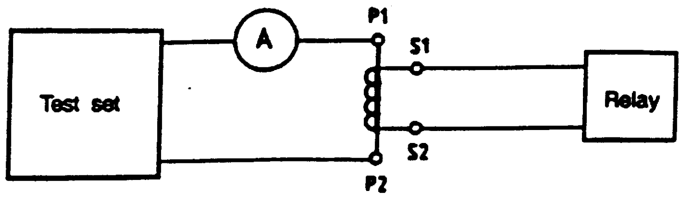

Fig. 5 Connection to enable the measuring of the primary operate range

Demands imposed on current transformers

The consumption of power in the current circuit of RACID is very low compared to that of electromechanical overcurrent relays. This implies that, if an electromechanical overcurrent relay is replaced by a RACID, a higher accuracy limit factor is automatically obtained for the same current transformer. This is worth noting in the case of installations where the short–circuit power has increased due to the increase of transformer power.

To ensure reliable relay operation, the following requirements must be fulfilled.

Definite time delay
The accuracy limit factor (ALF) should be twice the start value set on I› or I⏚ ›.

Inverse time delay
The accuracy limit factor should be 20 times the value set on I› or I⏚ ›. Alternatively, saturation should not occur at the current which corresponds to the lowest operate time with unchanged selectivity.

Instantaneous function
In cases when the instantaneous function is utilized, the accuracy limit factor should be at least 1.5–2.0 times the value set on I» or I⏚ ». The margin depends on the time constant of the network. As a rule, distribution networks have low time constants and therefore a margin of 1.5 times the set value should be sufficient.

In the case of overcurrent relays with an inverse time characteristic, it generally applies that saturated current transformers result in longer tripping times. When the current transformers are saturated, the display on RACID will therefore indicate a tripping current that is too low.

Accuracy limit factor (ALF) – Calculation example

Current transformers' data

Ratio	50–100/5/5 A		
Core 1	5 VA	a = 2.6	b = 0.05
Core 2	30 VA	a = 5.2	b = 0.07
Connected	100/5/5 A		
Relay I_n = 5 A	Burden 0.3 VA		

(The burden specified for RACID applies at a current $I = I_n$ or I_g.)

Data or secondary conductors from current transformers to relay.

Cross section = 2.5 mm². Length of copper = 25 m (single length).

Burden, relay $= \frac{0.3\ VA}{5^2\ A^2} = 0.012\ ohm$

Burden, secondary conductor =

$$\varrho \frac{L}{a} = 0.0175 \frac{25}{2.5} = 0.175\ ohm$$

Thus, $Z_{tot} = 0.012 + 0.175 = 0.187$ ohm

It should be noted that the main burden of the current transformer circuit is the resistance of the secondary conductors.

The formula for determining the accuracy limit factor n is:

$$n = \frac{a}{b + c} = \frac{5.2}{0.07 + 0.187} = 20$$

Correct measurements in the secondary circuit are therefore guaranteed up to 20 times 5 A.

In solidly earthed systems which are subject to fault currents of high magnitude, the total resistance of the current transformer circuit must be taken into consideration; thus, according to the example, L = 2 x 25 m, if it is required to have a phase relay operate even in the event of earth faults. The accuracy limit factor must then be adapted to the maximum earth fault current, the total resistance (2 x 25 m) and the maximum short–circuit current and a single length (1 x 25 m).

If an earth fault relay, residual current connected to the CT:s, is incorporated in the measuring circuit, as shown in Fig. 6, the earth fault relay must also be taken into consideration.

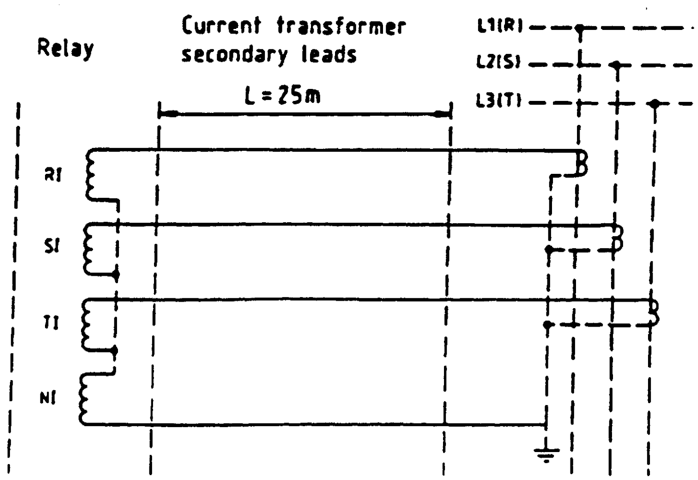

Fig. 6 Circuit with earth fault relay NI, residual current connected to the line CT:s.

Selectivity plan

Calculation example

The current and time settings of an overcurrent relay, that has a normal inverse characteristic, are to be calculated. The relay is located in a radial network as shown in Fig. 7. Determine the fault current referring to a voltage of 22 kV.

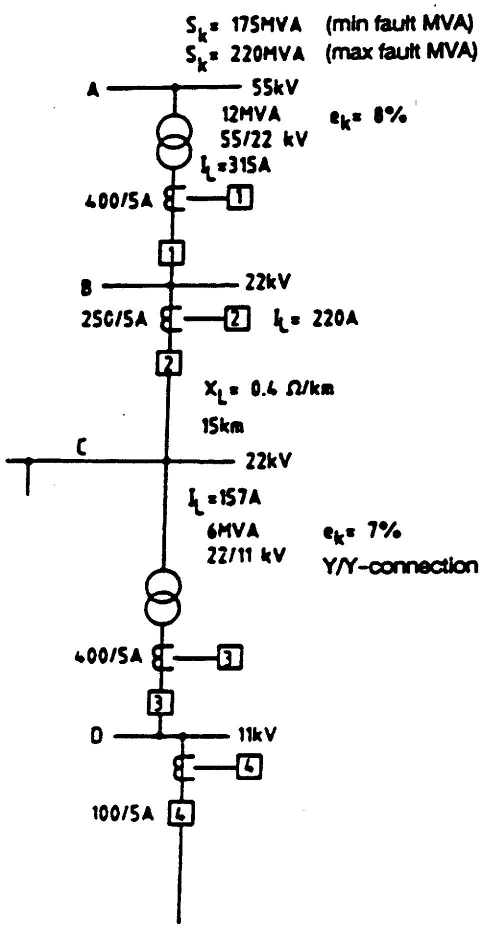

Fig. 7 Radial network

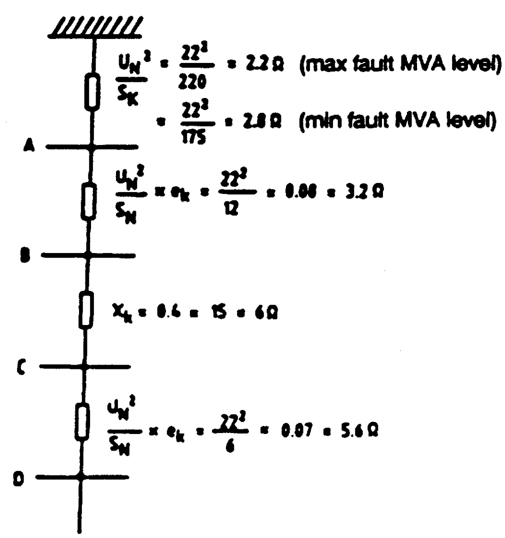

Fig. 8 Equivalent impedance network

Three-phase short-circuit current $I_k = \dfrac{22}{\sqrt{3} \cdot X_k}$

I_{kA} max $= \dfrac{22}{\sqrt{3} \cdot 2.2}$

I_{kA} min $= \dfrac{22}{\sqrt{3} \cdot 2.8}$

I_{kB} max $= \dfrac{22}{\sqrt{3}(2.5 + 3.2)}$

I_{kB} min $= \dfrac{22}{\sqrt{3}(2.8 + 3.2)}$

Max. values
I_{kA} = 5 770 A
I_{kB} = 2 350 A
I_{kC} = 1 110 A
I_{kD} = 750 A

Min. values
I_{kA} = 4 540 A
I_{kB} = 2 120 A
I_{kC} = 1 060 A
I_{kD} = 720 A

a) Relay 4

The present setting of relay 4 is retained.
The primary setting, referred to 22 kV, is given in the time curves in Fig. 9.

I› = (start function): 50 A
I» = (instantaneous function): 250 A
k = 0.10

Referred to the relay side:

$$I› = 50\,A \cdot \frac{22}{11} \cdot \frac{5}{100} = 5\,A$$

$$I» = 250\,A \cdot \frac{22}{11} \cdot \frac{5}{100} = 25\,A$$

Relay setting

I_n = 5 A

$$I› = 1.0 \cdot I_n \; (\frac{5}{5} = 1.0)$$

$$I» = 5.0 \cdot I_n \; (\frac{25}{5} = 5.0)$$

b) Relay 3

The rated current I_L of the power transformer is 315 A at 11 kV.
A normal setting for the start function is I› = 1,6 x I_L = 500 A.

Relay setting:

$$I› = 500 \cdot \frac{5}{400} = 6.25\,A$$

I_n = 5 A

$$I› = 1.25 \cdot I_n \; (\frac{6.25}{5} = 1.25)$$

Referred to 22 kV, the starting current will be:

$$I› = 500 \cdot \frac{11}{22} = 250\,A$$

The instantaneous function must be blocked in order to achieve selectivity for faults on outgoing lines from D. For the timing function k = 0.05 is chosen from the time curve in Fig. 9.

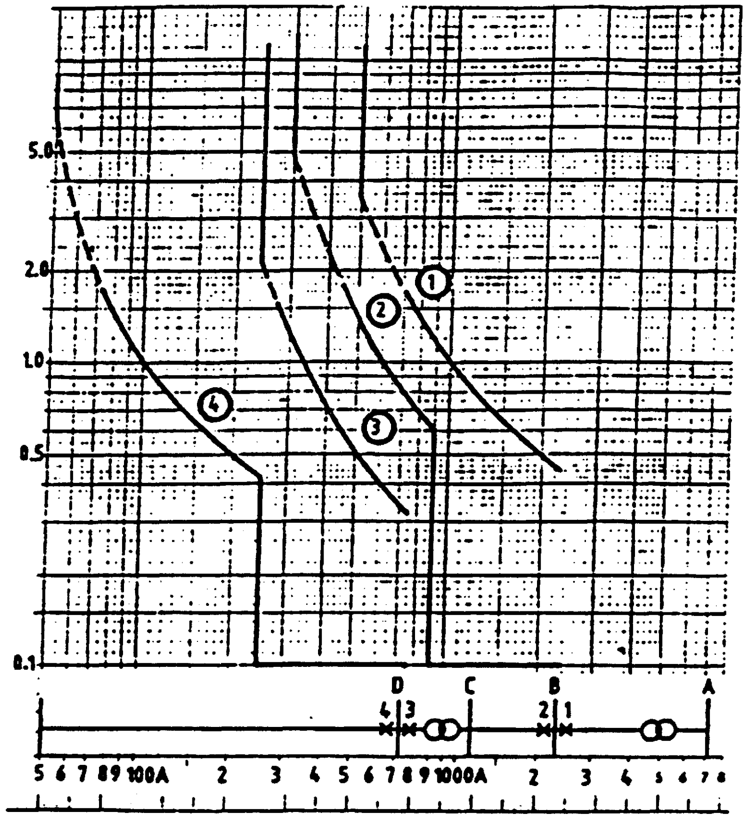

Fig. 9 Operate–time curves

c) Relay 2

This relay constitutes a backup protection for faults occurring on busbar D. Determine the smallest 2-phase fault current on busbar D.

$$I_{kmin} = 720 \cdot \frac{\sqrt{3}}{2} = 620\ A$$

Preliminary setting of start current.

$I> = 0.7 \times I_{kmin} = 0.7 \times 620 = 430$ A

Select start current setting I> = 300 A in order to obtain a good margin to the transmission current $I_L = 220$ A. The instantaneous function must be selective with respect to relay 3.

Select $I_{inst} = 1.2 \times 750 = 900$ A. Select k = 0.10 from the time curve in Fig. 9.

Set the operate values:

$$I> = 300 \cdot \frac{5}{250} = 6\ A$$

$$I\gg = 900 \cdot \frac{5}{250} = 18\ A$$

$I_n = 5$ A
I> = 1.2 x 5 A
I» = 3.6 x 5 A

d) Relay

The primary setting of the start current is:

I> = 315 x 1.6 = 500 A

The relay constitutes a backup protection for faults which occur up to breaker 3. In the case of faults in the near vicinity of the breaker, the safety factor in respect of a 2–phase fault will be:

$$\frac{720 \cdot \frac{\sqrt{3}}{2}}{500} = 1.25$$

Select k = 0.10 from the time curve in Fig. 9.

The instantaneous function cannot be used.

DESIGN

General

The RACID consists of 3 p.c. boards, a supply unit, input circuits, processor board and a transformer unit. They are mounted in an aluminium case that has an internal system of screens in order to achieve high immunity against interference.

The supply unit is a primary switched dc convertor. This is provided with interference suppressor as well as a rectifier and smoothing capacitor on the input in order to be supplied with ac as well. The primary and secondary circuits are galvanically isolated from each other by means of a transformer. On the secondary side, the supply unit has three voltage levels, +5, ±15 and +24 V for supplying the microprocessor, input circuits and output relays. The levels of the three secondary voltages are monitored continuously and, in the event of a fault, an alarm is issued via the monitoring relay of RACID. The supply can be either ac or dc from 48 to 220 V ±20% and is independent of polarity.

In case RACID should be supplied from 19–36 V dc an additional dc/dc convertor RXTUG 21H ordering number RK 732 105–AB and a 5 W 10 ohm resistor should be used. The resistor should be connected in between the dc/dc convertor and RACID.

Via the input transformers of the phase currents and the neutral, incoming currents are converted to a voltage. The voltage is processed in a bandpass filter, is rectified in an idealistic rectifier and then treated in a low–pass filter and the neutral are of identical design and are entirely independent of each other.

The microprocessor is located on a p.c. board together with display, setting potentiometers, selector switches, pushbuttons and indicating light–emitting diodes. The p.c. board constitutes the front of the relay. Via multiplexors, the processor senses cyclically selected time characteristics and output signals from the input board. In addition to the protective functions, the processor controls all logic interlocks and indicators and, on the display, indicates set values, operate values and fault currents in the event of a trip.

The entire process in monitored continuously by the built-in monitoring circuits of the relay. The K5 signal relay is incorporated in the monitoring circuits. (Refer to the diagrams on pages 17 and 18.)

In cases when the RACID is provided with extra output relays, the outputs can be programmed with the S1 selector switch. This is located on the same p.c. board as the input circuits. The switch is accessible after removing the plastics cover at the rear. Reconnections are made, for example, with a pen as shown in the illustration.

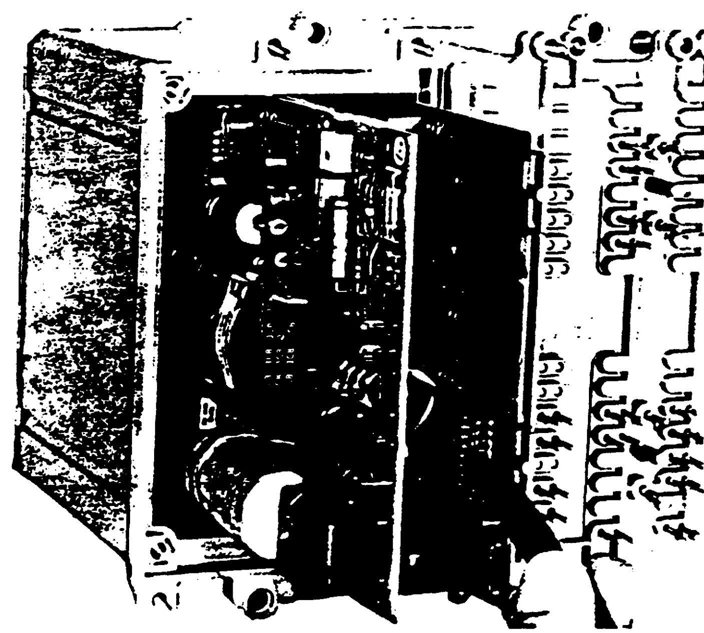

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Fig. 10 S1 selector switch for programming the trip relay and extra signal relays

Versions

Table 2 shows the Cat. Nos., circuit diagrams and terminal diagrams of all the different versions.

The properties determining the choice of version are:

- is the relay to be of 2-phase (2I>) or 3-phase (3I>) type
- is it to incorporate a earth fault relay (I⏚)
- is the relay to incorporate a test switch
- is it to be mounted on apparatus bars and thus intended for COMBIFLEX connections or,
- is it to have screw terminals and this intended for fully recessed or semi-recessed installation in a panel

Note!
Versions with 2 measuring ranges are provided with 3 extra output relays K1, K2 and K3 and the selector switch S1 for programming. See the diagrams (Fig. 11, Fig.12 and Fig. 13).

Table 2

RACID			3I > + I↓ Cat. No. Circuit diagram Terminal diagram	3I > Cat. No. Circuit diagram Terminal diagram	2I > + I↓ Cat. No. Circuit diagram Terminal diagram
COMBI-FLEX connection	With test switch on 30C apparatus bar	2 measuring ranges	RK 671 203-AA 7431 154-AB 7431 154-ABA	RK 671 213-AA 7431 154-CB 7431 154-CBA	RK 671 223-AA 7431 154-EB 7431 154-EBA
	Without test switch on 24C apparatus bars	2 measuring ranges	RK 671 103-AA 7431 144-AA -	RK 671 113-AA 7431 144-CA -	RK 671 123-AA 7431 144-EA -
	Without test switch and apparatus bars	2 measuring ranges	RK 671 003-AA 7431 144-AA -	RK 671 013-AA 7431 144-CA -	RK 671 023-AA 7431 144-EA -
Screw terminals	Without test switch	2 measuring ranges	RK 671 303-AA 7431 155-AA -	RK 671 313-AA 7431 155-CA -	RK 671 323-AA 7431 155-EA -

Wiring diagram

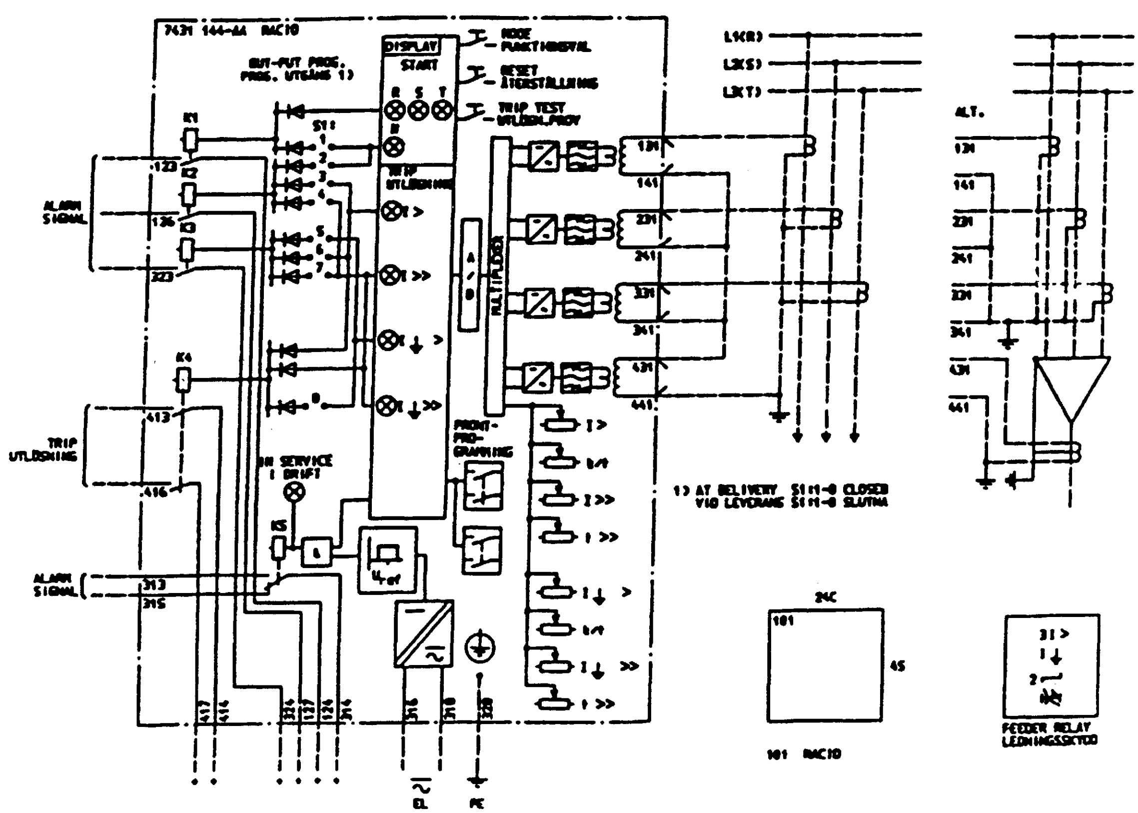


Fig. 11 RACID with three-phase time-overcurrent and earth fault relay both with two ranges of measurement. COMBIFLEX connections is made via a separately mounted RX4 terminal base

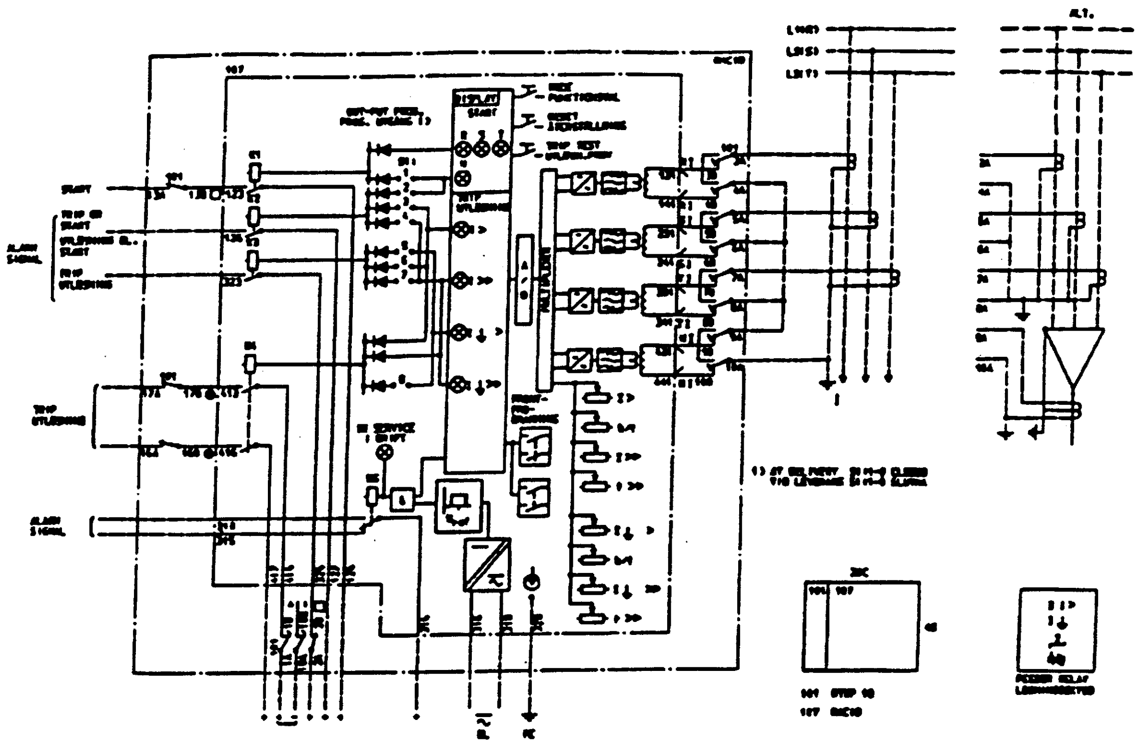


Fig. 12 RACID identical to that in Fig. 11 but fitted with an RTXP 18 test switch. Mounted on 30C apparatus bars, RACID via an RX 4 terminal base

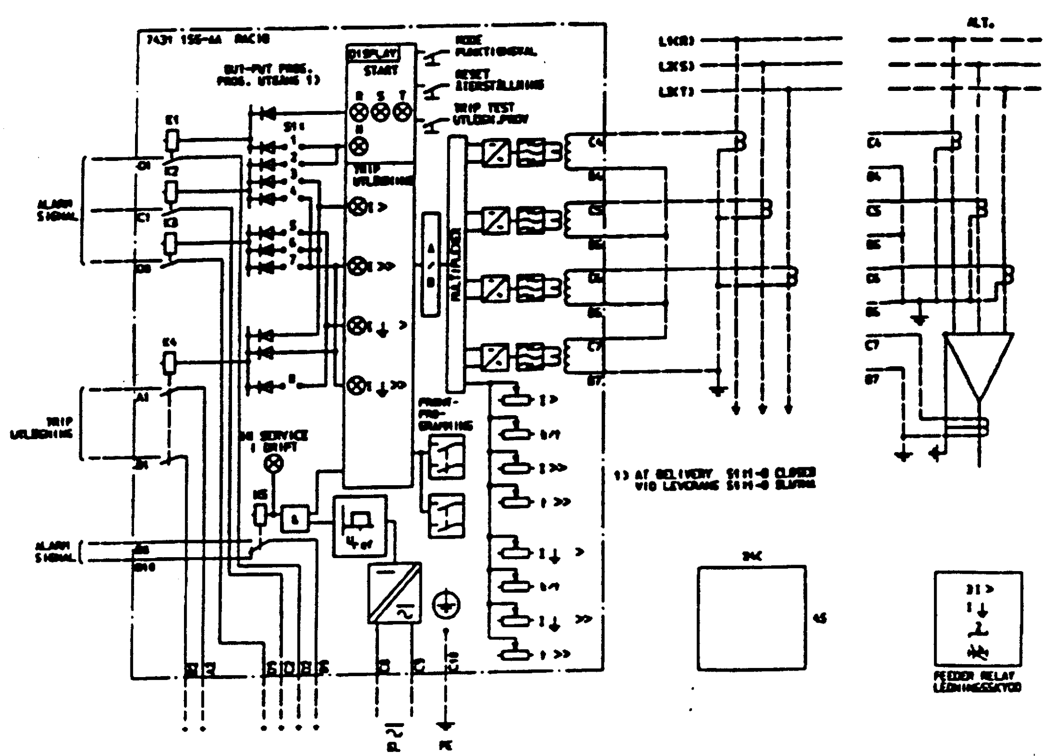
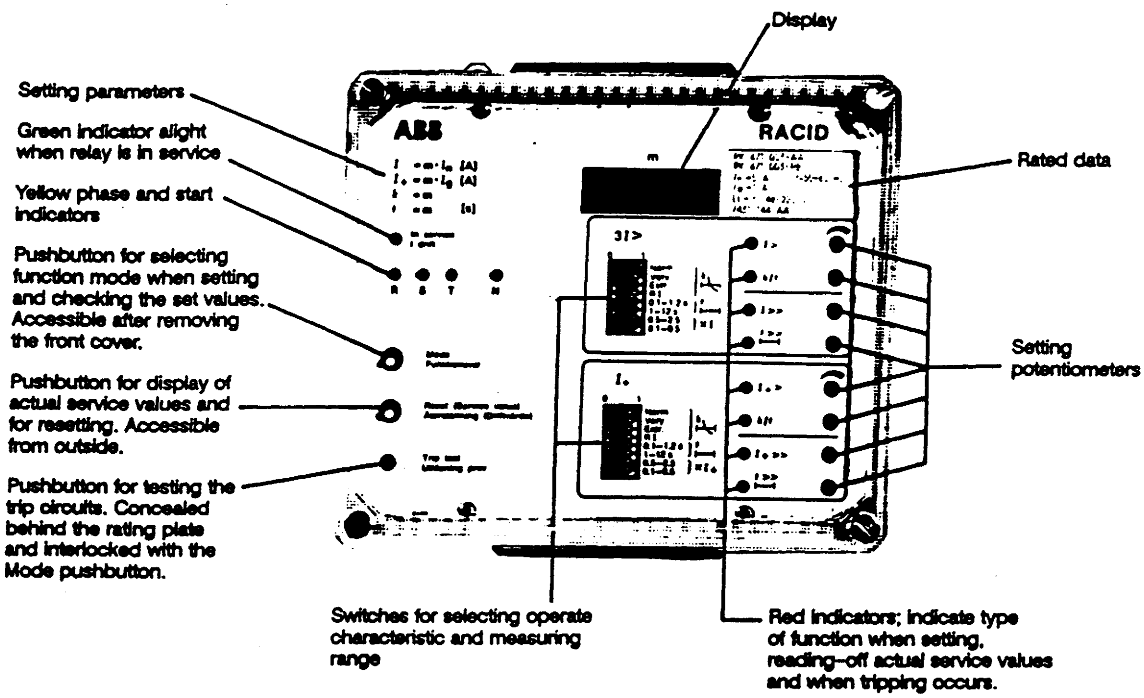


Fig. 13 RACID identical to that in Fig. 11 but fitted with a fixed-mounted terminal block, on the rear for screw connection

Setting

The front view below show the setting devices, indicators, pushbuttons etc. on RACID.



(SE 900 661)

Fig. 14 Setting devices, indicators, pushbuttons etc. on RACID

The time characteristic of the time-overcurrent relay and the earth fault relay are chosen by means of the selector switches. Fig. 15 illustrates the selector switches for relays that have two ranges of measurement.

In versions that have one range of measurement, the selector switches under the broken line, i.e., switches 7 and 8, are covered by the name plate. On delivery from the factory, the selector switch 7 of the overcurrent relay is in position 1 and that of the earth fault relay in position 0. If these positions are changed the display will indicate erroneous values.

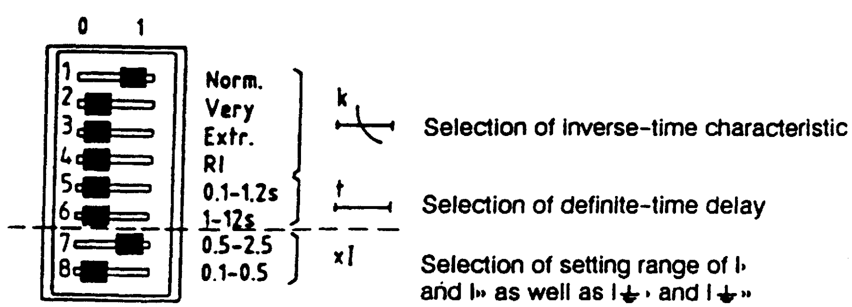


Fig. 15 Switches for selecting time-delay characteristic and measuring range

If no time–delay characteristic is selected, the display will indicate flashing zeros and the relay will trip when the current exceeds the set operate value. If two characteristics are selected simultaneously, flashing zeros will also be indicated and the relay will operate in accordance with the upper of the selected time–delay characteristics.

The version with **one range of measurement** provides the setting ranges for:

The time–overcurrent relay:

Start and delayed function	Instantaneous function
(0.5–2.5) x I_n	(2–30) x I_n

Earth fault relay:

Start and delayed function	Instantaneous function
(0.1–0.5) x I_g	(0.5–8) x I_g

In the case of versions with **two ranges of measurement**, the desired setting range is chosen with the aid of the selector switches.

If the **(0.5–2.5) x I** selector switch or the **(0.5–2.5) x I⏚** selector switch is set to position 1, the range is obtained for:

Start and delayed function	Instantaneous function
(0.5–2.5) x I_n x I_g respectively	(2–30) x I_n x I_g respectively

If the **(0.1–0.5) x I** selector switch or the **(0.1–0.5) x I⏚** selector switch is set to position 1, the range is obtained for:

Start and delayed function	Instantaneous function
(0.1–0.5) x I_n and x I_g respectively	(0.5–8) x I_n and x I_g respectively

The operate current and delay are set with the potentiometers. Refer to Fig. 16.

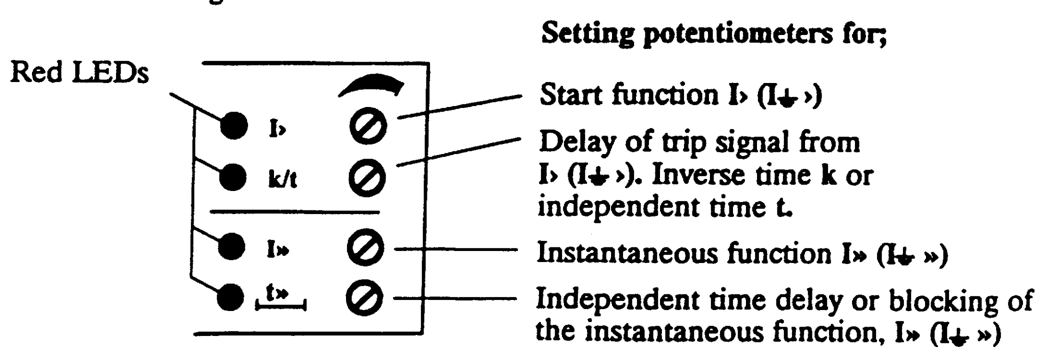
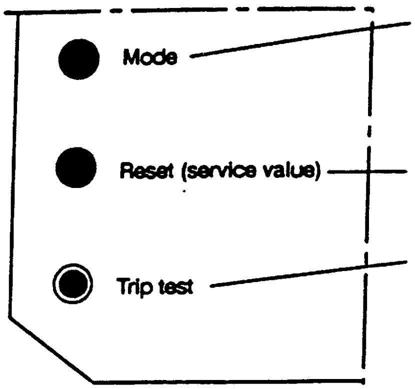


Fig. 16 Potentiometers for making settings

The instantaneous function is made inactive by turning the t» potentiometer up to its maximum position. The display should then indicate 999 for both I» and t».

If operate values are set outside of the applicable setting range, the display indicates this by flashing.

The pushbuttons on the left of the front have the following functions:



Selection of mode when setting operate value. The display shows the set value of the indicated function.

Resetting and indication of fault and service currents.

Activation of all output relays when testing. (Function interlocked by the **Mode pushbutton.**)

Fig. 17 Pushbuttons

The set operate values are indicated on the display by repeatedly depressing the **Mode pushbutton.** When, for example, the light–emitting diode for I> is alight, the display indicates the factor **m**. The set operate value for I> is then **m x I_n** A. The values set for other functions are indicated by repeatedly depressing the pushbutton. Refer to table 3.

Trip–relay and signal–relay outputs

The version with one range of measurement has one trip relay, K4, that has twin contacts, and one signal relay, K5, for signalling in the event of faults in the electronic circuits or in the event of an auxiliary supply failure. The version with two ranges of measurement has three additional signal relays, K1, K2 and K3. In the latter version, the output relays can be programmed with the aid of the S1 selector switch, as shown in Fig. 18. Each contact, 1 to 8, on the switch can be closed by means of jumper links. The contact data are given in the section entitled TECHNICAL DATA. On delivery, the contacts on the switch are closed.

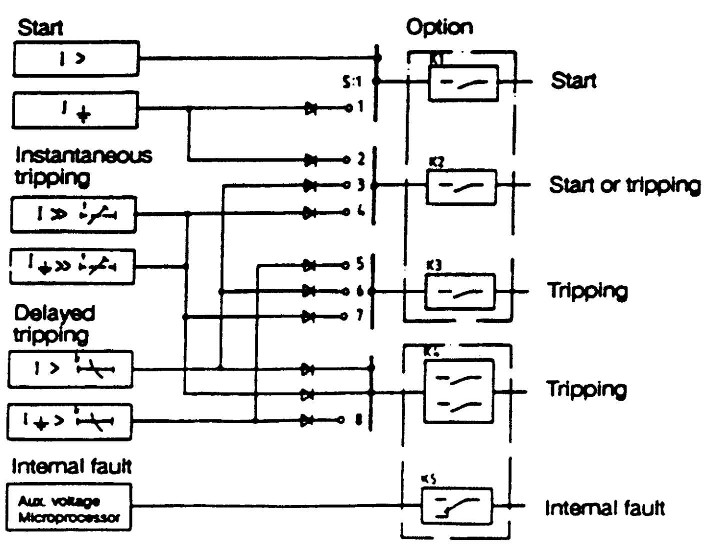


Fig. 18 Programming the output relays with the S1 selector switch

The output relays are easily checked by depressing the recessed **Trip test** pushbutton, located on the front of the relay, until the Fig. **888** is shown on the display. Thereafter, simultaneously depress the **Mode** pushbutton whereupon the output relays pick-up directly. The relays remain in the picked-up position as long as the pushbuttons are kept depressed.

Indication and presentation of actual service values and values during a fault

During normal service, the green LED marked **In service** is alight. If the internal monitoring system of the relay detects a fault or if the power supply is interrupted, the monitoring relay drops out and the LED goes out.

Service values
By repeatedly depressing the **Service value** pushbutton, a presentation is given of the actual currents in the R, S and T phases and in the neutral at the same time as the applicable yellow LEDs, **R, S, T** and **N**, light up.

The current is presented on the display as a factor **m** of the relay's rated current I_n, in the case of phase currents, and I_g in the case of neutral current.

Example: **m** = 0.42 and I_n = 5 A gives an actual current = 0.42 x 5 = 2.1 A.

If the service value sequence is not continued up to when the display and LEDs are extinguished, these will extinguish automatically after approximately 8 minutes.

Resetting the indicators when starting and after a trip
When the current exceeds the set operate value, the relay starts and the yellow LEDs, **R, S, T** and **N**, light up for the phase or phases influenced by the fault. The diodes thus function as start indicators.

If the fault results in tripping, one of the red LEDs will start flashing (trip indicator) and indicate the type of fault (tripping function). If only the start is indicated, the indicator(s) are extinguished by depressing the **Reset** pushbutton.

If a trip is indicated (flashing red LED), it will show a fixed light when the **Reset** pushbutton is depressed for the first time. At the same time, the yellow LED **R** will light up and indicate that the fault current in the R-phase is shown as factor m on the display. When the **Reset** pushbutton is depressed a second time, the LED S lights up and the current in the S-phase is displayed, and so on until the button is depressed a fifth time whereupon the LEDs and the display are extinguished.

If more than one function issues a trip impulse simultaneously, the trip indications are given an order of priority as shown here below:

1. I» Instantaneous trip due to overcurrent
2. I⏚ » Instantaneous trip due to earth fault
3. I› Delayed trip caused by overcurrent
4. I⏚ › Delayed trip caused by earth fault

TECHNICAL DATA

Definitions

I_n = rated current of time–overcurrent relay
I_g = rated current of earth fault relay
I = actual current
I_s = set operate value, overcurrent or earth current

Time–overcurrent relay

Rated current I_n 1 A or 5 A, 50–60 H

Setting range for:	Start and delayed function	Instantaneous function
1 meas.range	0.5–2.5 x I_n	2–30 x I_n
2 meas.ranges		
0.1–0.5 x I [1]	0.1–0.5 x I_n	0.5–8 x I_n
0.5–2.5 x I [1]	0.5–2.5 x I_n	2–30 x I_n

[1] The measuring range is selected from the front of the relay

Earth fault relay

Rated current I_g 0.03 A, 0.20 A, 1.0 A or 5.0 A,50–60 Hz

Setting range for:	Start and delayed function	Instantaneous function
1 meas.range	0.1–0.5 x I_g	0.5–8 x I_g
2 meas.ranges		
0.1–0.5 x $I_{\downarrow}$ [2]	0.1–0.5 x I_g	0.5–8 x I_g
0.5–2.5 x $I_{\downarrow}$ [2]	0.5–2.5 x I_g	2–30 x I_g

[2] The measuring range is selected from the front of the relay

Common data

Inaccuracy ±5% or ±1 digit of set operate value shown on display

Consistency of operate value during repeated measurement ±1%

Resetting ratio
f=50–60 Hz >95%

Operate time	Start function Typical times	Instantaneous function Typical times
I = 1.3 x I_s	40 ms	45 ms
I = 3 x I_s	35 ms	40 ms
I = 10 x I_s	30 ms	35 ms

Resetting time

When I drops instantaneously to 0		
I = 2 x I_s	40 ms	50 ms
I = 10 x I_s	50 ms	55 ms
I = 20 x I_s	55 ms	60 ms

When I drops instantaneously to 0.9 I_s		
I = 2 x I_s	65 ms	65 ms
I = 10 x I_s	70 ms	70 ms
I = 20 x I_s	75 ms	75 ms

Transient overreach
I< 20 x I_n (I_g)   < 5%
Applies at source time constant L/R < 50 ms

Dc component's influence on operate value:
If, in the case of a fully developed dc component, the relay operates for a stationary current that is factor K, (< 1), times the set operate current (without dc component), the transient overreach of the relay expressed as a percentage, is

$$\frac{1-K}{K}\cdot 100$$

Power consumption of current circuit at rated current I_n and I_g.

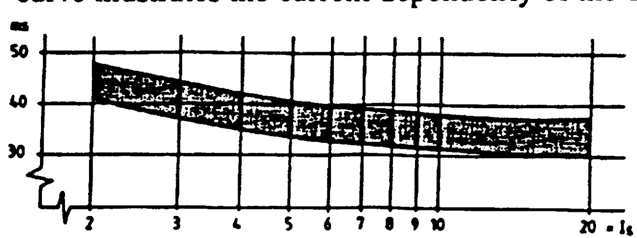
	Lowest measuring range	Highest measuring range
Time-overcurrent relay	(0.1–0.5) x I_n	(0.5–2.5) x I_n
I_n = 5 A	< 0.30 VA	< 0.30 VA
I_n = 1 A	< 0.03 VA	< 0.03 VA
Earth fault relay	(0.1–0.5) x I_g	(0.5–2.5) x I_g
I_g = 5 A	< 0.30 VA	< 0.30 VA
I_g = 1 A	< 0.03 VA	< 0.03 VA
I_g = 0.2 A	< 25 mVA	< 20 mVA
I_g = 0.03 A	< 20 mVA	< 15 mVA

Overload capacity of the current circuit

Time-overcurrent	Continuous	1 second
I_n = 5 A	3 x I_n	100 x I_n
I_n = 1 A	3 x I_n	100 x I_n
Earth fault relay		
I_g = 5 A	3 x I_g	100 x I_g
I_g = 1 A	3 x I_g	100 x I_g
I_g = 0.2 A	10 x I_g	100 x I_g
I_g = 0.03 A	15 x I_g	100 x I_g

Operating characteristic

Instantaneous function
At a time setting t» = 000, the basic relay time is obtained. The curve illustrates the current dependency of the basic time.



The instantaneous function can be purposely delayed 0.1 to 1.2 seconds in increments of 0.01 s at an inaccuracy of <20 ms. This applies at a current corresponding to twice the set operate value. When t» is set to its maximum, the instantaneous function is blocked. The display then shows 999.

Delayed function
Definite time setting

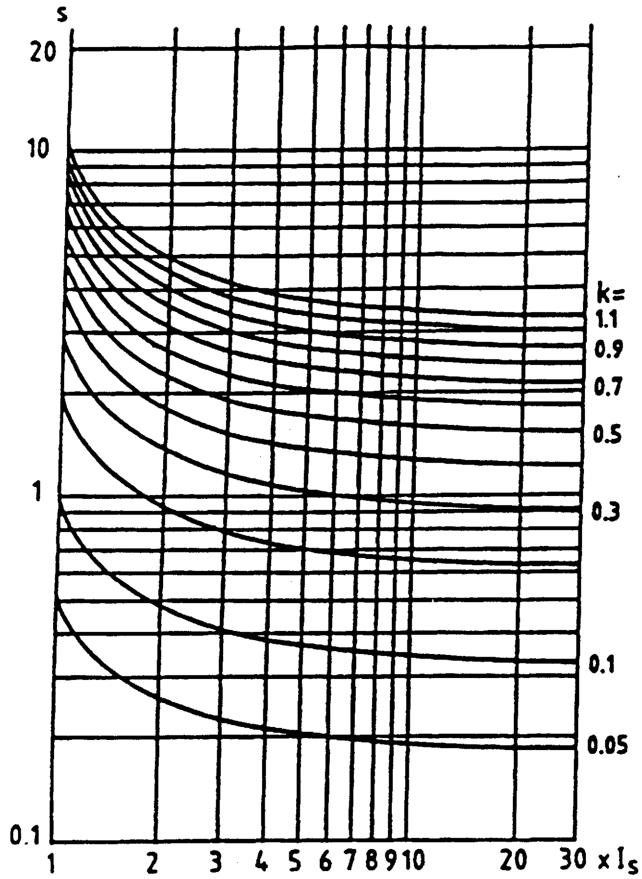
0.1–1.2 s in increments of 0.01 s	Inaccuracy < 20 ms
1.0–12 s in increments of 0.1 s	Inaccuracy < 50 ms
	Apply at a current corresponding to twice the set operate value
Resetting time, $I < 20 \times I_s$	60 ms (typical time)
Recovery time, $I < 20 \times I_s$	< 45 ms
Impulse margin time, $I < 20 \times I_s$	< 65 ms

Inverse time function

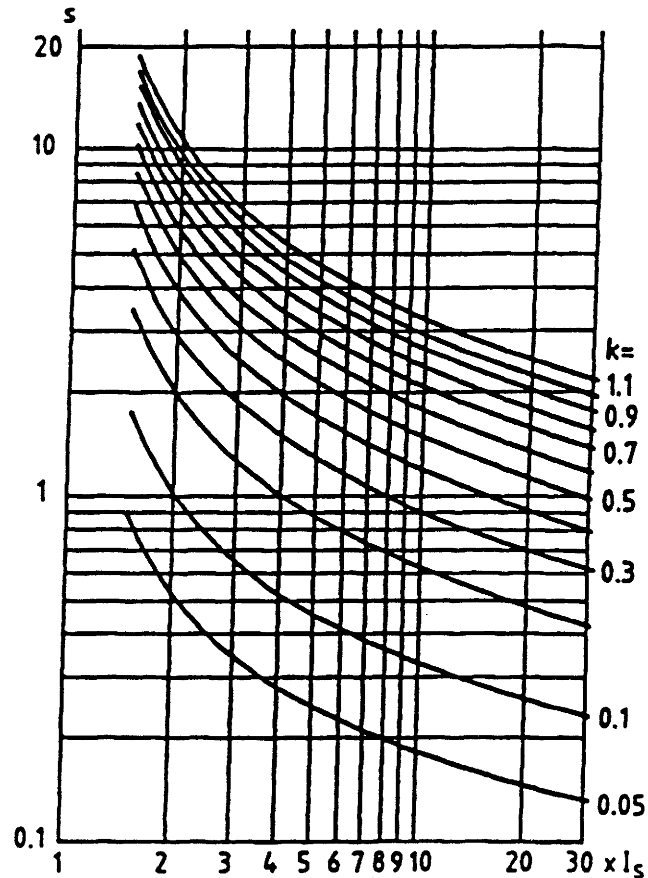
	Normal inverse	**Very inverse**	**Extremely inverse**	**RI–curve**
Accuracy class as per IEC 255 k-factor = 1.0	5	5	5	Not IEC standard
Resetting time (typical) $I < 20 \times I_s$	60 ms	60 ms	60 ms	60 ms
Recovery time $I = 20 \times I_s$	< 45 ms	< 45 ms	< 45 ms	< 45 ms
Impulse margin time $I = 20 \times I_s$	< 55 ms	< 45 ms	< 45 ms	< 60 ms
Setting range	K-factor 0.05 to 1.1 in increments of 0.01			

The inverse–time curves are shown on the next pages.

Inverse time curves



RI–curves



Normal inverse

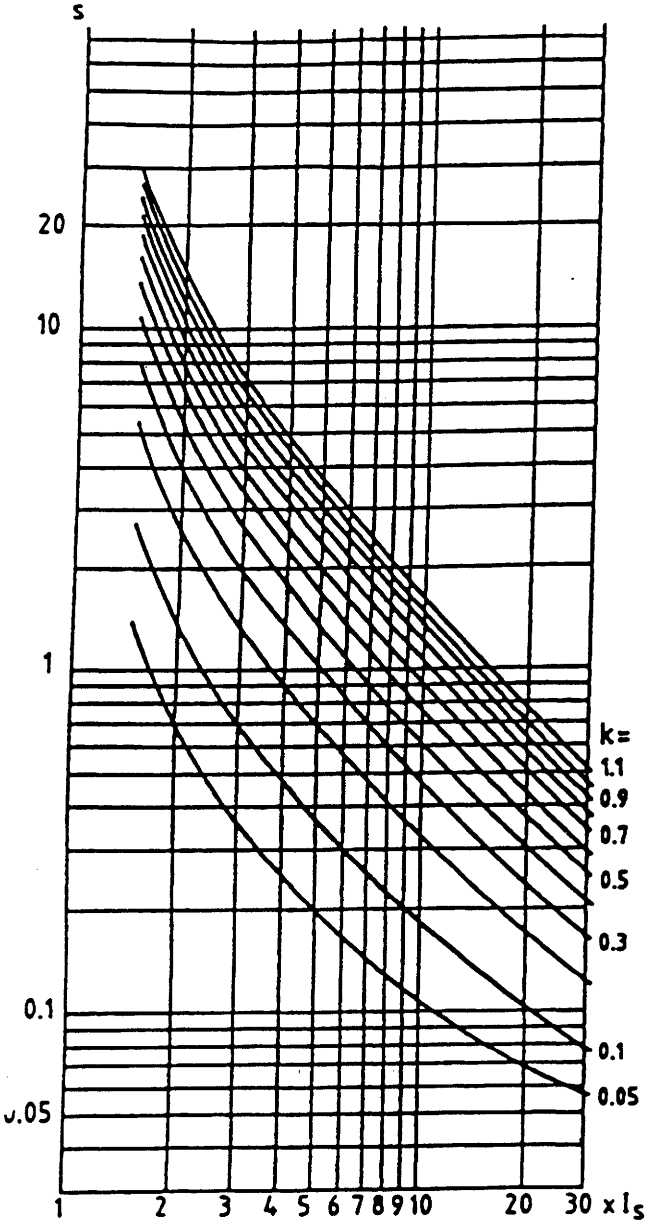
The following formulas for determining the operate time in seconds apply to the curves shown above:

Characteristic	Operate time
RI–curves	$t = \frac{1}{0.339 - \frac{0.236}{I}} \cdot k$
Normal inverse	$t = \frac{0.14}{I^{0.02} - 1} \cdot k$

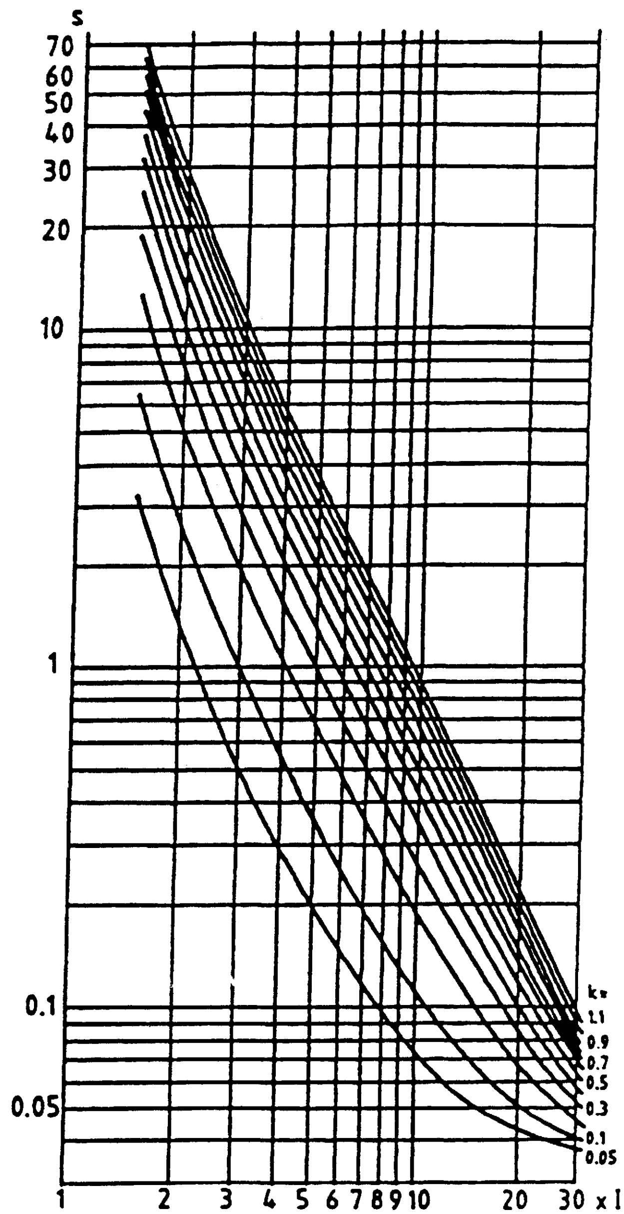
where
k = scale constant according to the curves
I = multiple of set current I_s

tolerance in % = 5 cosh (arctan (dt/dI))

Note that the output relay extends the operate time, determined by means of the above formulas, by 30 (I–k) ms.



Very inverse



Extremely inverse

The following formulas for determining the operate time in seconds apply to the curves shown above:

Characteristic	Operate time
Very inverse	$t = \frac{13.5}{I-1} \cdot k$
Extremely inverse	$t = \frac{80}{I^2-1} \cdot k$

where
k = scale constant according to the curves
I = multiple of set current I_s
tolerance in % = 5 cosh (arctan (dt/dI))
Note that the output relay extends the operate time, determined by means of the above formulas, by 30 (I–k) ms.

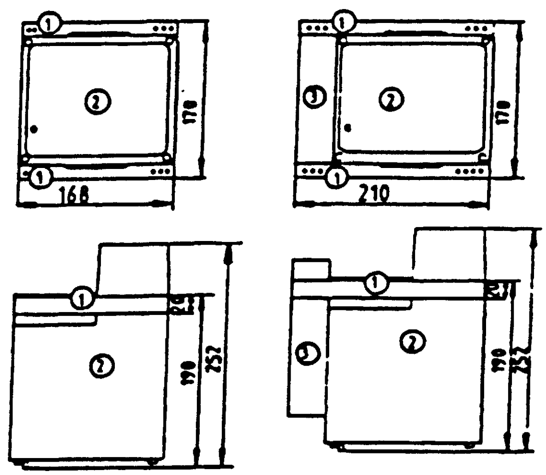
Auxiliary supply		48–220 V ±20% dc or ac and 50–60 Hz	
Power consumption of auxiliary circuit:			
Before operation		< 10 W	
After operation		< 13 W	
Contact data		Signal relay	Trip relay
System voltage dc/ac		250/250 V	250/250 V
Insulation voltage across open contact		1 kV	1.5 kV
Current carrying capacity:			
Continuous		5 A	5 A
Ability to make and conduct L/R > 10 ms:			
200 ms		30 A	50 A
1 s		10 A	25 A
Breaking capacity			
ac P.F. > 0.4	250 V	8 A	12 A
dc L/R < 40 ms	48 V	1 A	5 A
"	110 V	0.4 A	0.25 A
"	220 V	0.2 A	0.15 A
Insulation tests			
Dielectric test			
current circuits	IEC Publ. 255–5	2.5 kV, 50 Hz, 1 min	
remaining circuits		2.0 kV, 50 Hz, 1 min	
Impulse voltage test	IEC Publ. 255–5	5 kV, 1.2/50 µs, 0,5 J	
Disturbance test			
Power frequency test	IEC Publ. 255–6	50 Hz, 0.5 kV, 2 min	
Fast transient test	(SS436 1503)	4–8 kV, 2 min	
1 MHz burst test	IEC Publ. 255–6	2.5 kV, 2 s	
Ambient temperature range		-5°C to +55°C	
Storage temperature		-40°C to +70°C	
Dimensions			
COMBIFLEX version			
Relay without test switch		(4S 24C) H = 170, B = 168, D = 252 mm	
Relay with test switch		(4S 30C) H = 170, B = 210, D = 252 mm	
Screw terminals		(4S 24C) H = 170, B = 168, D = 292 mm	
Weight (separate relay)			
COMBIFLEX version		3.75 kg	
With screw terminals		4.6 kg	

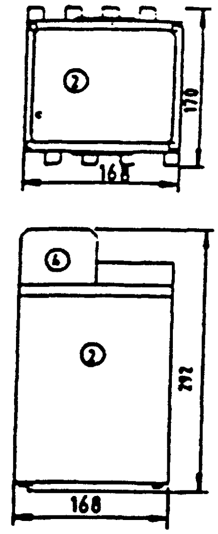
INSTALLATION AND CONNECTION

Dimension drawings

COMBIFLEX version | **Screw terminals**

Without test switch | With test switch

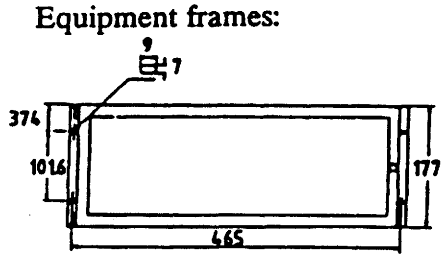




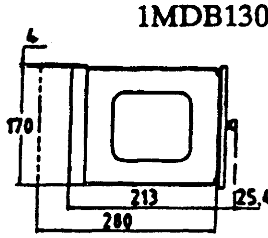
1 Apparatus bar
2 Relay
3 Test switch
4 Screw terminals

19" equipment frames

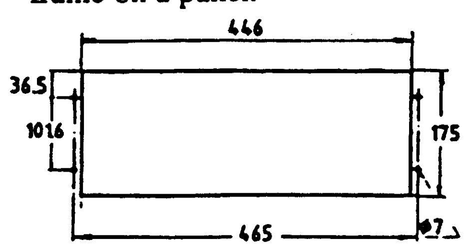
Equipment frames:



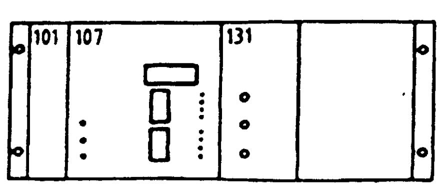
Refer to Catalogue 1MDB13003-EN



Configuration of holes for mounting one equipment frame on a panel:



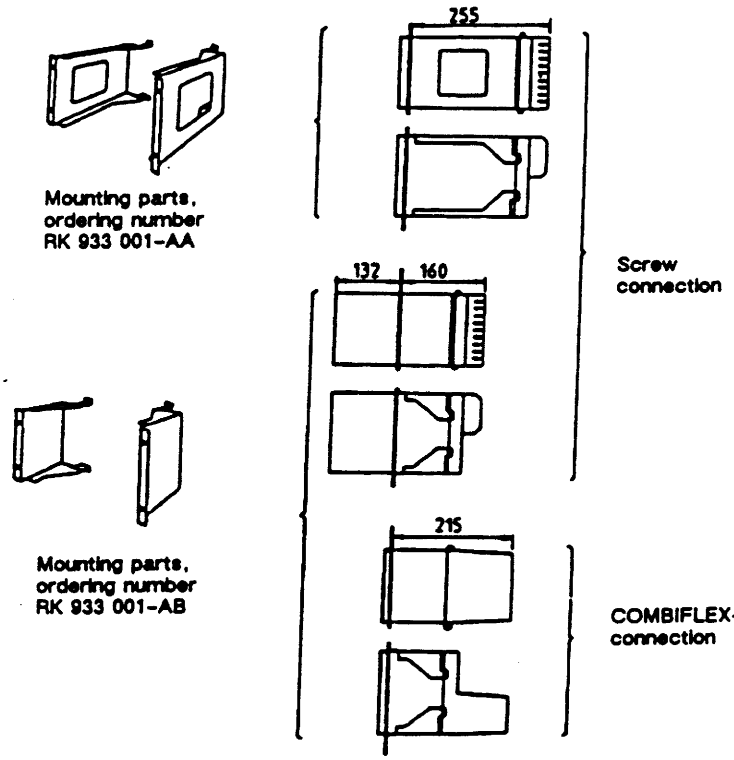
Example of item designations when mounted in a equipment frame:



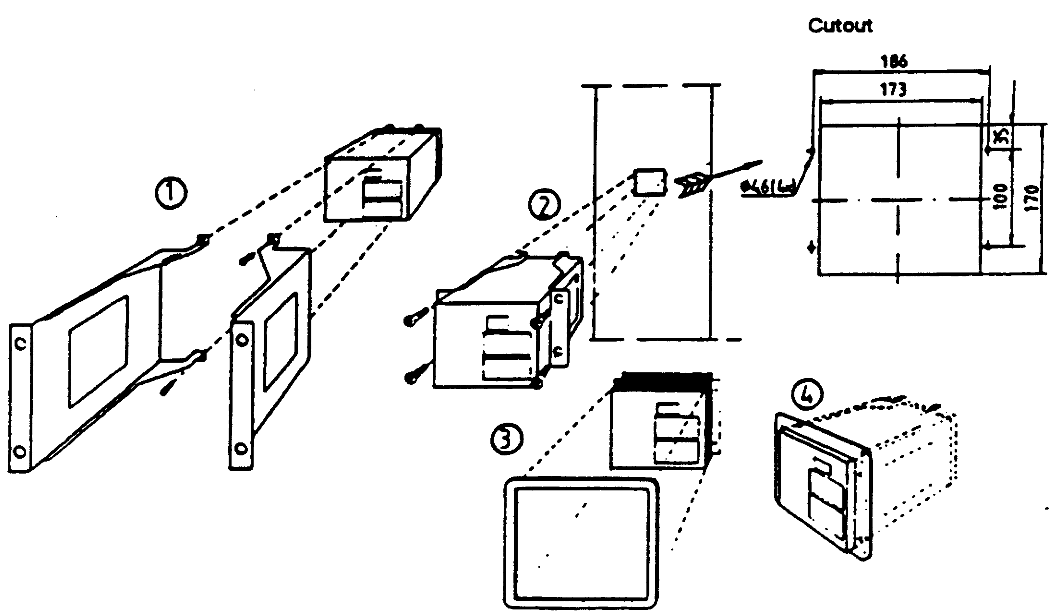
Position	
101	RTXP 18
107	RACID
131	XXXX

On panel

RACID can be mounted on a panel, flush or semiflush, as shown below.

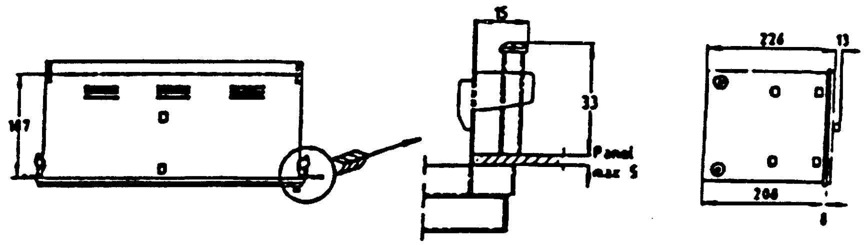


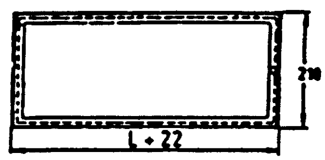
Configuration of holes and installation instructions



The set of mounting parts for flush mounting contains attachment plates 1, requisite screws and rubber frame 3.

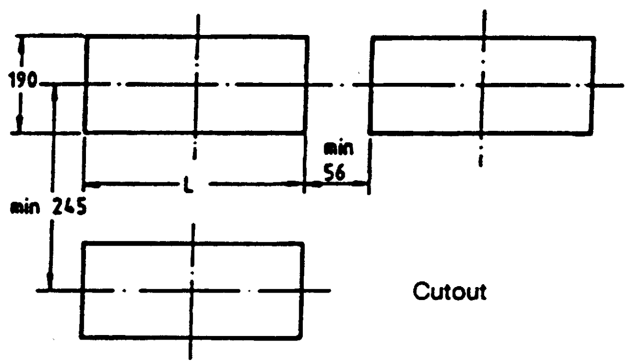
RACID with COMBIFLEX connection can also be installed in a RHGX-type case fully or semi-flush mounted in the panel. The following dimension drawings and configuration of holes are applicable. Reference is made to Catalogue 1MDB13003-EN.





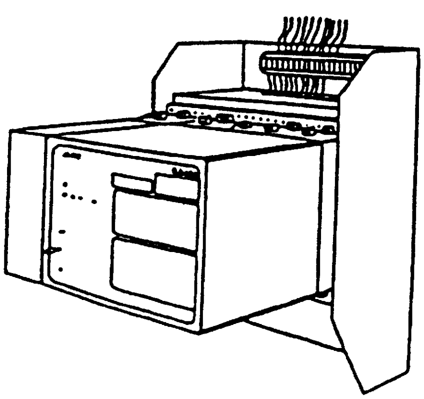
RHGX	L	Modules
8	196	24C
12	280	36C
20	448	60C

Hole configuration in the panel. Dimension L is given in the table above.

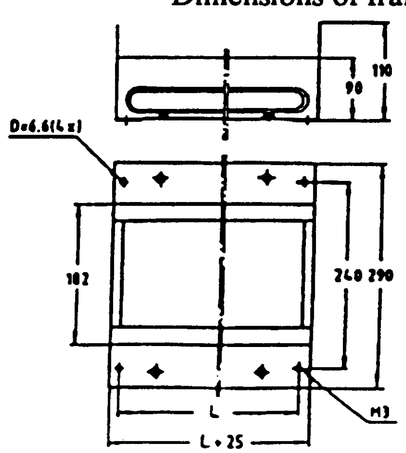


Front connections

For surface mounting and when front connections are required, a frame with a screw terminal block is required, Refer to Catalogue 1MDB13003-EN.

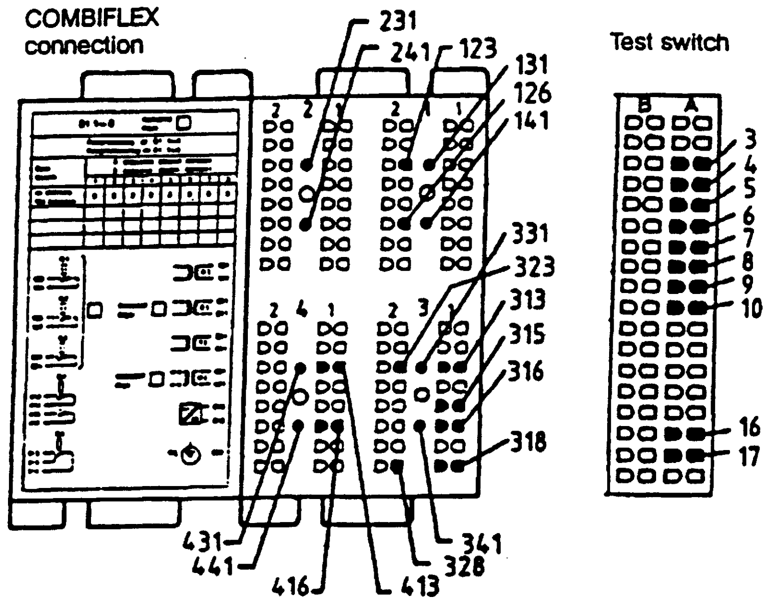


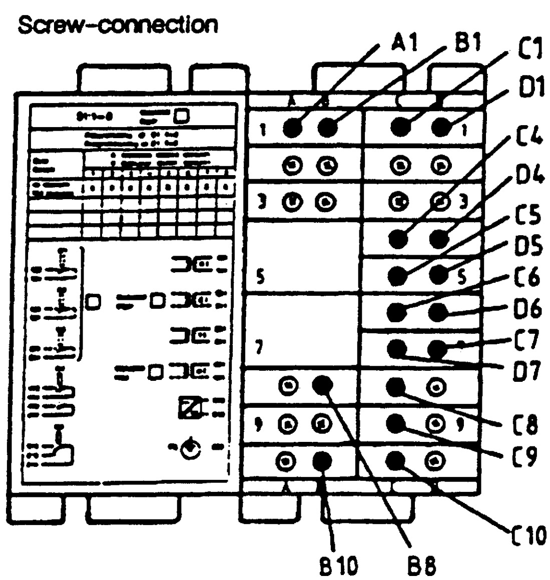
Dimensions of frame



L	Modules
400	60C
190	30C

Terminal designations The figure shows the RACID and test switch viewed from behind.





	Function	COMBIFLEX connection	Test switch	Screw-connection
Inputs	RI SI TI NI ⎓48 220V ±20	131, 141 231, 241 331, 341 431, 441 316, 318	3, 4 5, 6 7, 8 9, 10 -	C4, D4 C5, D5 C6, D6 C7, D7 C8, C9
Outputs	Tripping Supervision Signal Protected earth	413, 416 313, 315 123, 126, 323 328	16, 17 - - -	A1, B1 B8, B10 D1, C1, D8 C10

TESTING

Checking the set values

By repeatedly depressing the Mode pushbutton, check that the set values are correct. The table below shows how the display indicates the set values at the different modes.

Table 3

Function	Red LED alight	Display shows
Start current in the case of definite–time tripping	I› or I⏚›	Factor m i.e. $\frac{I_s}{I_n}$ and $\frac{I_s}{I_g}$ 1)
Inverse–time tripping	k/t	k–factor as per selected inverse time characteristic
Delay in the case of definite–time tripping		Seconds
Operate current in the case of instantaneous tripping	I» or I⏚ »	Factor m i.e. $\frac{I_s}{I_n}$ and $\frac{I_s}{I_g}$ 1)
Instantaneous tripping (Basic time)	t»	000
Instantaneous tripping Delayed		Seconds
Instantaneous tripping		999

1) I_s = set operate value

Secondary injection test

Appropriate test equipment

These instructions presume that the relay is provided with ABB's RTXP 18 test switch. For relays without test switch or with other types of test switch, other connection points than those shown in Fig. 19 must be used for the test equipment.

Suitable test equipment

- SVERKER test set with built–in timer
- Class 1 ammeter which measures the rectified mean value [x)]
- RTXH 18 test–plug handle including test leads
- Screwdriver

x) If an RMS–metering instrument is used, a certain difference in the operate values of the relay may be observed if the test current contains harmonics. In principle, the input circuit of the relay measures the rectified mean value.

Programming the output relays

If the RACID incorporates additional signal relays, investigate how these are to be programmed with respect to the plant. Extract the relay, remove the protective cover at the rear and, with the S1 selector switch, program as required. Refer to Fig. 10 on page 16.

Use preferably a small soldering iron to seal the selector switch contacts. Note the applicable program on the label affixed to the protective cover. Check that the rated data of the relay agree with those desired and with the existing plant data.

Note! Make it a rule always to de–energize all circuits leading to the relay before it is removed from its plug–in base. Extremely high voltages can be generated and damage occur due to flashovers caused when an energized relay is removed.

Connection of SVERKER–type test set

The diagram illustrates the connections of the test set when measuring the R–phase operate current via the test–plug handle, terminals 3 and 4, and when measuring the operate time via terminals 17 and 18.

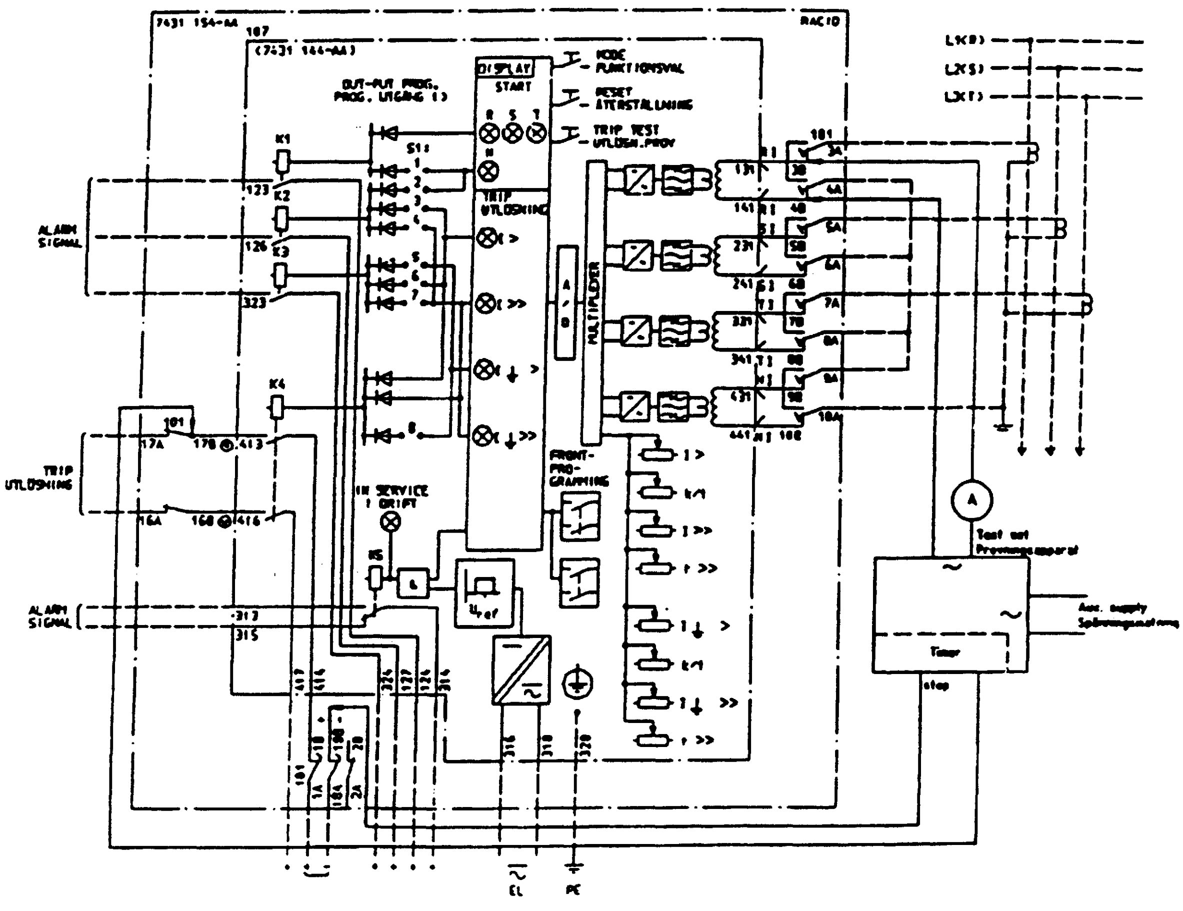


Fig. 19 Example showing the connections of a SVERKER–type test set

Checking the start and resetting values of the input circuits

Connect the auxiliary supply and other circuits to the relay. Check that the **In service** LED is alight and that the K5 relay is activated, i.e., that the contact between terminals 313 and 314 on RACID is closed. With the selector switches on the relay front, select the time characteristic for I› and I⏚ ›.

Check that the programming, accomplished with the S1 selector switch, has been correctly performed.

With the **Mode** pushbutton, light the I> diode. Inject a current in the R–phase of the relay (terminals 3–4 on the test plug handle). Gradually increase the current until the relay starts, i.e., at the same instant when the I> diode is extinguished. Read–off the start current indicated by the ammeter and, if necessary, adjust the set operate value.

The deviation must not exceed 5% of the set operate value or one digit of that shown on the display. Furthermore, check that the resetting value is greater than 0.95 times the operate value.

Checking the operate time

Check the operate time, measured on the trip relay, in the following manner:
Connect a timer as shown in Fig. 19. Increase the current to three times the operate value of I> and inject the current instantaneously. Check that the operate time is now approximately 40 ms (typical value).

Repeat the test on the S and T phases without altering the set operate value.

Test the earth fault relay in an identical manner. The I⏚> LED should then be alight. This is lighted by means of the **Mode** push-button. This will facilitate the checking of the operate value.

Checking the delay

With the aid of the **Mode** pushbutton, check that the current definite–time delay or **k**–factor is set.

Definite time
Set the current to a value corresponding to twice the operate value of I> and I⏚> and, at this current, check the operate time. For the 0.1–1.2 s time scale, the deviation should be <20 ms and for the 1–12 s time scale <50 ms of the set value.

Repeat the test on the other phases and on the earth fault relay when such is incorporated.

Inverse time
Check the selected inverse time curve by measuring the operate time at a current corresponding to 2, 6 and 9 times the set operate value of I> and I⏚>. The test is made in a similar manner to that applicable to the definite–time delay. Check that the operate times lie within the desired range of the selected **k**–factor.

It is essential that the current is held at a constant level during the measurements, especially when measuring lengthy operate times and/or currents of high magnitude.

Checking the instantaneous functions

Turn down the t» potentiometer to a minimum. With the **Mode** push-button, select the I» function and set the desired operate value with the aid of the applicable potentiometer. Connect the test set to the R–phase (terminals 3–4 on the test plug handle). Inject a current corresponding to the set operate value. Interrupt the current and reset the relay.

Inject the current instantaneously and check that the relay operates. Repeat the test with currents around the operate value and, in this manner, seek the operate value. Adjust the set operate value.

In conjunction with the checking of the operate level, measure the basic time of the relay.

Set the desired delay of the instantaneous function, using the **Mode** pushbutton and the t» potentiometer. If possible inject a current corresponding to twice the operate value of I». Inject the current instantaneously and measure the operate time. The deviation from the set delay should be < ±20 ms. Check the operate values of the other phases without changing the relay settings.

Set and test the instantaneous function of the earth fault relay in the same manner.

This is done by depressing the **Trip test** pushbutton until the display shows flashing lights. Thereafter, simultaneously depress the Mode pushbutton. All incorporated output relays should then be activated.

Note! Prior to commencing the test, always block the outputs with RTXH 18, or interrupt in another manner the circuits which can cause the tripping of the breaker if breaker operation is not desired. After commissioning the relay, check the load-current indication in all phases by depressing the **Service value** pushbutton.

Abbreviated test routine

With the abbreviated test routine mentioned below, a check is made to ensure that the relay input circuits measure the appropriate current. Furthermore, via the microprocessor's program and logic, check that the output circuits operate correctly in respect to the different functions.

- If the RACID incorporates additional signal relays. program these relays as required
- Note the actual programming on the rear protective cover
- Check the relay data against the plant data
- Check that the current-transformer circuits are connected correctly
- Insert the relay, switch on the auxiliary supply and check that the In service diode lights up
- Check that all signal circuits are correctly connected by activating all the output relays with the aid of the Trip test and Mode pushbuttons
- Set the required operate values
- Using an ammeter, measure the actual secondary current from the current transformers. Compare this with the actual load current, specified on the relay, in phase R, S, and T.
  The deviation should be less than 5% or one digit.

The above-mentioned abbreviated test verifies that the relay is connected in the correct manner and that it measures correctly.

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