ABB Network Partner AB

RXZK 21/22/23H and RAZK Under-impedance relay and protection assemblies

User´s Guide

1MRK 509 006-UEN
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General

- Single or three phase versions with separate measuring elements for each phase
- Non-directional or directional operation selectable
- Instantaneous and time delay functions

  - RXZK 21H has one measuring zone
  - RXZK 22H has two measuring zones
  - RXZK 23H has one measuring zone with a generator, or system, out-of-step function
- Safe operation for fault cases when the fault current is lower than maximum load current
- The relays and protection assemblies are used in a wide range of applications where impedance measurement is a suitable way to detect faults and abnormal conditions, e.g.;

  - as main short circuit protection to obtain better selectivity than with non-directional or directional overcurrent relays
  - as back-up protection for cables and overhead lines, transformers, reactors and synchronous machines
  - as an out-of-step protection for synchronous machines and tie-line applications
  - as loss-of-excitation protection for synchronous machines

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1 Application

1.1 Relay settings, connections and use

The relays, all together, have a number of features, functions and possibilities that make them very flexible. In normal cases only some of the them are used for a certain application.

Setting of scale constant Is
The constant Is is applicable to all applications, but is only used in order to get a wide setting range for X and R, and is the first to be set, based on primary data and desired operation value.

It is obtained by multiplying the relay’s rated current Ir by a factor 0,1 to 1,0 that is settable by switches on the front plate.

For currents below 0,5 times Is the relay is automatically blocked. This eliminates need for separate current detectors. For fault currents above 50 times Is, the value 50 x Is will be used for impedance calculation (RXZK 21H and 22H).

Setting of impedance Z
The impedance set on the relay is as measured by the relay in the secondary circuit, not the actual impedance in the primary circuit. The recalculation takes into consideration the possible differences in ratios of the current and voltage transformers (CTs and VTs).

When the relay measures phase voltage and phase current the primary impedance Zprim in ohms/phase is recalculated to secondary value Zsec according to formula:

$$\text{Zsec} = \text{Zprim x CTprim/CTsec x VTsec/VTprim} \quad \text{ohms/phase}$$

If the relay measures phase-to-phase voltage and phase current:

$$\text{Zsec} = \sqrt{3}\,\text{x Zprim x CTprim/CTsec x VTsec/VTprim} \quad \text{ohms/phase}$$

As Z = jX + R, the secondary values for X and R are calculated correspondingly

In most practical cases the reach setting ratio between R and X will be less than 10. The relays allow ratios (0,05 - 20) to 1, limited by using same Is constant.

For RXZK 22H the setting ratio R:X is limited to (0,6 - 2) to 1. Zone 2 shall always be set larger than, or equal to zone 1! Otherwise the operation will be as for zone 1.

The setting is made on the relay front plate by using potentiometers and switches according to indicated formulas.

In most cases the impedance setting shall be adapted to the protected item (line, transformer etc.) with a certain margin (over or under). This in order to prevent unwanted overreach or underreach, due to inaccuracy in primary and secondary circuits, as well as transient phenomena in the network.

A 20% minimum margin is recommended as a general rule, but detailed calculations should be made if this is a critical issue.

In certain cases (synchronous machines in particular) the pu (per unit) impedance is used instead of actual ohms for calculations, in which case the pu value has to be converted to ohms for setting the relay. See following formula.

1 pu = rated load impedance Z of the machine = U^2/S ohms/phase, where
U = voltage between phases in kV
S = nominal power in MVA

If the relay has 2 impedance stages, the time delayed stage can be set to overreach and the instantaneous stage set to underreach, and hence get selectivity with other relays in the system and fast fault clearance for nearby faults on own feeder or transformer, etc.

The actual earth fault coverage by setting of R should be calculated taking into consideration the zero sequence impedance. In general a separate sensitive earth fault relay is used, which means that the detection by the impedance relay is not critical.

Setting the characteristic angle a
The impedance equation Z = jX + R (ohms/phase with phase voltage and phase current) plotted into the R-X diagram will give an angle between Z and R-axis between 0 and ±90 degrees. This is based on that the measuring (zero) point (and VT location) is in origo and outgoing active power flow is in “forward direction”, i.e the 1st and 4th quadrant. Any additional phase shift in measuring circuits due to using phase-to-phase voltage and direction of vectors shall always be considered.

The typical angle for an overhead line is 70 degrees or below for distribution (L1) and 80 degrees and above for transmission (L2). Cable (C) angles are typical 45 degrees. Generator’s (G) stator winding’s angle is close to 90 degrees and for a transformer (T) it is 80 degrees or above.

Setting of characteristic angle a shall normally correspond to the protected object’s angle in order to have same resistive coverage close to the relay, as well as far away.

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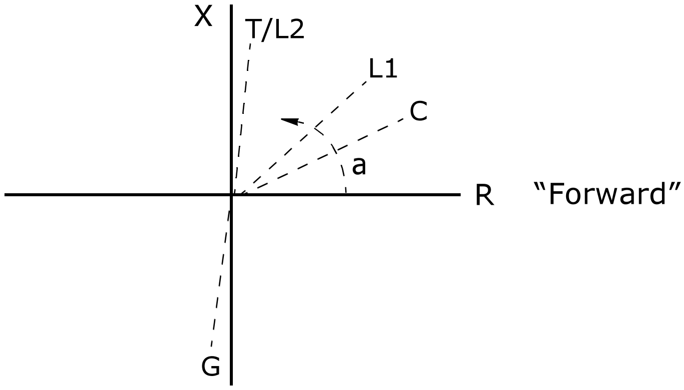


Fig. 1

For single phase assemblies phase-to-neutral or phase-to-phase voltages are both used. Any adjustment of angle α setting, due to phase-to-phase measurement, shall be calculated from case to case and is generally not considered in this document.

For phase short circuit protection assemblies phase-to-phase voltages are normally used. For two phase faults there is no phase shift. For three phase faults a 15% longer reach and a phase shift of +30 degrees will occur, meaning that the measuring characteristics are different. With R set at minimum 50% of X (in ohms/phase) and α 15 degrees lower setting of α, this is in most cases compensated for.

Setting directional vs. non-directional

In radial circuits, operation will be directional even with non directional setting as "reverse" requires reverse flow of active energy.

The directional settings must be used in some special applications, such as for protection of synchronous machines, and is further described in section 1.2.

The directional setting can be used as alternative or complement to non-directional in order to improve line protection selectivity in meshed networks or where else the energy can flow in both directions, such as for transformers.

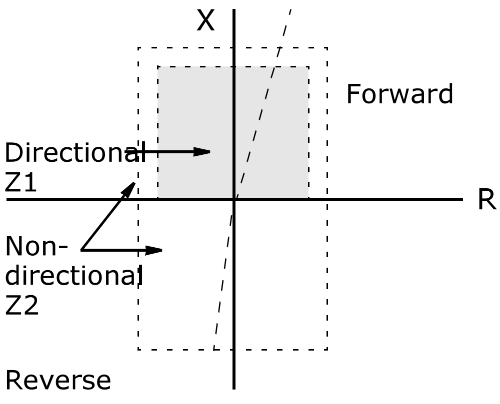


Fig. 2

Instantaneous (non delayed start) function vs. time delayed function
The instantaneous function may be used for signalling only, and connected to an event recorder. Abnormal, but not dangerous situations may occur in the network. As long as transient, and with short duration or non frequent, the service may not need to be interrupted. Investigations and maintenance can be made at a planned occation.

A trip function on the other hand, indicates that a dangerous situation has occured, with requirements to isolate the fault. For reasons of distinguishing from transient events and to obtain selectivity it is often time delayed. Tripping may be instantaneous when limits are surpassed substantially, and a time delay may worsen the damage.

Delayed tripping is thus used to prevent unnecessary interruption, and instantaneous function is used for low fault impedance and normally meaning high currents. These settings correspond to what is normally applied on overcurrent protection relays, but give better selectivity.

For a fault current above 50 times Is the RXZK 23H relay (contact 314) will operate instantaneously and without Z measurement

Setting of time delay:
A general rule is setting with shortest time delay without risking unwanted tripping at transient and non dangerous situations. Such transients may occur at transformer switching-in, faults on adjacent lines etc. The relay allows up to 5 seconds delay of tripping. For longer times external arrangements are necessary, and adding a time relay RXKL1 is a suitable solution.

For radial cable and OHL networks the tripping delay can be very short, or instantaneous, if the set reach has enough margin to not overreach into next station.

Setting of angle β (for RXZK 22H)
This angle is normally set to 0.
In some cases, such as line protection where a very wide R setting is required, there may be an interference with the rated load. This may also occur at temporary, but normal load peaks. The relay setting can therefore be adapted to cover such cases by introduction of a sector where the impedance measurement is blocked. This will also result in that the resistive coverage is limited for nearby faults and have to be measured by other relays.

The blocking is only valid for non directional Z2< operation (directional Z2α< is unaffected)

Use of binary inputs
Binary inputs are in form of miniature relays that shall be activated with DC (different terminals depending on auxiliary voltage used)

Binary input 1 is used for external blocking of output signals:
RXZK 21H: all outputs, except Zα<
RXZK 22H: Z1< and Z2<, except Z2α<
RXZK 23H: all outputs

Blocking can be used for obtaining selectivity, where the signal is sent by another relay to the RXZK relay.
Blocking can also be necessary during certain network conditions.

Binary input 2 is always used for remote resetting of signals on the relay, if this is applicable.

<u>Output contact functions</u>
The individual contact function is indicated on the relay diagrams, as non delayed or delayed, non directional Z1< and Z2< or directional Z2α<. In some cases function is selected by the switches. Blocking can be made externally by the binary inputs.

By combination of output contacts additional functions can be obtained:
RXZK 21H: Output contact 317 in series with contact 327 gives time delayed directional operation

RXZK 22H: Output contact 317 in series with contact 327 (Z2α<) gives time delayed directional operation of zone 2

Output contact 314 in series with contact 327 (Z2α<) gives instantaneous directional operation of zone 1
Two directional zones are obtained by

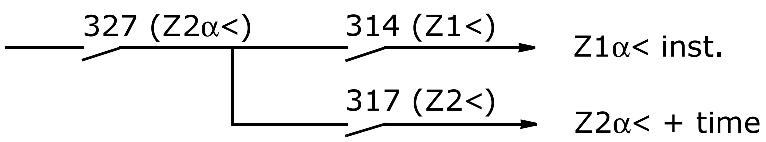


Fig. 3

Adding separate auxiliary, time and signal relays will give:

- stronger contacts with heavy duty ratings
- more parallel output contacts
- additional time delay
- more indications (flags)

Connection of AC current and voltage

For single phase relays the phase values (same phase) of voltage and current may be used. Provided that the instrument transformers are correctly connected together, 0-points and phase points shall be connected to the relay according to diagrams, with 0 on terminals 325 and 341 respectively. The forward directional measurement is then for “outflow” of active power, corresponding to 1st and 4th quadrant in the impedance diagram.

For some single phase measurements with symmetrical “phase faults” and for three phase assemblies phase-to-phase voltages are used, and with following connections.

Measuring voltages	U_{RT}	U_{SR}	U_{TS}
Measuring currents	I_R	I_S	I_T

- Using phase voltages U_{RT} compared to U_{R0} means a phase shifting of -30 degrees (lagging) which shall be considered at a setting, that is decreased by 30 degrees.
- Shifting of voltage polarity e.g. U_{RT} to U_{TR} corresponds to a directional shifting of 180 degrees.
- The RXZK relay includes a feature to memorize the voltage and to use 10V as minimum value, in case it should be lower in reality.

In some cases where it is important to get same reach for multiphase faults i.e. 2-phase and three-phase faults, delta connected current and voltage inputs should be used for the three impedance relay elements. I.e.;

Measuring voltages	U_{R-S}	U_{S-T}	U_{T-R}
Measuring currents	I_{R-S}	I_{S-T}	I_{T-R}

Please note that the delta connection does not permit detection of single phase to ground faults. Versions of the RAZK relay assemblies provide internal auxiliary CT’s to obtain the delta currents. It is also possible, where allowed by national standards and conventions, to obtain the same connection by using delta connected primary CT’s.

Connection of DC voltage

The relay shall be fed with +24 V, 0V, -24 V supplied from a RXTUG DC/DC converter.
This converter can supply up to 4 RXZK units, meaning that one assembly may be fed from another assembly in the same cabinet.
Connection of input voltage with wrong polarity to the converter will not cause damage.

A LED on the converter and a LED on each measuring relay will indicate “in service”. Loss of DC on the output of the converter will result in a signal contact drop-out.

Before plugging in or drawing out the converter or a measuring relay, the DC input to the converter **must be disconnected or trip contacts isolated!** Failing to do so may result in unwanted output signals (tripping)!

Earthing

Make sure that terminal 117 on all RXZK relays and the RXTUG converter are connected to earth!

1.2 Over head lines and cables

Applications considered are as short circuit protection instead of, or as complement to (back-up of), overcurrent relays, differential relays and distance relays.

An overcurrent relay has no limited reach, and can thus operate for faults beyond next station. Therefore time selectivity is used. On the other hand a certain back-up is provided for down stream relays. The differential relay is exact in reach, i.e. covering protected section to 100%, on the other hand not providing any back-up for other sections.

An impedance relay can be set to operate for faults on own section only (with a certain margin), or set to operate for own section and in addition giving a back-up for a defined part of next down stream section, or a combination there of with 2 zones.

Protection of radial circuits:

- Measuring relay RXZK 21H with 1 non-directional impedance setting, as back-up relay, or
- Measuring relay RXZK 22H with 2 non-directional impedance settings

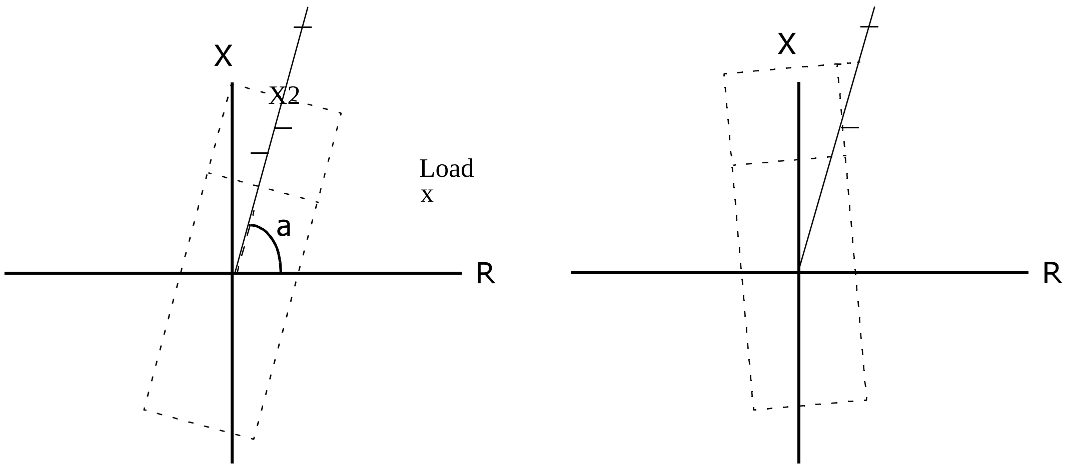
Protection of circuits with infeed from both directions:

- Measuring relay RXZK 22H with 1 directional zone (create Z1α< by connecting Z2α< & Z1< contacts in series), and one non-directional zone (Z2<)

General recommendation of settings unless specific calculations are made:

- With one non directional zone set X to cover 130% of the line/cable, with time delay
- With two zones set X1< to cover 70% of the line with instantaneous operation and X2< for 130% of the line with time delay
- R is set to a value = 0,6 * X, or higher, but below 50% of load impedance, with R2 = R1
- Set a to line angle, or as a general rule 70 degrees for distribution overhead lines, 80 degrees for transmission overhead lines and to 45 degrees for cables (phase-phase measurement of voltage)
- Set a time delay that with a minimum of 0,3 sec. exceeds the instantaneous operation time of the downstream relay.

In all cases separate sensitive earth fault protection relays should be used



Over head line 2 phase faults at 3 phase faults 30 degrees shift

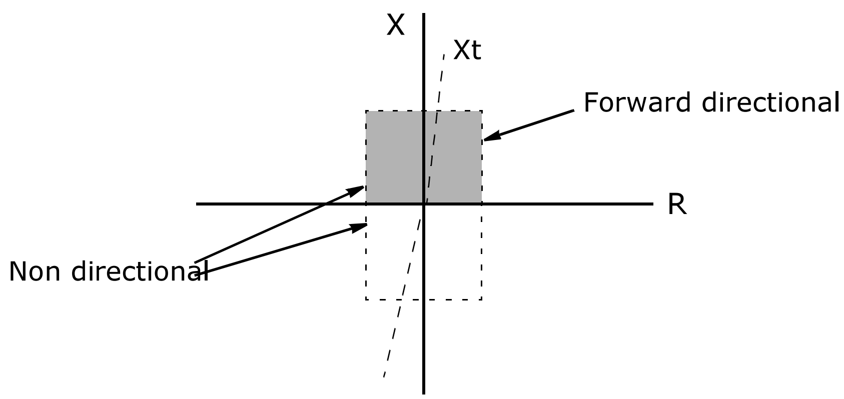
Fig. 4

1.3 Transformers and reactors

Applications considered are as short circuit protection instead of overcurrent relays and as back-up to differential relays. For use as protection of generator transformer see section 1.2.3

The relay is normally connected to VTs and CTs on the HV side.
Phase and current shifts due to D/Y connections and other factors complicate the settings for faults in the secondary winding (as seen from the relay), and detailed calculations will be necessary for good coverage.

Relay RXZK 21H provides a delayed directional, or non directional, back-up tripping for faults in the transformer (or reactor). Setting with X = 150% reach into the transformer (1,5 * Xt), and R=X is recommended as a general rule. Time delay 0,8 sec., and angle α 90 degrees (ph-ph). The non directional setting will also provide back-up for busbar and line faults on HV side.



(Xt = transformer short circuit reactance)

Fig. 5

By using RXZK 22H as main protection and creating an instantaneous directional zone Z1α< (created by connecting contacts for Z1< and Z2α< in series), with setting 0,7 * Xt, and the time delayed non directional Z2<, or directional zone Z2α< (created by connecting contacts for Z2α< and Z2< in series) a better coverage through the transformer is obtained. Setting = 1,5 * Xt is recommended. Set R = X.

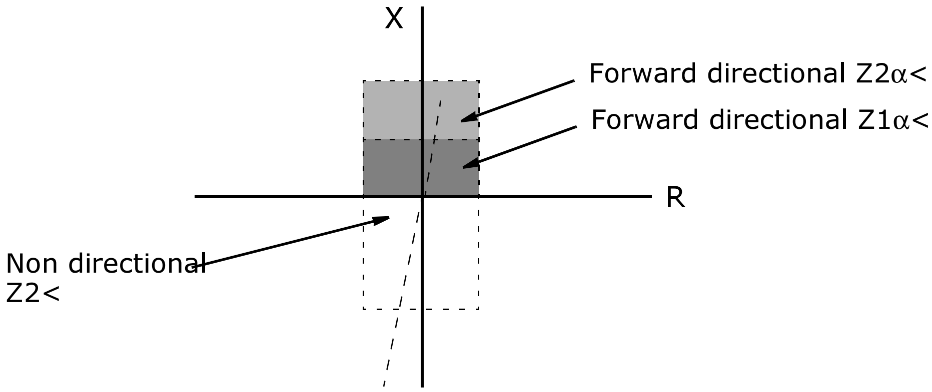


Fig. 6

1.4 Synchronous machines

In most cases the CTs are mounted on the machine neutral side and the VTs on the machine terminals. This is the standard case on which the standard application cases below are based. The applications as generator and motor protection are similar, with the main difference that normal flow direction of active energy is opposite.

<u>Short circuit protection of generator - transformer block:</u>
The main purpose is to protect the generator bus, the low voltage part of the step-up transformer and a part of the stator winding. With the machine connected to the network the relay will have a limited reach to detect faults in the windings, seen from the terminals. This due to that the voltages and currents measured are dependent on two different impedances, from fault to neutral and from fault to terminals. The impedance relay shall thus only be used as back-up or in parallel with another protection.

Typical application is zone 1 with an instantaneous X setting corresponding to 70% of the transformer short circuit impedance (0,7*Xt). Typical D/Y transformer connection may cause selectivity problems due to phase shifting etc. if the setting is increased above 70%. R1 setting can be same as X1. Setting of back-up zone X2 and R2 can be up to 70% of load impedance. Both zones are non-directional with α=90 degrees (ph-ph). RXZK 22H is suitable, or with only one zone (either of them) relay RXZK 21H.

Machine(s) connected directly to a busbar:
Only a one zone delayed back-up zone shall be used. Setting as for zone 2 above.

Typical time delay as back-up is 0,8 sec.

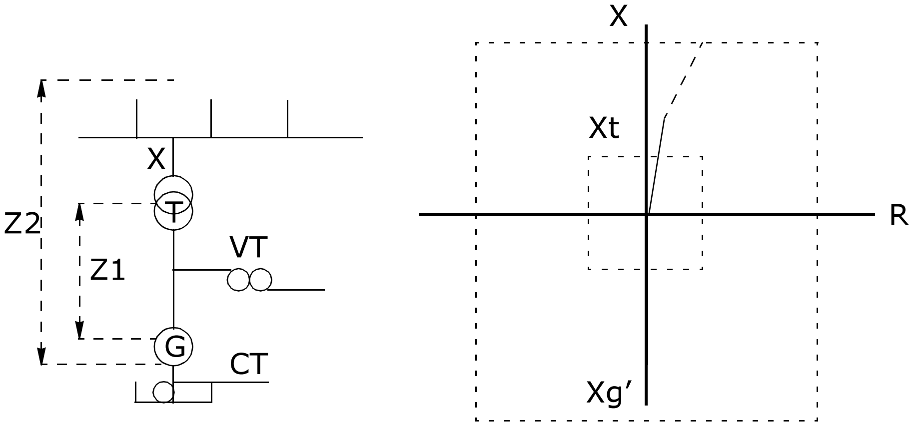


Fig. 7

Loss-of-excitation protection

Failure in the excitation system will result in that the machine consumes uncontrolled reactive power from the network, but may still operate as a synchronous generator, or in certain cases lose synchronism. The situation may not be dangerous immediately, but signalling and a controlled stop are often required. In some instances the generator may be operated in a controlled way under-excited to consume capacitive VAR from the network, which must be distinguished from a fault situation. Protection relays for under-excitation primarily recommended by ABB measure the capacitive current with a directional current relay that is adapted to the generator’s capability curve as in protection relay type RAGPK. Another way to detect the under excited operation is by an under impedance relay such as type RXZK.

The normal and abnormal situations can be distinguished by the directional impedance relay that is set to detect an impedance Z in reverse direction. Due to transient phenomena in the network a time delay is required. 2 sec. is recommended as a general rule.

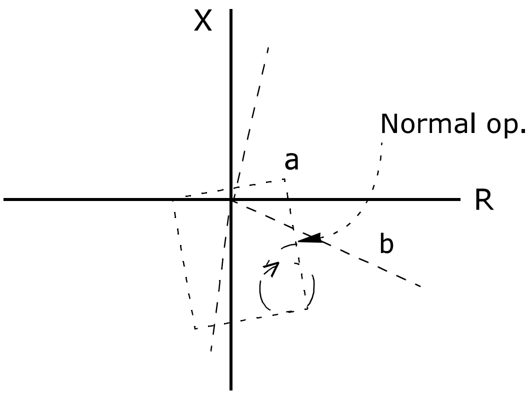


Fig. 8

Single phase assemblies with RXZK 22H shall be used, with reversed directional setting, such as by changing voltage polarity. Contacts for Z2< and Z2α< are connected in series.
The Z setting shall follow the machine's capability curve as well as possible, and assuming that the terminal voltage is unaffected, i.e. Z = 1/I ohms/phase in pu. The straight line characteristics of RXZK impedance measurement will approximately correspond to the capability curves, but detailed calculations and measurements may be necessary.

Set X at 1/Iq with where Iq is the maximum current (capacitive) allowed at no active load.
Set R and α to obtain best approximation of a straight line of I according to the capability curve.
Set β to cut off operation close to R axis

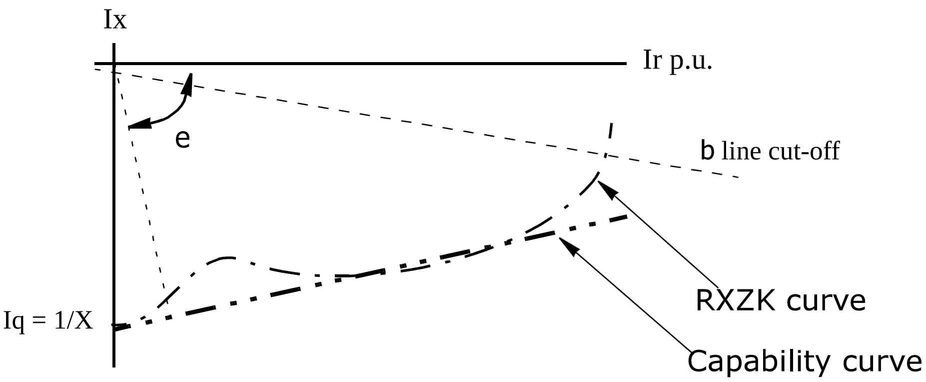


Fig. 9

The figure shows a capability curve with approx. 75 degrees ε and corresponding RXZK line with setting of R = 0,5 *X, angle α 105 degrees (ph-neutr.) and setting β at 15 degrees.
Increase angle α for lower angle ε
Z1< can be set to act as instantaneous short circuit protection

<u>Out-of step protection</u>
An out-of-step condition is characterized by asynchronous operation with the field circuit regulation in operation. It is normally mechanically harmful to the generator and the generator shall be tripped as soon as possible.
The main reason for loss of synchronism is a slow clearing of a two or three phase fault in the network. The rotor accelerates due to the energy fed into the turbine. Finally (after 0,5 seconds or more) a poleslip occurs when the generator emf exceeds 180 degrees vs. the network, and the generator enters motoring quadrants with active energy consumption until the slip is 0 degrees. This situation will be difficult to normalise without shutting down the machine. However, normally the fault in the network is cleared by primary or back-up protection well in time, and a pole-slip never occurs, only a power swing.

In case a pole slip is detected the tripping shall occur as close to 0 degrees emf angle as possible in order to protect the breaker from excessive voltage.

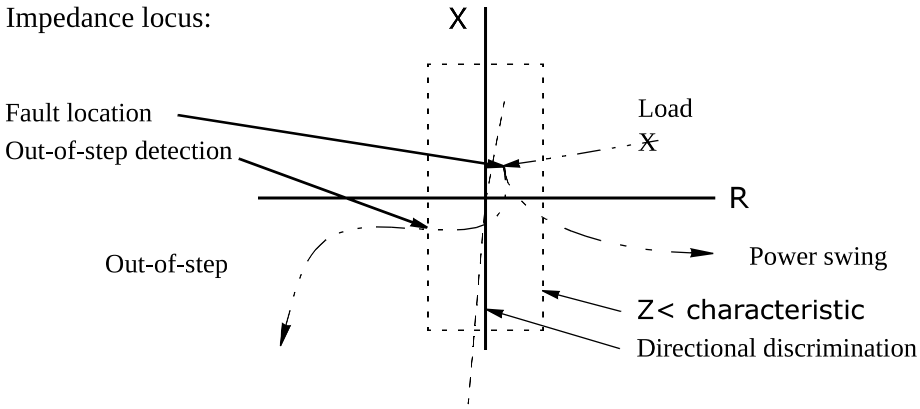


Fig. 10

The relay RXZK 23H is used as detector of an out-of-step condition, that is defined as resetting of Z< function according to figure.
As the out-of-step output only operates for a “passing through”, and is not sensitive to direction, it can be used for synchronous motors as well.

If settings are suitable the RXZK 23H relay’s impedance output contacts can be used as a separate additional function, e.g. together with two additional phase impedance elements as a short circuit protection or fault detector. The timer setting delay for this output is 0 - 5 s.

If no detailed calculations are made for a particular case, extensive dynamic simulations have shown that a reactance setting of 0,4 pu and a resistance setting of 0,2 pu, with angle α 90 degrees (ph-neutr.), will detect most cases of out-of-step.

1.5 System Out-of-step

The RXZK 23H relay assemblies can be used to detect loss of synchronism between to electrical systems. The relay is installed in a line end and will trip the line if the impedance locus is possing through the impedance rectangle in either direction. Reference is made to generator out-of-step described in 1.5.

1.6 Other

Besides a number of standard combinations as described in section 9 it is possible to combine RXZK relays in assemblies with up to 4 measuring relays. Several protection functions in one assembly, such as for a generator + transformer or more zones for a line, are thus possible.

Together with other measuring relays, such as current relay RXIDK, voltage relay RXEDK, directional current relay RXPDK and other relays in the COMBIFLEX family, a great variety of tailor made applications and assemblies will be achievable. Special user’s instructions from case to case may be issued.

2 Measurement principles

The RXZK 21H, RXZK 22H and RXZK 23H relays constitutes the measuring units of RAZK. For setting of operate values and relays/LEDs functions, *see section 4*.

When the processor starts it executes a self test sequence. If the processor fails to start in a proper way the LEDs will indicate by flashing, or the “In service” LED will not be lit. The program in the microprocessor is executed in a fixed loop with a constant looptime. The loop is supervised by an internal watch dog which initiates a program restart if the program malfunctions.

Test sequence:	**Test error indication:**
Config registers	All LED’s are flashing in clockwise rotation
RAM	Left red LED is flashing
ROM	Right red LED is flashing
A/D	All red LED’s are flashing

Fig. 11 Self test error indication of the RXZK 2xH relay

2.1 RXZK 21H/22H

The current and voltage values are filtered. The filtered values are applied to zero-crossing detectors and a new phase-angle is calculated in the microprocessor at every zero-crossing. If the input-voltage decreases below 10 V the voltage phase is memorized, the current phase is allowed to change for 100 ms after the voltage phase has been memorised

If the input-voltage or the input-current are outside the impedance measuring area the measured impedance is calculated according to Fig. 12**.**

Case	**Input-voltage**	**Input-current**	**Impedance**	**Comments**
1	275V	0,4 x Is	275V / 0,4 x Is	No operation
2	10V	measured	10V / measured	-
3	10V	50 x Is	10V / 50 x Is	Always operation
4	measured	measured	measured / measured	-
5	measured	50 x Is	measured / 50 x Is	-

Fig. 12 The impedance measurement limits.

<u>Start up mode</u>
When the input energizing quantities enters the measurable area during start-up or at connection, the relay uses circular characteristic for 200 ms. During these 200 ms the impedance reach will be equal to the lowest setting of reactive (x) or resistive (r) reach.

When the input-voltage has been over 10 V for more than 200 ms, the relay will automatically switch over to normal characteristic. Otherwise, the relay will continue to use circular characteristic.
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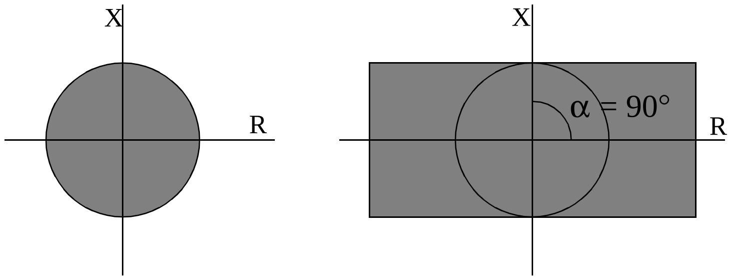

Fig. 13 Function characteristics during start-up mode versus settings for the RXZK 21H relay.

Voltage memory
When the input-voltage has been over 10 V for more than 200 ms, the voltage memory function becomes enable.
If the input-voltage then drop below 10 V and a start or a trip ocurrs during the first 100 ms, the relay stores the present phase-angle j after these 100 ms and continue to use it
Otherwise, the relay automatically switch over to start-up mode (circular characteristic) and the impedance reach will be automatically adjusted to the lowest setting of reactive (x) or resistive (r) reach.

Binary inputs, RXZK 21H
There are two binary inputs on the relay.

Switch 5	Switch 6	Binary input 1 activated
B	B	Blocking all functions except the directional function Z_{α}<
	B T1	Blocking Trip 1 function
E	E St	Enables Start function
	E Acc. T2	Trip 2 changes to an instantaneously function

Fig. 14 Table describing the function of binary input 1 on RXZK 21H.

The function on binary input 1 on RXZK 22H is selectable with a switch in the front between Block / Acc. Z2<. When “Block” is selected, active signal on binary input 1 block all functions except the directional function (Zα<). If “Acc Z2<“ is selected active signal on binary input 1 makes the Z2< Trip instantaneous.

The binary input 2 “bin in reset” is used for remote resetting of the indicating Trip.

The binary inputs are galvanic separated from the electronics with a opto-coupler.

<u>Reset button</u>

The reset button has two functions, LED check and resetting the LEDs. When the button is depressed, the Start and Trip LEDs are lit and the "In service" LED is switched off. When the button is released the LEDs will shown actual status.

<u>Zone Z<, Zα<</u>

The RXZK 21H function characteristics are accounted in Fig. 15. The non-directional function, zone Z< operates when the U/I x cos (j-α) < x (reactive reach) and U/I x sin (j-α) < r (resistive reach). For impedance zone Z< definite time 0 - 1,2 s and 0 - 5 s delay is available. The directional function, zone Zα< operates for the same impedance reach as Z< but the phase angle j must be between α ± 90°. The Z< or the Zα< start function is selectable by switch.

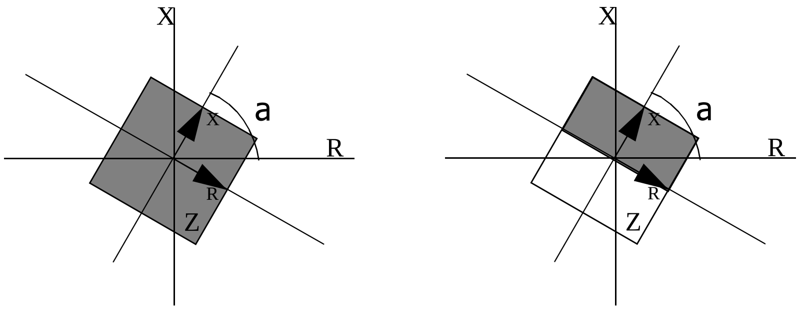

Fig. 15 Function characteristics for Z< and Zα< at α=60 ° for the RXZK 21H relay.

<u>Zone Z1<, RXZK 22H</u>

The instantaneously non-directional function operates when the U/I x cos (j-α) < X (reactive reach P1) and U/I x sin (j-α) < R (resistive reach P1 x k). During start-up mode the function operates for circular characteristic and the operate value will be set to the lowest setting of X and R. The function characteristic is shown in Fig. 16.

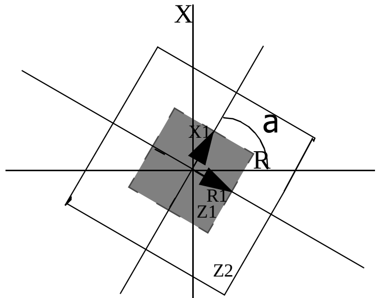

Fig. 16 Function characteristic during normal service for Z1< at α =60°.

Zone Z2< / Z2α<, RXZK 22H

The operator select between the two functions with a switch in the front of the relay.

Zone Z2<, RXZK 22H

The instantaneously non-directional function operates when the U/I x cos (j-α) < X (reactive reach P2) and U/I x sin (j-α) < R (resistive reach P2 x k), the function can also change the impedance reach around resistive reach with the β-angle.

If β-angle = 0°

During start-up mode the function operates for circular characteristic and the operate value will be automatically adjusted to the lowest setting of X and R.

If β-angle = 15, 30 or 45°

The function is always disabled during start-up mode.

The function characteristics are shown in Fig. 17.

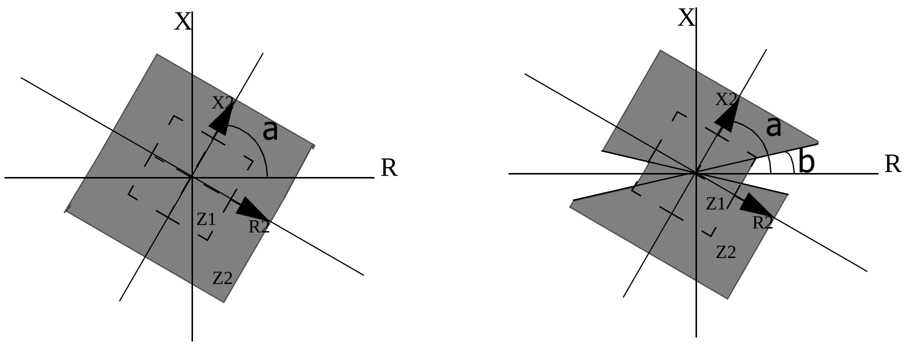

Fig. 17 Function characteristics during normal service for Z2< at α =60°.

Zone Z2a<,RXZK 22H

The instantaneously directional function operates when the U/I x cos (j-α) < X (reactive reach P2), U/I x sin (j-α) < R (resistive reach P2 x k) and the phase angle j must be between α ± 90°.

During start-up mode the function operates for circular characteristic and the operate value will be set to the lowest setting of X and R. The function characteristic is shown in Fig. 18.

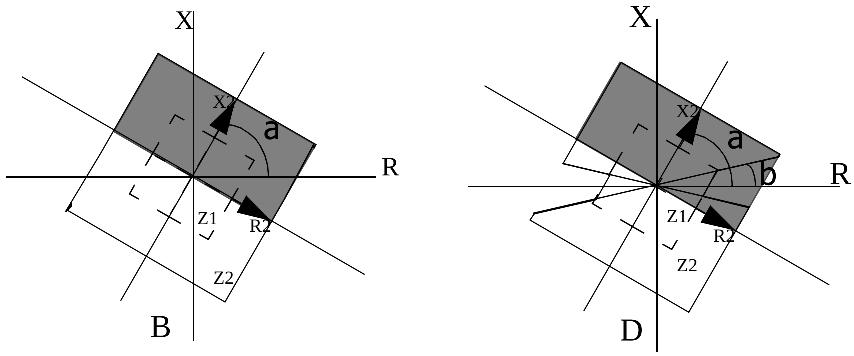

Fig. 18 *Function characteristics during normal service for Z2α< at α =60°.* *Note that Z2α< operates independent of α set β angle.*

Functional diagrams

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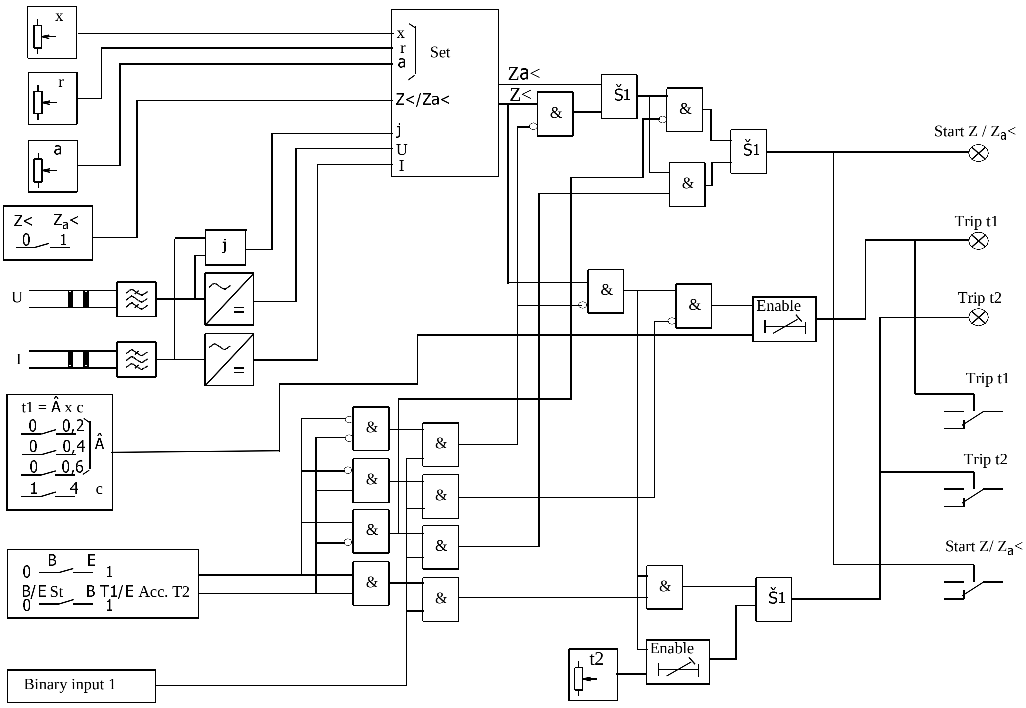

Fig. 19 *Functional blockdiagram illustrating the mode of operate on for the RXZK 21H relay.*

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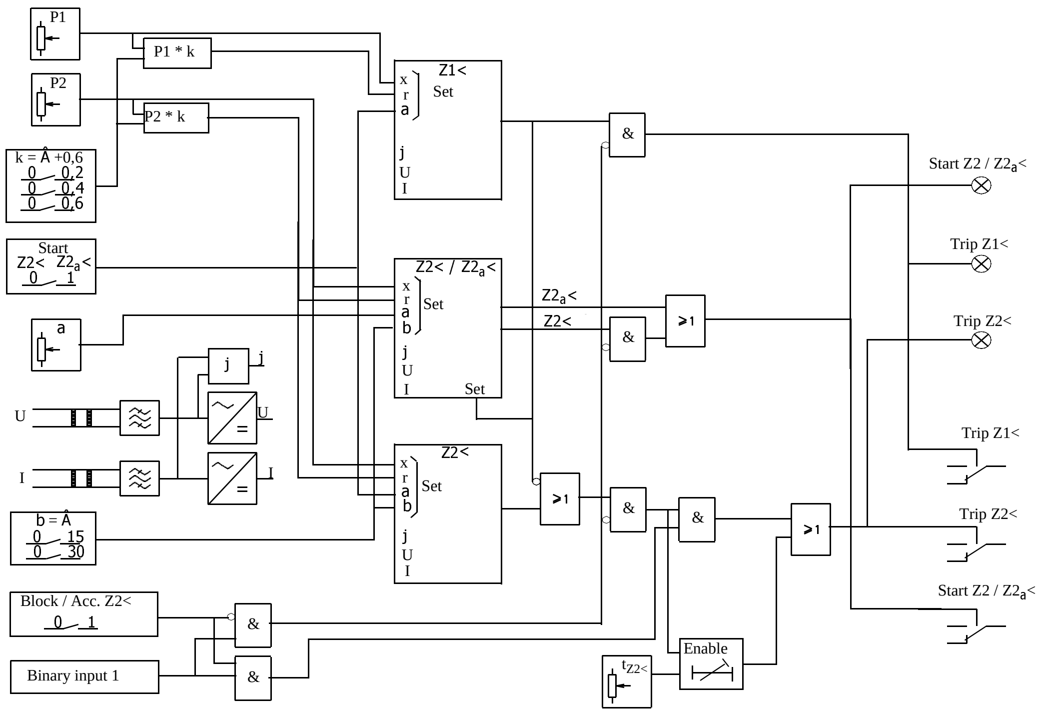


Fig. 20 Functional blockdiagram illustrating the mode of operate on for the RXZK 22H relay.

2.2 RXZK 23H

The current and voltage values are filtered with a moving average filter to reduce ripple. The filtered values are applied to zero-crossing detectors and a new phase-angle is calculated in the microprocessor at every zero-crossing. If the input-voltage decreases below 10 V the phase-angle is stopped from being updated.

If the input-voltage or the input-current are outside the impedance measuring area the measured impedance is calculated according to Fig. 21**.**

Case	Input-voltage	Input-current	Impedance	Comments
1	200V	0,4 x Is	200V / 0,4 x Is	No operation
2	10V	measured	10V / measured	-
3	-	Š50 x Is	Overcurrent function	Always operation
4	measured	measured	measured / measured	-

Fig. 21 The impedance measurement limits.

Binary inputs
There are two binary inputs on the relay. Active signal on binary input 1 blocks all functions.

The binary input 2 “bin in reset” is used for remote resetting of the “Z< / I> Trip” and “OOS Trip” LED indicators.

The binary inputs are galvanic separated from the electronics with a opto-coupler.

Reset button
The reset button has two functions, LED check and resetting the LEDs. When the button is depressed, the “Z Trip”, “Z Start” and “OOS” LEDs are lit and the “In service” LED is switched off. When the button is released the LEDs will show the actual status.

The Z< Zone
The RXZK 23H function characteristics are accounted in Fig. 22. The zone Z< function operates when the U/I x cos (j-α) < x (reactive reach) and/or U/I x sin (j-α) < r (resistive reach). The I>/ Z< operates with definite time delay 0 - 5 s. The current function operates when the injected current increases over 50 times Is. The current function operates with the same time delay as the Z< function

.

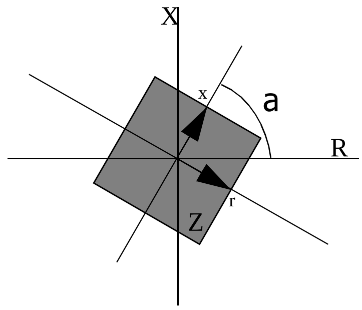


Fig. 22 Function characteristics during normal service for Z< at α=60 °

The Out-Of-Step function OOS
The out of step function operates when two conditions has been fulfilled. In order to achieve an out-of-step trip the impedance has to leave the set impedance reach on the opposite side of the directional element (characteristic angle, α) from where the impedance entered the set impedance reach. Example of the OOS characteristics illustrated in Fig. 23.

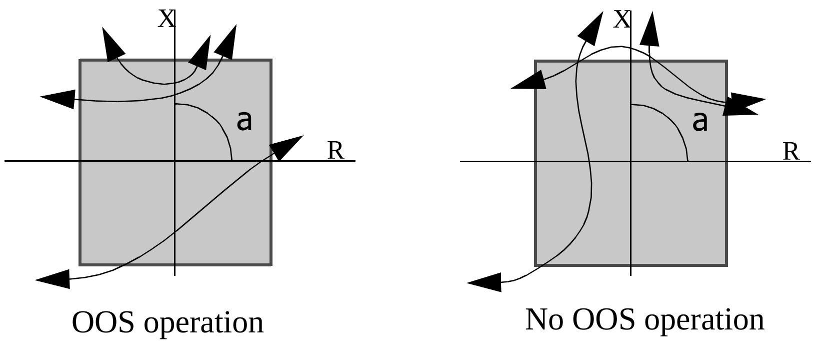


Fig. 23 Examples of OOS operation and no OOS operation at α=90°

The minimum time, for the impedance to pass through the set impedance reach, is 170 ms to ensure operation. The OOS function is disabled when current increases over 50 x Is. If current decreases below 50 x Is the impedance must re-enter the set impedance reach to ensure OOS operation. The OOS function resets when the injected current decreases below 0,5 x Is.

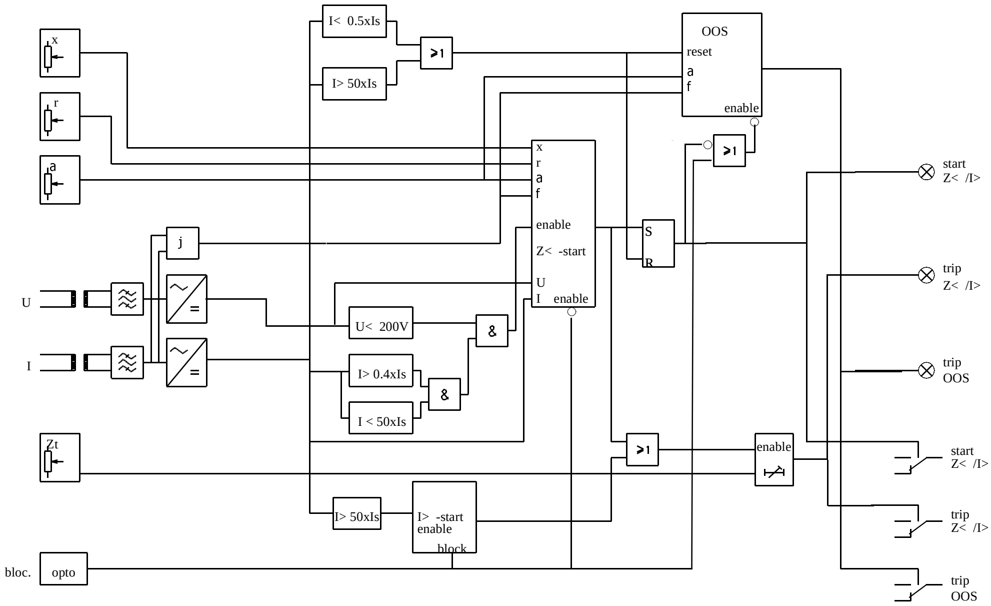


Fig. 24 Functional blockdiagram illustrating the mode of operate on for the RXZK 23H relay.

3 Design

The under-impedance protection type **RAZK** is designed in a number of variants with up to two zones for single-phase or three-phase application. Each protection relay is available with or without test switch RTXP 18, DC-DC converter RXTUG 22H or tripping relays RXME 18.

All the protection assemblies are built up by modules in the COMBIFLEX“ modular system mounted on apparatus bars. The connections are done by COMBIFLEX“ socket equipped leads.

The type of modules and their physical position and the modular size of the protection are shown in the *Buyer´s Guide* and in the Circuit Diagram of respective protection. The following sections 3.1 to 3.4 describes modules that can be included in RAZK assemblies.

3.1 Test switch

The optional test switch **RTXP 18** is a part of the COMBITEST testing system described in the *Buyer´s Guide*, Document No. 1MRK 512 001-BEN. A complete secondary testing of the assembly can be performed by using a test-plug handle RTXP 18 connected to a test set. When the test-plug handle is inserted into the test switch, preparations for testing are automatically carried out in a proper sequence, i.e. blocking of tripping circuits, short-circuiting of current circuits, opening of voltage circuits and making the protection terminals available for secondary testing. RTXP 18 has the modular dimensions 4U 6C.

All input currents can be measured by a test plug RTXM connected to an ammeter. The tripping circuits can be blocked by a trip-block plug RTXB and the protection can be totally blocked by a block-plug handle RTXF 18.

3.2 DC-DC converter

The optional DC-DC converter **RXTUG 22H** converts the applied battery voltage to an alternating voltage which is then transformed, rectified, smoothed and in this application regulated to ±24 V DC. The auxiliary voltage is in that way adopted to the measuring relays. In addition, the input and output voltages will be galvanically separated, which contributes to damping of possible transients in the auxiliary voltage supply to the measuring relays. The converter has a built-in signal relay and a green LED for supervision of the output voltage.

RXTUG 22H has the modular dimensions 4U 6C. It is described in the *Buyer´s Guide*, Document No. 1MRK 513 001-BEN.

3.3 Measuring relay

The under-impedance relays **RXZK 21/22/23H** are static, microprocessor based relays with impedance, angular and time settings. The relays consist mainly of input transformers for current and voltage adaption and isolation, filter circuits, digital-analog converter, microprocessor, MMI consisting of a programming switch and potentiometers for setting, and LEDs for function and in service indications, and three output relays, each with a change-over contact. The output relays operate for instantaneous or, for delayed operation according to variant and programming. The relays have also a binary input for remote resetting of the LED indications and a relay for remote blocking (or releasing).

The relay exists in 3 variants:

RXZK 21H, one impedance measuring zone with

- two time delayed non directional outputs
- one selectable output
  - Zone instantaneous directional or,
  - Zone instantaneous non directional

RXZK 22H, two impedance measuring zones with

- Zone 1 instantaneous non directional output
- Zone 2 time delayed non directional output
- one selectable output
  - Zone 2 instantaneous directional or,
  - Zone 2 instantaneous non directional

RXZK 23H, one impedance measuring zone with

- one instantaneous non directional output
- one time delayed non directional output
- one output indicating out-of-step condition (synchronous machine)

3.4 Tripping relay

The optional auxiliary relay **RXME 18** is used as tripping relay. It has two heavy duty make contacts and a red flag. The flag will be visible when the armature picks-up and is manually reset by a knob in the front of the relay. Typical operate time is 35 ms.

RXME 18 has the modular dimensions 2U 6C. The relay is described in the *Buyer´s Guide*, Document No. 1MRK 508 015-BEN.

4 Setting and connection

4.1 General connections and operation

The modular relays requires a dc-dc converter type RXTUG 22H for an auxiliary voltage supply ±24 V. Connection of the voltage RL shall be made only when the binary input is used.

The relay is delivered with a short-circuiting connector RTXK for mounting on the rear of the terminal base. This connector will automatically short-circuit the current input when the relay is removed from its terminal base.

NOTE! The auxiliary voltage supply should be interrupted or the output circuits should be blocked to avoid the risk of unwanted alarm or tripping, before the relay is plugged into or withdrawn from its terminal base.

There are four LED indicators. The trip indicators seal-in and are reset manually by the ”Reset” push-button or electrically via the binary input, while the start indicator resets automatically when the relay resets.
When the ”Reset” push-button is depressed during normal operating conditions, all LEDs except "In serv." will light up.

When connecting the relay to the auxiliary voltage, the relay performs a self test. The ”In serve.” LED is alight, after performing the self test and when the relay is ready for operation. In case of a fault, the LEDs will start flashing.

ESD!
The relay contains electronic circuits which can be damaged if exposed to static electricity. Always avoid to touch the circuit board when the relay cover is removed during the setting procedure.

4.2 RXZK 21H setting and connection

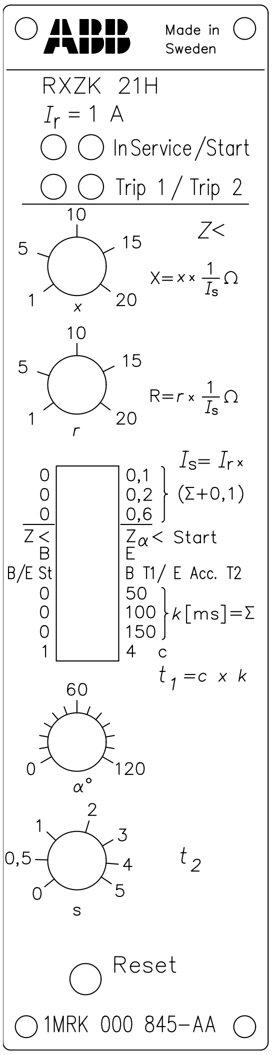


Fig. 25 Front layout

Rated current of the relay, I_r (available variants: 1 A or 5 A)

<u>LED indicators</u>:
In serv. (green): indicates relay in service.
Start (yellow): indicates operation of Z</Z_α< start (no time delay).
Trip1 (red): indicates operation of Z< after the set time delay t_1.
Trip2 (red): indicates operation of Z< after the set time delay t_2.

Potentiometer (P1) for setting of the reactive reach X.

Potentiometer (P2) for setting of the resistive reach R.

10-pole programming switch (S1) for setting of the scale-constant I_s, nondirectional or directional function Z</Z_α<, binary input function of Block and Enable modes, time delay t_1 for the function Z< Trip1.

Potentiometer (P3) for setting of the characteristic angle α.

Potentiometer (P4) for setting of the time delay t_2 for the function Z< Trip2.

Reset push-button.

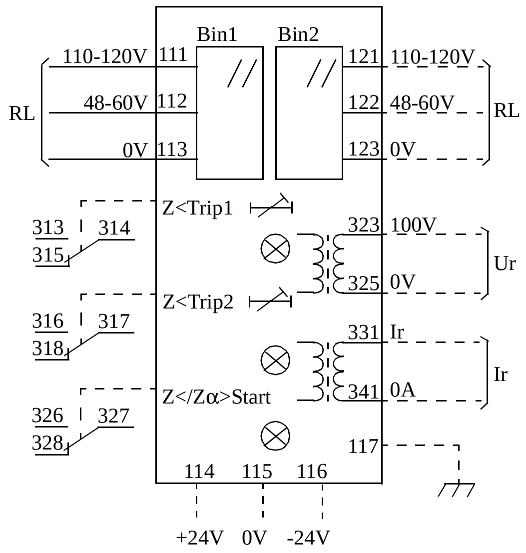


Fig. 26 Terminal diagram

Settings

All settings can be changed while the relay is in normal service.

1. Setting of the scale-constant I_S.

The scale constant I_s is equal to the rated current I_r times the sum of the set value of the switches S1:1, S1:2 and S1:3 plus 0,1. The setting range is from 0,1 to 1,0 × the rated current I_r.

2. Setting of the under-impedance function (Z<)

The setting range of the under-impedance function is expressed as Z = jX + R, where X and R are individually set as follows:

2.1 Setting of the reactive reach (X).

The operate value is set with potentiometer P1 according to the formula X = x * 1/Is (W), where x is the set value of P1.
The setting range of P1 is 1-20. Setting range of X is 1-200 W for I_r = 1 A and 0,2-40 W for I_r = 5 A.

2.2 Setting of the resistive reach (R).

The operate value is set with potentiometer P2 according to the formula R = r * 1/Is (W), where r is the set value of P2.
The setting range of P2 is 1-20. Setting range of R is 1-200 W for I_r = 1 A and 0,2 - 40 W for I_r = 5 A.

3. Setting of the directional function.

Set the programming switch S1:4 to “Z<“ for non-directional function or to “Z_α<“ for directional function.

4. Setting of the characteristic angle.

The characteristic angle, α, is settable between 0° to 120°. The angle is adjusted with potentiometer P3.

5. Setting of the time delay t_1.

The time delay has definite-time characteristic. The setting is done with the switches S1:7, S1:8, S1:9 and S1:10. $t_1 = c \cdot k$ where k is the sum of the set value of the switches S1:7, S1:8 and S1:9, and c is 1 or 4 depending on the position of switch S1:10. The setting rang is 0 - 1,2 s.

6. Setting of the time delay t_2.

The time delay has definite-time characteristic. The setting range is 0 - 5 s. The setting is done with potentiometer P4.

7. The binary input.

There are two binary inputs (Bin 1 and Bin 2) on the relay. Bin 1 (terminals 111/112-113) is used for blocking and enabling functions according to the setting of switches S1:5 and S1:6.
S1:5 on “B” and S1:6 on “B/E St” will block all functions except Z_α<.
S1:5 on “B” and S1:6 on “B T1/E AccT2” will block Z< Trip1.
S1:5 on “E” and S1:6 on “B/E St” will enable the function Z</Z_α< Start.
S1:5 on “E” and S1:6 on “B T1/E AccT2” will accelerate the Z< Trip2 function to an instantaneous function. The time delay is bypassed.
Bin 2 (terminals 121/122-123) is used for resetting of the LED indicators.
The functions are activated when a voltage RL is applied to the binary inputs.

<u>Tripping and start outputs</u>

The RXZK 21H relay has one start output for the Z</Z_α< function and two tripping outputs for the Z< function with the time delay t_1 and t_2. Each output is provided with one change-over contact. All outputs reset automatically when the impedance increases to a value over the resetting value of the relay.

4.3 RXZK 22H setting and connection

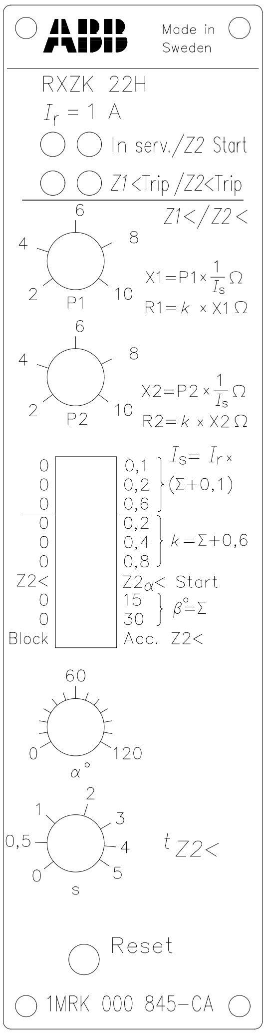


Fig. 27 Front layout

Rated current of the relay, I_r (available variants: 1 A or 5 A)

LED indicators:
In serv. (green): indicates relay in service.
Z2 Start (yellow): indicates operation of Z2< Start or operation of $Z2_\alpha$< Start (no time delay).
Z1< Trip (red): indicates operation of Z1< (no time delay).
Z2< Trip (red): indicates operation of Z2< after the set time delay t_{Z2}<.

Potentiometer (P1) for setting of the reactive reach X1 for Zone 1.

Potentiometer (P2) for setting of the reactive reach X2 for Zone 2.

10-pole programming switch (S1) for setting of scale-constant and functions.

S1:1-3 switches set the scale constant I_s for calculation of X. I_s affects reach of both zones.
S1:4-6 switches set the scale constant k, the multiplier for R1 and R2.
S1: 7 switch determines the operation of the output relay 3. Z2< Start non-directional or $Z2_\alpha$< Start directional.
S1:8-9 switches set the b angle for load discrimination of Z2< operation.
S1:10 switch determines the binary input Bin 1 function. Blocking of all functions except $Z2_\alpha$< or acceleration of Z2<.

Potentiometer (P3) determines the setting of the characteristic angle α×.

Potentiometer (P4) for setting of the time delay t_{Z2}< for the function Z2<.

Reset push-button for LED. Also used to check the LED operation.

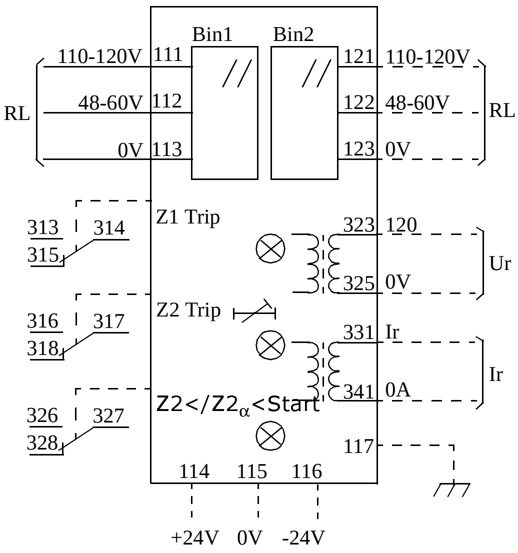


Fig. 28 Terminal diagram

Settings

All settings can be changed while the relay is in normal service. The relay needs a voltage above 10V for proper polarization of the directional function, maximum 250V. Rated voltage is 100V. The relay uses memory voltage in case the input voltage is below 10V during faults (short-circuits). Upon closing into a fault without prior voltage, the relay uses a non-directional circular characteristic. See type test documents 1MRK 509 006-TEN or User´s Guide 1MRK509 006-UEN for further information. The characteristic of the relay is shown in fig.29.

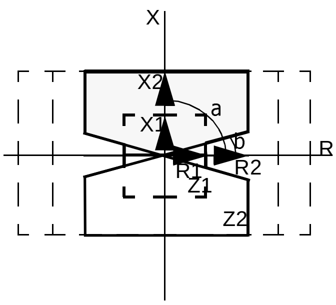


Fig. 29 Characteristic

1. Setting of the scale-constant I_S.

The scale constant I_s is equal to the rated current I_r times the sum of the set value of the switches S1:1, S1:2 and S1:3 plus 0,1. The setting range is from 0,1 to 1,0 × the rated current I_r.

2. Setting of the zone 1 under-impedance function (Z1<)

The setting range of the under-impedance function is expressed as Z1 = jX1 + R1 where X1 and R1 are set as follows:

2.1 Setting of the reactive reach (X1).

The operate value is set with potentiometer P1 according to the formula X1 = P1 * 1/Is (W).

The setting range of P1 is 2-10, corresponding to 2-100 W, for I_r = 1 A and 0,4 - 20 W for I_r = 5 A.

2.2 Setting of the resistive reach (R1).

The operate value is set with the swithes S1:4-6 according to the formula R1 = k · X1 (W), where k is the sum of the switches S1:4, S1:5 and S1:6

plus 0,6 (range 0,6 to 2,0), corresponding to 1,2-200 W, for I_r = 1 A and 0,24 - 40 W for I_r = 5 A.

3. Setting of the zone 2 under impedance function (Z2<).
The setting range of the under-impedance function is expressed as Z2 = jX2 + R2. Both X2 and R2 must be larger than X1 and R1.

3.1 Setting of the reactive reach (X2).
The operate value is set with potentiometer P2 according to the formula X2 = P2 * 1/Is (W).
The setting range of P1 is 2-10, corresponding to 2-100 W, for I_r = 1 A and 0,4 - 20 W for I_r = 5 A.

3.2 Setting of the resistive reach (R2).
The operate value is set according to the formula R2 = k · X2 (W), where k is the same as for R1, corresponding to 1,2-200 W, for I_r = 1 A and 0,24 - 40 W for I_r = 5 A.Thus zone 2 receives the same ratio between the X and R setting as for zone 1.

4. Setting of the directional function Z2$_{\alpha}$<.
Set the programming switch S1:7 to "Z2<" for non-directional function or to "Z2$_{\alpha}$<" for directional function.

5. Setting of the load discrimination area of Z2<.
The angle b is settable by the sum of switches S1:8 and S1:9 to 0°, 15°, 30° and 45°.

6. Setting of the function of binary input Bin 1.
Bin 1 is used for blocking or acceleration functions according to the setting of switch S1:10

1. **Blocking** S1:10 in left position blocks all functions except Z2$_{\alpha}$<
2. **Acceleration Z2<** S1:10 in right position enables instantaneous operation of Z2<.

7**. Setting of the characteristic angle.**
The characteristic angle, α, is settable between 0° to 120°. The angle is adjusted with potentiometer P3.

8. Setting of the time delay $t_{Z2<}$.
The time delay $\mathbf{t_{Z2<}}$ for zone 2 has definite-time characteristic. The setting is done with potentiometer P4. The setting range is 0 - 5 s.

9. The binary inputs.
There are two binary inputs (Bin 1 and Bin 2) on the relay. Bin 1 (terminals 111/112-113) is used for external blocking of all functions except Z2$_{\alpha}$< or acceleration of the Z2< trip function to an instantaneous function on contact 317. Bin 2 (terminals 121/122-123) is used for resetting of the LED indicators. The functions are activated when a voltage RL is applied to the binary inputs.

<u>Tripping and start outputs</u>
The RXZK 22H relay has two tripping outputs for the under-impedance functions (Z1< and Z2<) and one output for the start Z2</Z2$_{\alpha}$< function (non-directional or directional). Each output is provided with one change-over contact. All outputs reset automatically when the impedance increases to a value over the resetting level of the relay.

4.4 RXZK 23H setting and connection

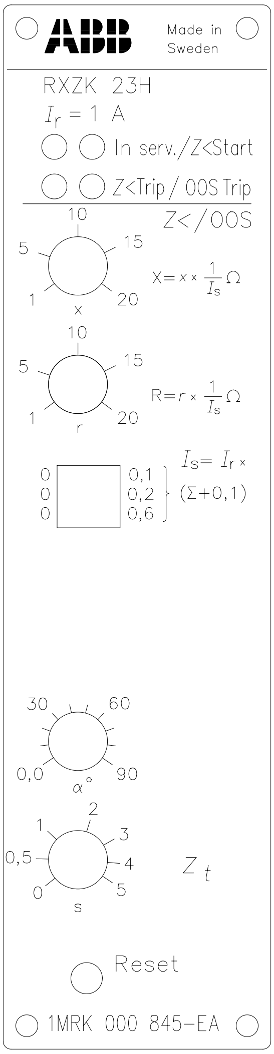


Fig. 30 Front layout

Rated current of the relay, I_r (available variants: 1 A or 5 A)

<u>LED indicators</u>:
In serv. (green): indicates relay in service.
Z< Start (yellow): indicates operation of Z< (no time delay).
Z< Trip (red): indicates operation of Z< after the set time delay.
OOS Trip (red): indicates operation of OOS, out-of-step (no time delay).

Potentiometer (P1) for setting of the reactive reach X.

Potentiometer (P2) for setting of the resistive reach R.

3-pole programming switch (S1) for setting of the scale-constant I_S.

Potentiometer (P3) for setting of the characteristic angle α.

Potentiometer (P4) for setting of the time delay for the delayed Z< trip function.

Reset push-button.

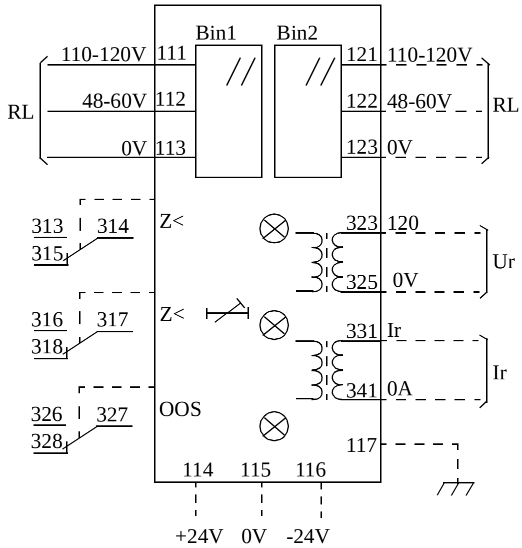


Fig. 31 Terminal diagram

Settings

All settings can be changed while the relay is in normal service.

1. Setting of the scale-constant I_S.

The scale constant I_S is equal to the rated current I_r times the sum of the set value of the switches S1:1, S1:2 and S1:3 plus 0,1. The setting range is from 0,1 to 1,0 × the rated current I_r.

2. Setting of the under-impedance function (Z<).

The setting range of the under-impedance function is expressed as Z = jX + R, where X and R are individually set as follows:

2.1 Setting of the reactive reach (X).

The operate value is set with potentiometer P1 according to the formula X = x * 1/Is (W), where x is the set value of P1.
The setting range of P1 is 1-20. Setting range of X is 1-200 W for I_r = 1 A and 0,2-40 W for I_r = 5 A.

2.2 Setting of the resistive reach (R).

The operate value is set with potentiometer P2 according to the formula R = r * 1/Is (W), where r is the set value of P2.
The setting range of P2 is 1-20. Setting range of R is 1-200 W for I_r = 1 A and 0,2-40 W for I_r = 5 A.

4. Setting of the characteristic angle α.

The characteristic angle, α, is settable between 0° to 90°. The angle is adjusted with potentiometer P3.

5. Setting of the time delay Z_t.

The time delay has definite-time characteristic for the Z< trip function. The setting range is 0 - 5 s. The setting is done with potentiometer P4.

6. The binary input.

There are two binary inputs (Bin 1 and Bin 2) on the relay. Bin 1 (terminals 111/112-113) is used for external blocking of all functions of the relay. Bin 2 (terminals 121/122-123) is used for resetting of the LED indicators. The functions are activated when a voltage RL is applied to the binary inputs.

Tripping and start outputs

The RXZK 23H relay has one start and one tripping output for the under-impedance function, and one trip output for the out- of-step function. Each output is provided with one change-over contact. All outputs reset automatically when the criteria for function decreases below the resetting value of the relay.

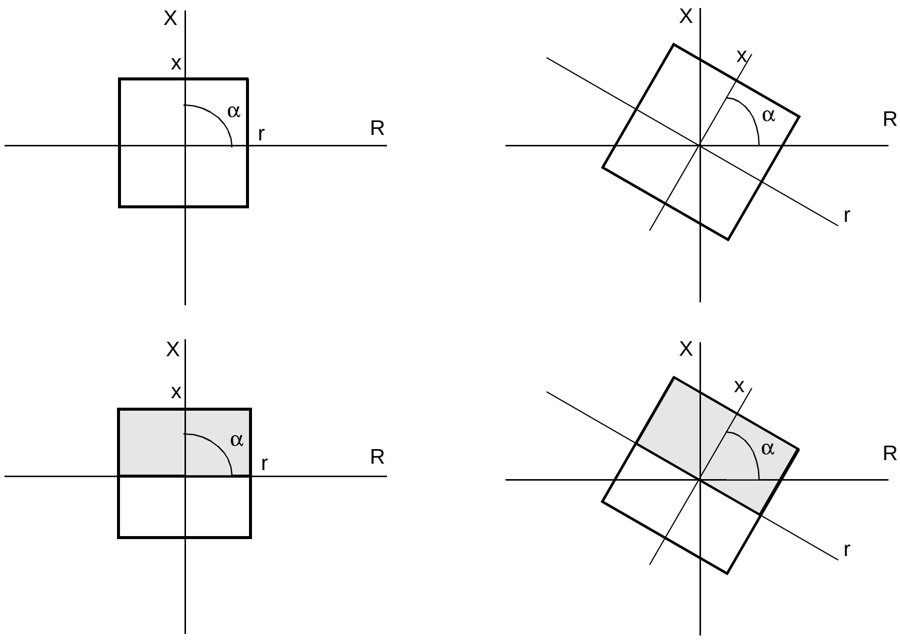
5 Technical Data for Impedance Relay RXZK 21/22/23H

Rated values

RXZK 21H		
Rated voltage U_r	100 V	
Rated current I_r	1 A or 5 A	
Scale constant I_S	(0,1 0,2 0,4 and 1,0) x I_r	
Setting ranges 1 A Variant 5 A Variant	 0,1-1 A 0,5-5 A	
Effective voltage range U	10-200 V	
Effective current range I	(0,5-50) x I_S	
Rated frequency f_r	50-60 Hz	
Setting range:		
Under-impedance function (Z <) Is = 0,1/0,5 Is = 0,2/1 Is = 0,4/2 Is = 1	Rated current 1A 10-200 Ω 5-100 Ω 2-50 Ω 1-20 Ω	Rated current 5A 2-40 Ω 1-20 Ω 0,5-10 Ω 0,2-4 Ω
Operation condition:		
Under-impedance function Z<	$Z = jX + R$	
Reactive reach x	1-20 $X = x \cdot 1/I_S$ (Ω)	
Resistive reach r	1-20 $R = r \cdot 1/I_S$ (Ω)	
Directional function Zα<	Same range as under-impedance function Z<, see figure 1.	
Auxiliary voltage EL	24-250 Vdc, ±20% (RXTUG 22H with output voltage ±24 V)	
Binary input voltage RL	Reconnectable 48-60 V and 110-220 VDC, -20% to +10%	
Maximum current 1 A variant continuously 5 A variant continuously 1 A variant during 1 s 5 A variant during 1 s	 4 A 20 A 100 A 350 A	
Maximum voltage continuously during 10 s	250 V 300 V	

Rated values

Power consumption:			
Current circuit	I = Is = 0,1/0,5 A I = Is = 1/5A	< 0,002 VA < 0,1 VA	
Voltage circuit	U = Ur	< 0,2 VA	
Auxiliary circuit		Max 3,0 W before and max 4,0 W after operation (without RXTUG 22H)	
Binary input	48-60 V 110- 220 V	Max 0,3 W Max 1,5 W	
Permissible ambient temperature		-5° to +55°	
Storage temperature		-20° to +70°	
Impedance function		**Z<**	**Z_α<**
Operate time	(typical)	50 ms	50 ms
Reset time	(typical)	50 ms	50 ms
Reset ratio	(typical)	110%	110%
Time function			
Time delay		Definite time	–
Setting range		0-5 s	–



Settings:

Reactive reach x = 10	Reactive reach x = 10
Resistive reach r = 10	Resistive reach r = 10
α = 90°	α = 60°

Z <, Under-impedance function

Z_α <, Directional under-impedance function

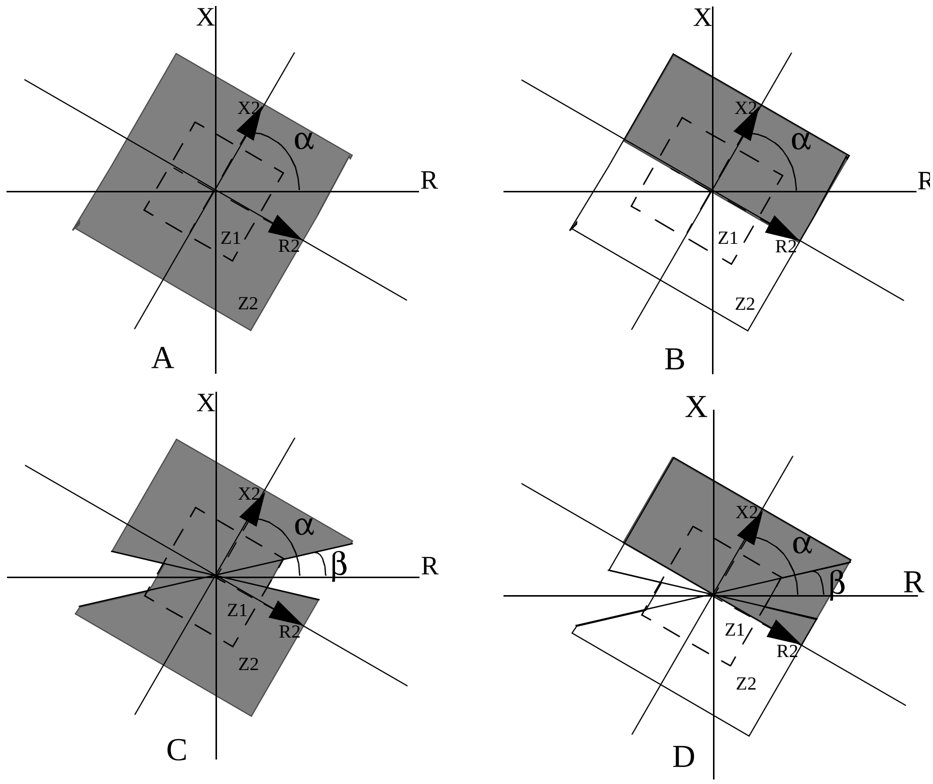
Fig. 1 Characteristic for the under-impedance function

Rated values

RXZK 22H				
Rated voltage U_r	100 V			
Rated current I_r	1 A or 5 A			
Scale constant I_s	(0,1 0,2 0,4 and 1,0) x I_r			
Setting ranges 1 A Variant 5 A Variant	 0,1-1 A 0,5-5 A			
Effective voltage range U	10-200 V			
Effective current range I	(0,5-50) x I_s			
Rated frequency f_r	50-60 Hz			
Characteristic angle αç	0-120°, see figure 2			
Characteristic angle β	0, 15, 30 and 45°, see figure 2			
Setting range for Z1< and Z2<	Rated current 1A		Rated current 5A	
Under-impedance function	X-axis	R-axis	X-axis	R-axis
Is = 0,1 / 0,5 Is = 0,2 / 1 Is = 0,4 / 2 Is = 1 / 5	20-100 Ω 10-50 Ω 5-25 Ω 2-10 Ω	12-200 Ω 6-100 Ω 3-50 Ω 1,2-20 Ω	4-20 Ω 2-10 Ω 1-5 Ω 0,4- 2 Ω	2,4-40 Ω 1,2-20 Ω 0,6-10 Ω 0,24-4 Ω
Operation conditions:				
Under-impedance zone 1	Z1 = jX1 + R1			
Z1< non-directional Setting range P1 Reactive reach x Resistive reach r Constant k	Instantaneous operation. 2-10 X1 = P1 x 1/I_S Ω R1 = X1 x k Ω(0,6-2,0) x P1, in steps of 0,2			
Under-impedance zone 2	Z2 = jX2 + R2			
Z2< non-directional or $Z2_{\alpha}$< directional and Z2< non-directional Setting range P2 Reactive reach x Resistive reach r Constant k	Instantaneous operation. Instantaneous operation, independent of β-angle Time delayed operation 2-10 X2 = P2 x 1/I_S Ω R2 = X2 x k Ω (0,6-2,0) x P2, in steps of 0,2 Note) The impedance reach for zone 1 should not be set higher than zone 2			
Auxiliary voltage EL	24-250 VDC, ±20% (RXTUG 22H with output voltage ±24 V)			
Binary input voltage RL	Reconnectable 48-60 V and 110-220 VDC, -20% to +10%			
Maximum current 1 A variantcontinuously 5 A variantcontinuously 1 A variantduring 1 s 5 A variant during 1 s	 4 A 20 A 100 A 350 A			
Maximum voltagecontinuouslydur-ing 10s	250 V 300 V			
Power consumption:				
Current circuit I = Is = 0,10,5A I = Is = 1/5 A	< 0,002 VA < 0,1 VA			
Voltage circuit U = Ur	< 0,2 VA			
Auxiliary circuit	Max 3,0 W before and max 4,0 W after operation (without RXTUG 22H)			
Binary input 48-60 V 110- 220 V	Max 0,3 W Max 1,5 W			
Permissible ambient temperature	-5° to +55°			
Storage temperature	-20° to +70°			

Rated values

Impedance function	**Z1 <**	**Z2 <**	**$Z2_{\alpha}$ <**
Operate time (typical)	50 ms	50 ms	50 ms
Reset time (typical)	50 ms	50 ms	50 ms
Reset ratio (typical)	105%	105%	105%
Time function			
Time delay	–	Definite time	–
Setting range	–	0 - 5 s	–



In the figures above the non-directional rectangular function Z2< and the directional function $Z2_{\alpha}$< are shown.
The time-delayed function Z2< use the same characteristic as Z2<.

The figures shows the characteristics during normal service.

A: Z2< non-directional characteristic
Setting: P1 = 5, P2 = 10, k = 1, β = 0°, α = 60°

B: $Z2_{\alpha}$< directional characteristic
Setting: P1 = 5, P2 = 10, k = 1, β = 0°, α = 60°

C: Z2< non-directional characteristic
Setting: P1 = 5, P2 = 10, k = 1, β = 15°, α = 60°

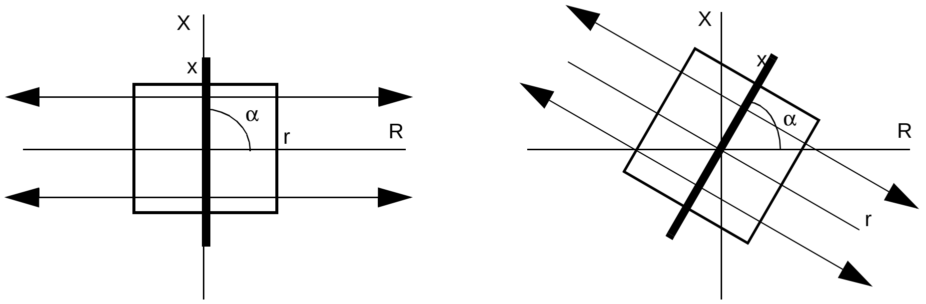
D: $Z2_{\alpha}$< directional characteristic
Setting: P1 = 5, P2 = 10, k = 1, β = 15°, α = 60°

Fig. 2 Characteristic for the under-impedance function

Rated values

RXZK 23H		
Rated voltage U_r	100 V	
Rated current I_r	1 A or 5 A	
Scale constant I_s	(0,1 0,2 0,4 and 1,0) x I_r	
Setting ranges 1 A Variant 5 A Variant	 0,1-1 A 0,5-5 A	
Effective voltage range U	10-200 V	
Effective current range I	(0,5-50) x I_s	
Rated frequency f_r	50-60 Hz	
Characteristic angle α	0-90°, see figure 3	
Setting range:		
Under-impedance function (Z<)	Rated current 1A	Rated current 5A
Is = 0,1 / 0,5 Is = 0,2 / 1 Is = 0,4 / 2 Is = 1 / 5	10-200 Ω 5-100 Ω 2,5-50 Ω 1-20 Ω	2-40 Ω 1-20 Ω 0,5-10 Ω 0,2-4 Ω
Operation conditions:		
Under-impedance function Z<	Z = jX + R	
Reactive reach x	1-20 X = x Þ 1 § I_s Ω	
Resistive reach r	1-20 R = r Þ 1 § I_s Ω	
Out-of-step function OOS	Same range as under-impedance function Z<, see figure 3.	
Over-current function	If the input-current is higher than 50 times selected scale constant (Is), a non-directional over-current function will operate. The relay contacts are the same as for the under-impedance function.	
Auxiliary voltage EL	24 - 250 VDC, ±20% (RXTUG 22H with output voltage ±10%)	
Binary input voltage RL	Reconnectable 48 - 60 V and 110 - 220 VDC, - 20% to + 10%	
Maximum current 1 A variantcontinuously 5 A variant continuously 1 A variant during 1 s 5 A variant during 1 s	 4 A 20 A 100 A 350 A	
Maximum voltage continuously during 10 s	250 V 300 V	
Power consumption:		
Current circuit I = Is = 0,1/0,5 A I = Is = 1/5 A	< 0,002 VA < 0,1 VA	
Voltage circuit U = Ur	< 0,2 VA	
Auxiliary circuit	Max 3,0 W before and max 4,0 W after operation (without RXTUG 22H)	
Binary input 48-60 V 110-220 V	Max 0,3 W Max 1,5 W	
Permissible ambient temperature	-5° to + 55°	
Storage temperature	-20° to + 70°	
Impedance function	**Z <**	
Operate time (typical)	50 ms	
Reset time (typical)	50 ms	
Reset ratio (typical)	110%	
Time function		
Time delay	Definite time	
Setting range	0-5 s	

Rated values



Settings:

Reactive reach x = 10	Reactive reach x = 10
Resistive reach r = 10	Resistive reach r = 10
α = 90°	α = 60°

▭ Z <, Under-impedance function

⟷ OOS, Out-Of-Step function

In order to achieve an out-of-step trip the impedance has to leave the set impedance reach on the opposite side of the characteristic angle (a) from where the impedance entered the set impedance reach.

Fig. 3 Characteristic for the under-impedance function

Insulation tests

RXZK 21H, RXZK 22H, RXZK 23H		Type test values	Ref. Standard
Dielectric test	open circuit other circuit overall open circuit	2,5 kV ac 1 min. 2,0 kV ac 1 min. 1,0 kV ac 1 min.	IEC 60255-5
Impulse voltage test		5 kV 1,2 µs, 0,5 J	IEC 60255-5
Insulation resistance		> 100 M Ω at 500 V DC	IEC 60255-5

Immunity tests

RXZK 21H, RXZK 22H, RXZK 23H	Type test values	Ref. Standard
Surge Immunity test	1 and 2 kV, normal service 2 and 4 kV, withstand test	IEC 61000-4-5, class 3 IEC 61000-4-5, class 4
AC injection test	500 V C C = 10 nF differential mode C = 100 nF common mode	SS 436 15 03 PL 4
Power frequency magnetic field Immunity test	Magnetic field 1000 A/m X, Y, Z-axis 3s	EN 61000-4-8
1MHz burst disturbance test	2,5 kV	IEC 60255-22-1 class 3
Spark test	4-8 kV	SS 436 15 03 PL4
Fast transient tests	4 kV	IEC 60255-22-4 class 4
Electric discharge test with cover on class 4	8 kV (contact discharge) 15 kV (air discharge) 8 kV Indirect application	IEC 60255-22-2 IEC 61000-4-2
Radiated electromagnetic field disturbance test	10 V/m 26-1000 MHz	EN 50082-2
Conducted electromagnetic disturbance test	0,15-80 MHz	EN 50082-2
Interruption in auxiliary voltage	2-200 ms No setting for interruptions < 40 ms	IEC 60255-11

Electromagnetic tests

RXZK 21H, RXZK 22H, RXZK 23H	Type test values	Ref. Standard
Electromagnetic emission, conducted	0,15-30 MHz class A	EN 50081-2
Electromagnetic emission, radiated	30-1000 MHz class A	EN 50081-2

TMechanical tests

RXZK 21H, RXZK 22H, RXZK 23H		Type test values	Ref. Standard
Vibration test	Response test Endurance test	2,0 g, 10-150 Hz 2 g, 10-150 Hz, 20 sweeps	IEC 60255-21-1, class II IEC 60255-21-1, class II
Shock tests	Response test Endurance test	5 g, 11 ms, 3 pulses 15 g, 11 ms, 3 pulses	IEC 60255-21-2, class I IEC 60255-21-2, class I
Bump test		10 g, 16 ms, 1000 pulses	IEC 60255-21-2, class I
Seismic tests	X-axis Y-axis Z-axis	3 g, 1-50 Hz 3 g, 1-50 Hz 2 g, 1-50 Hz	IEC 60255-21-3, class II IEC 60255-21-3, class II IEC 60255-21-3, class II

Contact data

RXZK 21H, RXZK 22H, RXZK 23H		Type test values
Highest system voltage		250 V ac, dc
Current carrying capacity	continuous during 1 s	5 A 15 A
Making and conducting capacity	during 0,2 s during 1 s	30 A 10 A
Breaking capacity	ac, cos φ >0,4, 250 V dc, L/R, < 40 ms 48 V 110 V 220 V 250 V	8 A 1,0 A 0,4 A 0,2 A 0,15 A

Additional general data

RXZK 21H, RXZK 22H, RXZK 23H	Type test values
Dimensions	4U 6C
Weight	0,7 kg

6 Receiving and handling

Remove the protection package from the transport case and make a visual inspection for transport damages. Check that all screws are firmly tightened and all relay elements are securely fastened.

Check that all units are included in accordance with the apparatus list.

Normal ESD (Electrostatic Discharge) precautions for microprocessor relays should be observed when handling the packages and separate relay units. Always avoid to touch the printed circuit board and components unless a proper grounding is secured.

If the protection package is to be stored before installation, this must be done in a dry and dust-free place, preferably in the original transport case.

7 Installation

The relays and the RXTUG 22H DC-DC converter are plugged into COMBIFLEX“ terminal bases type RX 4 or RX 2H. The terminal bases and the RTXP 18 test switch, when included, are fixed on apparatus bars to make up the protection assembly.

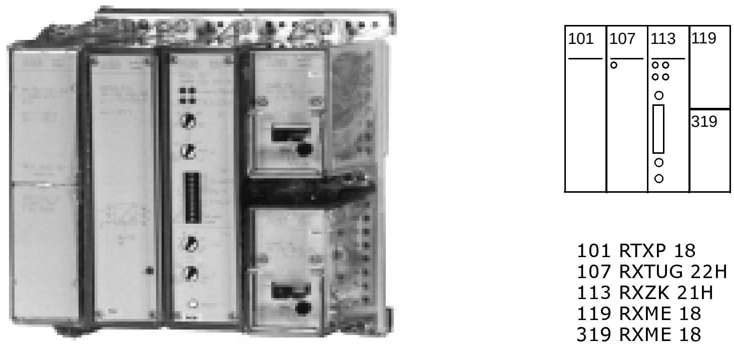


Fig. 32 RAZK 1 single phase impedance protection.

The protection assembly can be mounted in the following ways:

- on apparatus bars
- in a 19” equipment frame
- in RHGX case
- in RHGS case

The height and width of the protection assembly are given in the circuit diagram with height (U) and width (C) modules, where U = 44,45 mm and C = 7 mm. The depth of the protection assembly, including space for the connection wires, is approximately 200 mm.

All internal connections are made and the protection assembly is tested before delivery from factory.

Equipment frames and relay cases.
Detailed information on the COMBIFLEX“ connection and installation components is given in Catalogue 1MRK 513 003-BEN. Information on the relay mounting system is given in Catalogue 1MRK 514 001-BEN.

Case RHGS

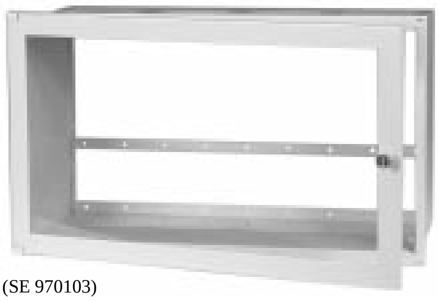

(SE 970103)

Fig. 33 RHGS case

RHGS cases for 19” cubicle mounting or surface mounting
This type of case can be used for all common ways of mounting. The RHGS cases are available in three different sizes, which can be combined with mounting accessories to get maximum flexibility. The cases can also be combined together with the protections in the 500 range.

RHGX 8


(SE 81702)

Fig. 34 RHGX case

RHGX cases for flush- or semi-flush panel mounting
The RHGX cases are available in five sizes. The case, a metal box open at the back, has a flange (with a rubber sealing strip) at the front which acts as a stop when the case is inserted into a front panel opening. At the front of the case there is a door with a window and a rubber seal.

Size: 4U 19”


(SE 96399)

Fig. 35 19” equipment frame

19” equipment frames
These types of equipment frames are used for cubicle mounting or panel mounting of plug-in units in the COMBIFLEX“ range. The frames are available in 3 sizes:

4U (17” x 19”)

8U (14” x 19”)

12U (21” x 19”)

for mounting 20, 40 and 60 module seats respectively.

Detailed information on the COMBIFLEX" connection and installation components is given in Catalogue 1MRK513 003-BEN.

7.1 Connections

The external connections (dotted lines on the terminal and circuit diagrams) are made with leads with 20 A COMBIFLEX" sockets to the RTXP 18 test switch and with 10 A sockets to the relay terminal bases.

Each unit in the protection assembly has a unique item designation. The item designations are based on a coordinate system of U and C modules, where the first figure stands for the U-module position starting from the left-hand side - seen from the front side of the protection assembly - and the nest two figures stand for the C-module position, starting from the top. The RTXP test switch in the example has item designation 101, where the first figure stands for the U-module position and the next two figures stand for the C-module designation.

The terminal designations include the item designation number of the unit followed by the terminal number marked on the rear of the terminal socket.

For plug-in units size 2H an additional figure 1 or 3 defines if the terminal is in the upper resp. lower part of the assembly.

Fig. below shows the rear of protection assembly RAZK, Order No. 1MRK 001 030-EA. The position of the terminals, which are used for external connections acc. to connection diagram 1MRK 001 030-EAA, is shown.

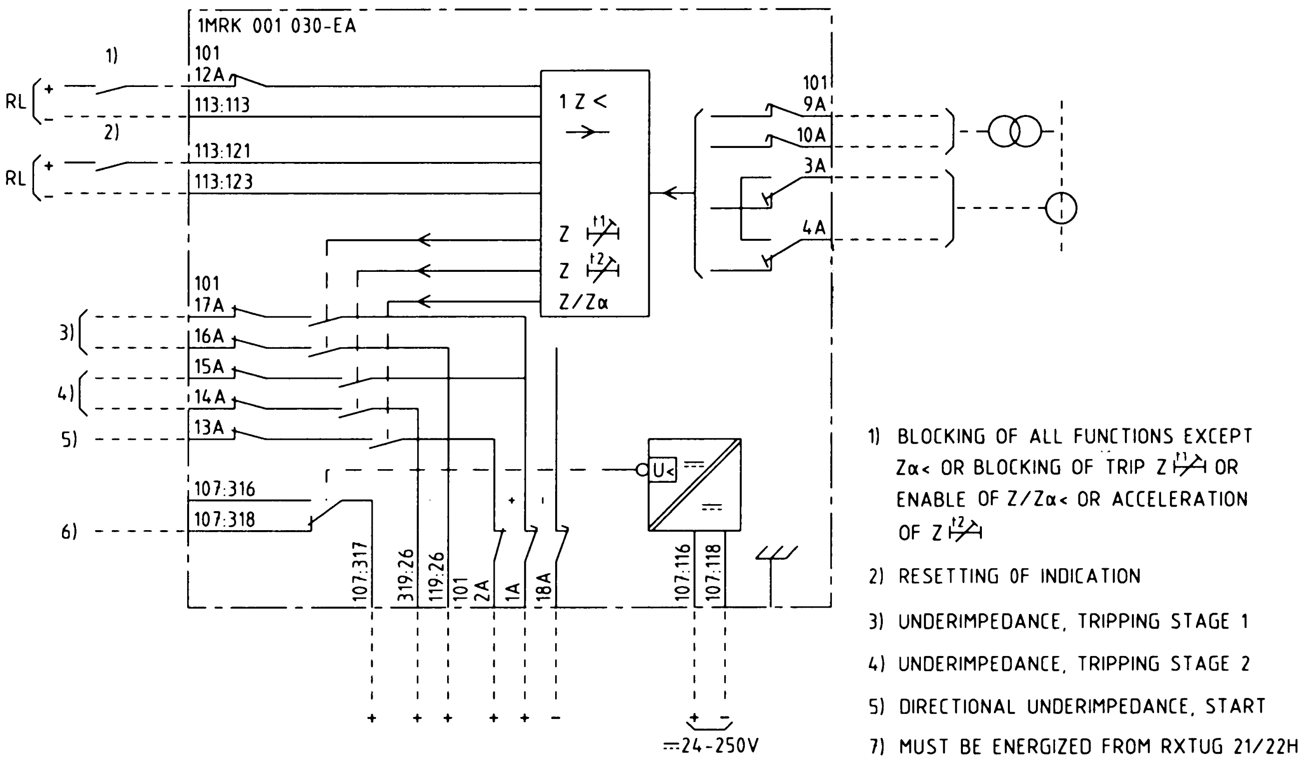


Fig. 36 Terminal diagram 1MRK 001 030-EAA

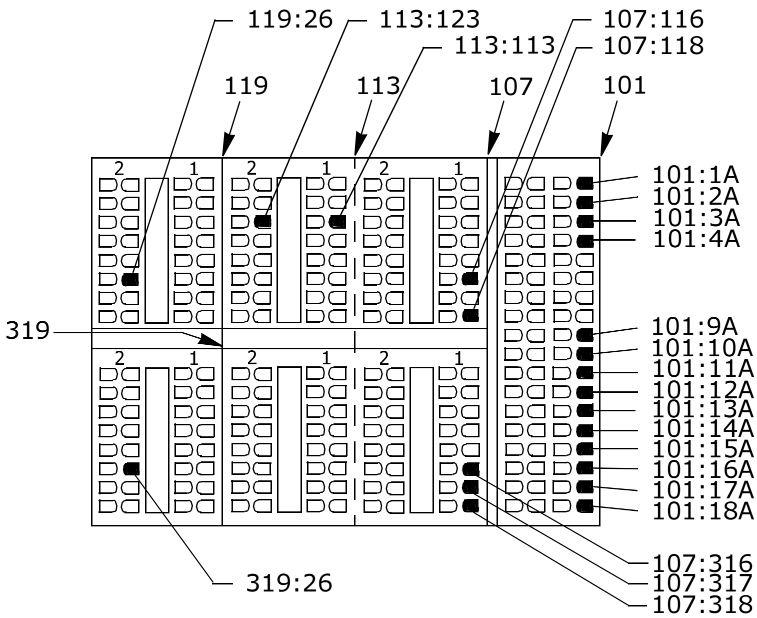


Fig. 37 Location of the terminals shown on diagram 1MRK 001 030-EAA

7.2 Testing

Secondary injection testing

The basic versions of the assemblies are provided with the COMBITEST test switch type RTXP 18.

When the test-plug handle RTXP 18 is inserted in the test switch, preparations for testing are automatically carried out in the proper sequence, i.e. blocking of the tripping circuits, opening of the VT circuits and making relay terminals accessible for testing.

When the test handle is in the intermediate position, only the tripping circuits are opened. When the test handle is fully inserted, the relay is completely disconnected from the current transformers and ready for secondary injection testing.

Relays which are not provided with test switch have to be tested in the proper way from external circuit terminals.

For testing of impedance relays, a test apparatus with supply of independent single phase voltage and current should be used. The independence should include a possibility for phase angle variation.

Suitable test equipment:

- Test set SVERKER for a simplified test
- Test set FREJA for a complete test
- RTXH 18 test plug with test leads

7.2.1 Complete functional testing

7.2.1.1 RXZK 21H

1.Connections: Connect the test set according to figure 38 to test the relay functions for phase L1 and insert the test-plug into the test switch**.**

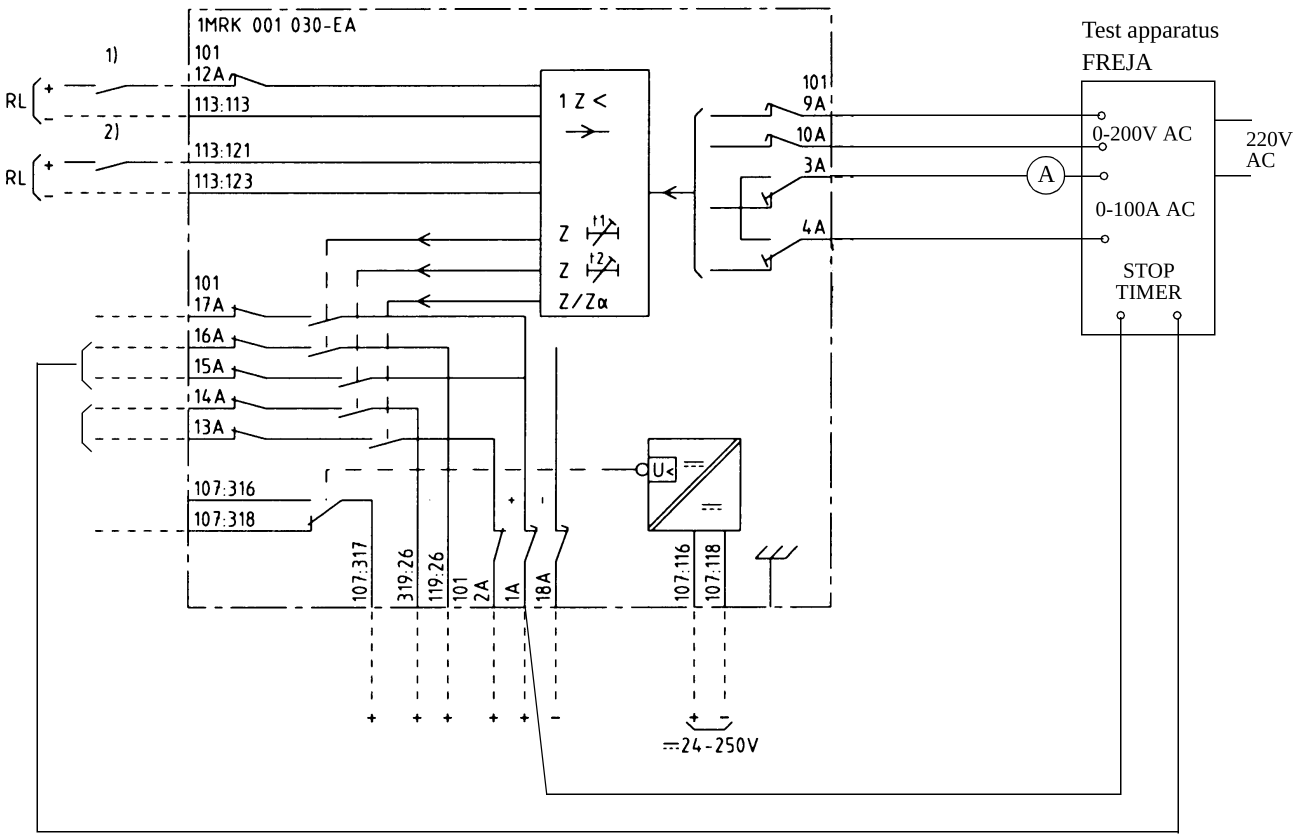


Fig. 38 Connection of test apparatus for testing of phase L1

2. Settings: Make the appropriate settings of relay functions, operate impedance, time delays and the function of the digital input. Guide for the setting of the switches and potentiometers on the front of the relays is given in *Section 7*, Setting.

Connect auxiliary voltage to test terminal 11 to activate the digital input if this is required for the relay function.

3. Measuring quantities for the relay: During the functional test the input voltage always has to be over 10 V. Select a current level according to the table below:

Potentiometer r and x within range	Input current
1 - 5	15 x I_S
5 - 10	5 x I_S
10 - 15	2 x I_S
15 - 20	1 x I_S

4. Testing the a **angle:** Set the Z</Zα< stage to operate at Zα< and enable the stage to operate. Energize the relay with half the set impedance and increase the current phase-angle towards α-90° until the start relay (Zα<) for phase L1 operates (output voltage on test terminal 13). Check the reset value.

5. Testing the X and R settings: Set the Z</Zα< stage to operate at Z< and enable the stage to operate. Apply more than the setted impedance on the voltage/current inputs. Decrease the injection voltage, with phase angle equal to α, until the start relay (Z<) for phase L1 operates (X direction). Change then the injected phase angle to α-90°. Decrease the injected voltage until the start relay (Z<) for phase L1 operates again (R direction).

Check also that the LED indicator for start is activated when Z< operates. Check the resetting values.

6. Testing the time delays: Move the timer stop wire from test terminal 13 to the test terminal 17 (t1). Energize the relay with twice the setted impedance and decrease the voltage to zero. Check the time delay and that the designated LED indicator is activated (“Trip 1”). Repeat the procedure for test terminal 15 (t2 and “Trip 2”).

Press the reset button and check that the LED indicators resets properly. Check also that the Binary input 2 resets the LED indicators.

7. Testing selected function: Set the Z</Zα< stage to operate at desired function. Check that the binary input operates properly according to *Section 7*, Setting.

7.2.1.2 RXZK 22H

1. Connections: Connect the test set according to figure 39 to test the relay functions for phase L1 and insert the test-plug into the test switch

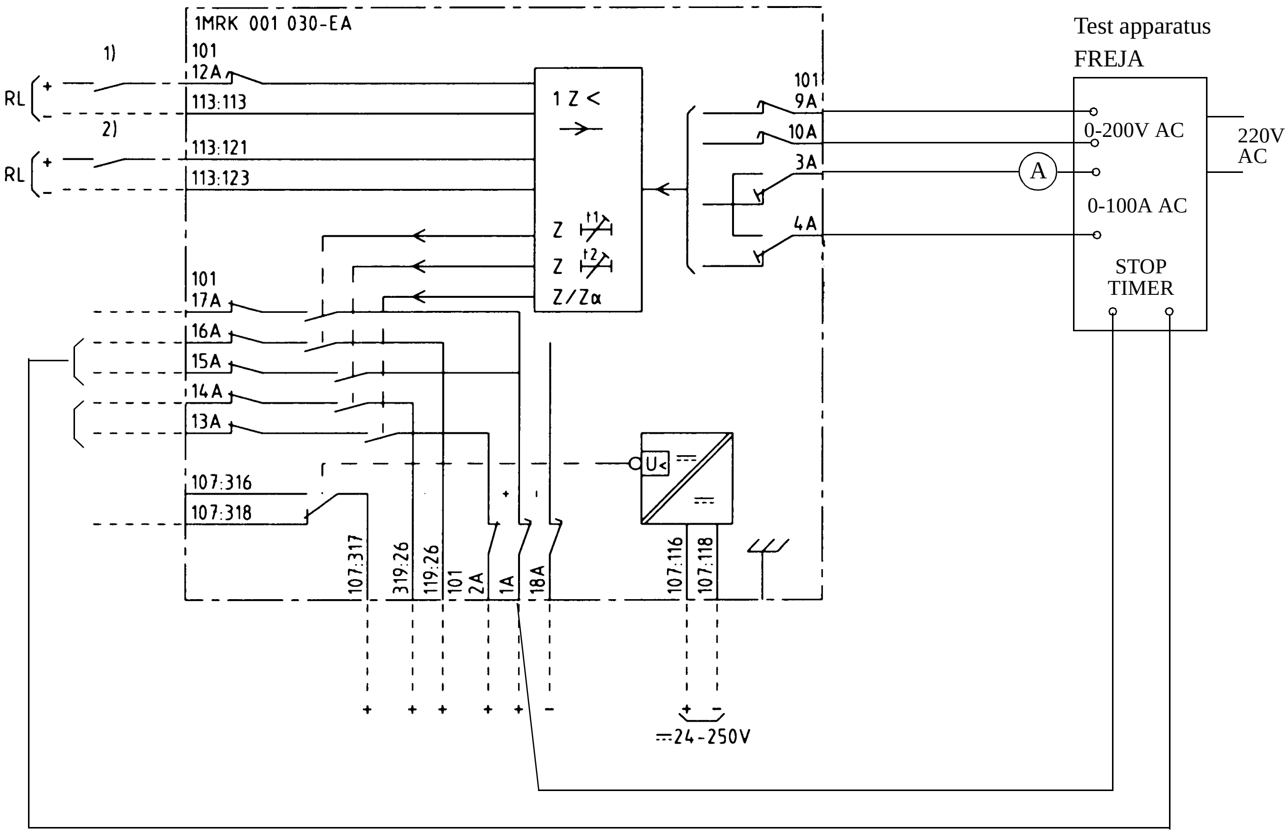


Fig. 39 Connection of test apparatus for testing of phase L1

2. Settings: Make the appropriate settings of relay functions, operate impedance, time delays and the function of the digital input. Guide for the setting of the switches and potentiometers on the front of the relays is given in *Section 7*, Setting.

Connect auxiliary voltage to test terminal 11 to activate the digital input if this is required for the relay function.

3. Measuring quantities for the relay: During the functional test the input voltage always has to be over 10 V. Select a current level according to the table below:

Potentiometer P1 and P2 within range	Input current
1 - 5	15 x I_S
5 - 10	5 x I_S
10 - 15	2 x I_S
15 - 20	1 x I_S

4. **Testing the α angle:** Set the Z2</Z2α< stage to operate at Z2α< and enable the stage to operate. Energize the relay with half the setted impedance and increase the current phase-angle towards α-90° until the start relay (Z2α<) for phase L1 operates (output voltage on test terminal 13). Check the reset value.

5. Testing the X and R settings: Set the Z2</Z2α< stage to operate at Z2< and enable the stage to operate. Set the b angle to zero. Apply then more than the setted impedance on the voltage/current inputs. Decrease the injection voltage, with phase angle equal to a, until the start relay (Z2<) for phase L1 operates (X direction). Change then the injected phase angle to α-90°. Decrease the injected voltage until the start relay (Z2<) for phase L1 operates again (R direction). Repeat the procedure for the Z1< stage (test terminal 15) with the time delay set to zero.

Check also that the LED indicator for start is activated when Z1<and Z2< operates. Check the resetting values.

6. Testing the time delays: Move the timer stop wire from test terminal 15 to the test terminal 17 ($t_{Z2<}$). Energize the relay with twice the setted impedance and decrease the voltage to zero. Check the time delay and that the designated LED indicator is activated (“Z2< Trip”).

Press the reset button and check that the LED indicators resets properly. Check also that the Binary input 2 resets the LED indicators.

7. Testing the b **angle:** Select appropriate b angle and energize the relay with impedance between the Z1< and the Z2< settings. Rotate the phase angle from 0° and check the Z2< start function (test terminal 13) according to the operate angle.

8. Testing selected function: Set the relay to operate at desired functions. Check that the binary input operates properly according to *Section 7*, Setting.

7.2.1.3 RXZK 23H

1. Connections: Connect the test set according to figure 40 to test the relay functions for phase L1 and insert the test-plug into the test switch**.**

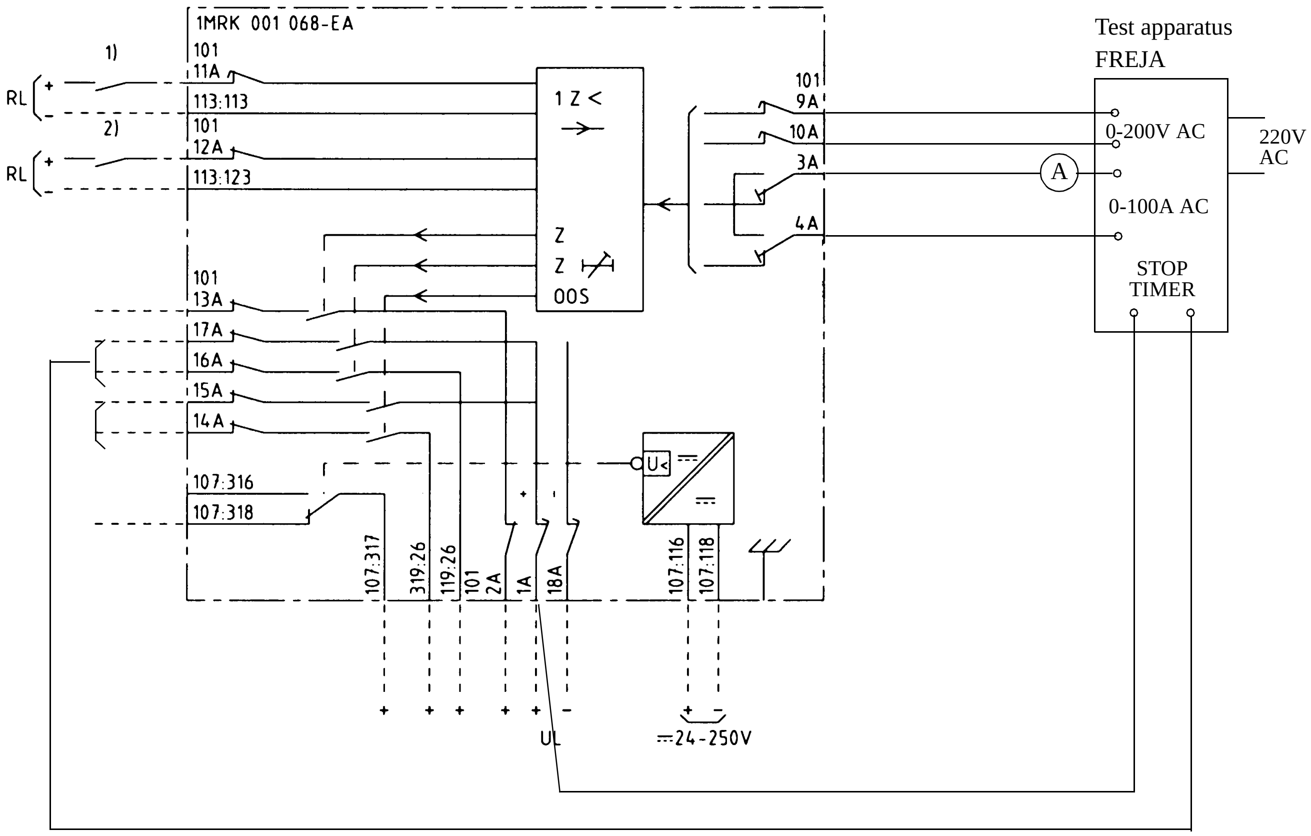


Fig. 40 Connection of test apparatus for testing of phase L1

2. Settings: Make the appropriate settings of relay functions, operate impedance, time delays and the function of the digital input. Guide for the setting of the switches and potentiometers on the front of the relays is given in *Section 7*, Setting.

Connect auxiliary voltage to test terminal 11 to activate the digital input if this is required for the relay function.

3. Measuring quantities for the relay: During the functional test the input voltage always has to be over 10 V. Select a current level according to the table below:

Potentiometer r and x within range	Input current
1 - 5	15 x I_S
5 - 10	5 x I_S
10 - 15	2 x I_S
15 - 20	1 x I_S

4. **Testing the** a **angle:** Set the Z< stage to operate at minimum resistive reach (R) and maximum reactive reach (X). Energize the relay with half the setted reactive impedance and increase the current phase-angle towards α-90° until the start relay (Z<) for phase L1 operates (output voltage on test terminal 13). Notice the operate phase-angle (j1). Continue to rotate the phase-angle until the Z< function resets. Then start to decrease the phase-angle until the Z< function operates again. Notice the operate phase-angle (j2). Calculated the a angle according to formula below. Use negative values in case of crossing the j = 0 axis (j1=350× => j1=-10×).

$$a = \varphi 1 + \frac{\varphi 2 - \varphi 1}{2}$$

5. Testing the X and R settings: Set the Z< stage to operate at desired reach. Apply then more than the setted impedance on the voltage/current inputs. Decrease the injection voltage, with phase-angle equal to α, until the start relay (Z<) for phase L1 operates (X direction). Change then the injected phase angle to α-90°. Decrease the injected voltage until the start relay (Z<) for phase L1 operates again (R direction).

Check also that the LED indicator for start is activated when Z< operates. Check the resetting values.

6. Testing the OOS function: (output voltage on testterminal 13) Apply more than the setted impedance on the voltage/current inputs with a phase-angle equal to α-90°. Decrease the applied voltage to zero, increase the phase-angle 180°, increase the voltage until the OOS trip function operates.

To reset the OOS-trip function the input current must decrease below 0,5 x I_s.

7. Testing the time delay: Move the timer stop wire from test terminal 15 to the test terminal 16 (Z< Trip). Energize the relay with twice the setted impedance and decrease the voltage to zero. Check the time delay and that the designated LED indicator is activated (“Z< Trip”).

Press the reset button and check that the LED indicators resets properly. Check also that the Binary input 2 resets the LED indicators.

8. Testing the selected function: Set the relay to operate at desired settings. Check that the binary input operates properly according to *Section 7*, Setting.

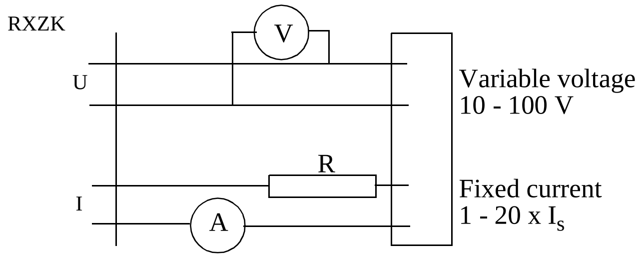
7.2.2 Simplified testing

Simplified testing/verification can be performed with:

Test set SVERKER or a single phase voltage and current generator.
Two multimeters, class 0,5 or better.

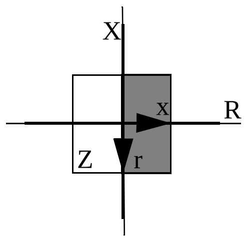
The simplified testing is useful for verification of that the relay operates, not to verify exact operating values.

Simplified testing/verification with a generator, principle sketch.

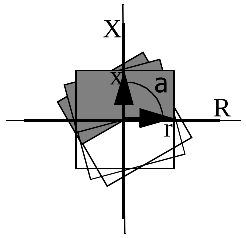


During the test the input-voltage always has to be over 10 V.
Select a resistor R that makes I typical according to the table below:

r and x-value within range:	Input-current
1 - 5	15 x Is
5 - 10	5 x Is
10 - 15	2 x Is
15 - 20	1 x Is

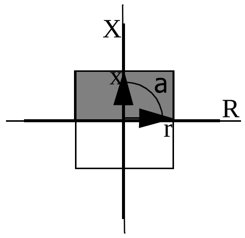


1 Check x-value for reactive reach.
Set the operate value for directional function Zα<.
Set the relay angle to 0 degrees for checking x-value.



2 Adjust relay angle a **to 90 degrees.**
Set the relay angle to 120 degrees. (RXZK 23H, α = 90 degrees.)
Set the r-value to maximum.
Energize the relay with half set impedance according to r-value.
Adjust the relay angle towards 90 degrees until Zα< Start occurs.

3 Check r-value for resistive reach.
Set the operate value for non-directional function Z<.
Check the r-value.



3 Select function.
Switch between non-directional or directional Start function Z< / Zα<.

7.3 Commissioning

Besides testing according to 7.2 the commissioning work includes check of all external circuits connected to the protection and check of voltage ratio for the VTs and directional connections.

The DC circuits and tripping circuits should be checked, including operation of the circuit-breaker(s).

8 Maintenance

Under normal conditions, the impedance protection relays require no special maintenance. The covers should be mounted correctly in position and the holes for the resetting knobs sealed with plastic plugs.

In exceptional cases, burned contacts on the output relays can be dressed with a diamond file.

Under normal operating conditions and when the surrounding atmosphere is of non-corrosive nature, it is recommended that the relays be routine tested every four to five years.

9 Circuit and terminal diagrams

The table below shows the different variants of the under impedance protection RAZK.

Type	Number of measuring relays	Test switch	DC-DC con-verter	Tripping relay	Ordering No. 1MRK 001	Circuit Diagram 1MRK 001	Terminal diagram 1MRK 001	Dia-grams
RAZK 211	1	x			029-BA	030-BA	030-BAA	On request
RAZK 211	1		x		029-CA	030-CA	030-CAA	On request
RAZK 211	1	x	x		029-DA	030-DA	030-DAA	On request
RAZK 211	1	x	x	x	029-EA	030-EA	030-EAA	Attached
RAZK 213	3	x			029-NA	030-NA	030-NAA	On request
RAZK 213	3	x	x		029-PA	030-PA	030-PAA	On request
		x	x		029-PB	029-PB	029-PBA	On request
RAZK 213	3		x		029-YA	030-YA	030-YAA	On request
RAZK 213	3	x	x	x	029-ZA	030-ZA	030-ZAA	On request
		x	x	x	029-ZB	029-ZB	029-ZBA	Attached
RAZK 221	1 (2xt)	x			064-BA	065-BA	065-BAA	On request
RAZK 221	1 (2xt)		x		064-CA	065-CA	065-CAA	On request
RAZK 221	1 (2xt)	x	x		064-DA	065-DA	065-DAA	On request
RAZK 221	1 (2xt)	x	x	x	064-EA	065-EA	065-EAA	On request
RAZK 223	3 (2xt)	x			064-NA	065-NA	065-NAA	On request
RAZK 223	3 (2xt)	x	x		064-PA	065-PA	065-PAA	On request
		x	x		064-PB	064-PB	064-PBA	On request
RAZK 223	3 (2xt)		x		064-YA	065-YA	065-YAA	On request
RAZK 223	3 (2xt)	x	x	x	064-ZA	065-ZA	065-ZAA	Attached
		x	x	x	064-ZB	064-ZB	064-ZBA	Attached
RAZK 231	1	x			067-BA	068-BA	068-BAA	On request
RAZK 231	1		x		067-CA	068-CA	068-CAA	On request
RAZK 231	1	x	x		067-DA	068-DA	068-DAA	On request
RAZK 231	1	x	x	x	067-EA	068-EA	068-EAA	Attached
RAZK 233	3	x			067-NA	068-NA	068-NAA	On request
RAZK 233	3	x	x		067-PA	068-PA	068-PAA	On request
RAZK 233	3		x		067-YA	068-YA	068-YAA	On request
RAZK 233	3	x	x	x	067-ZA	068-ZA	068-ZAA	On request

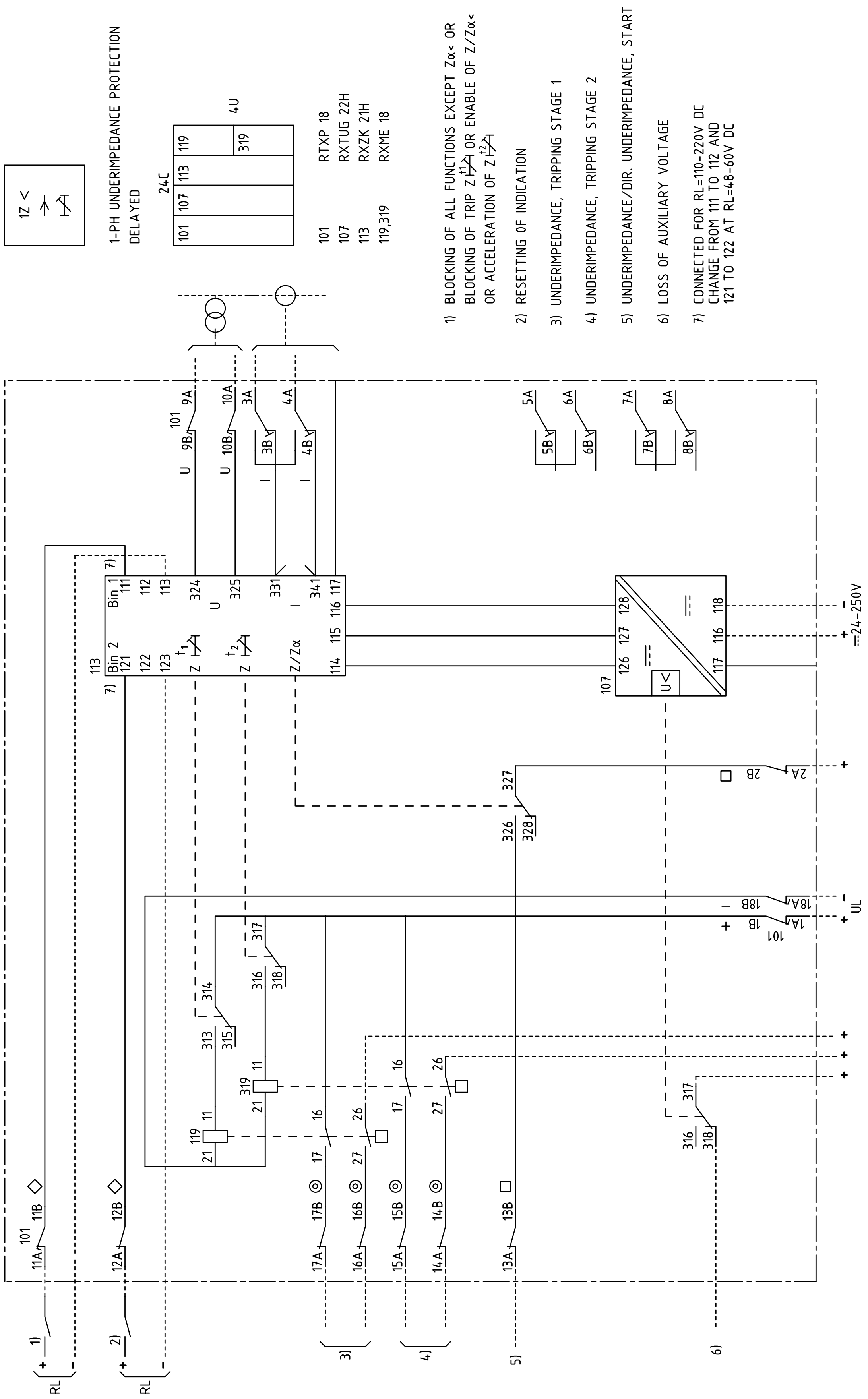


Fig. 41 Circuit diagram 1MRK 001 030-EA

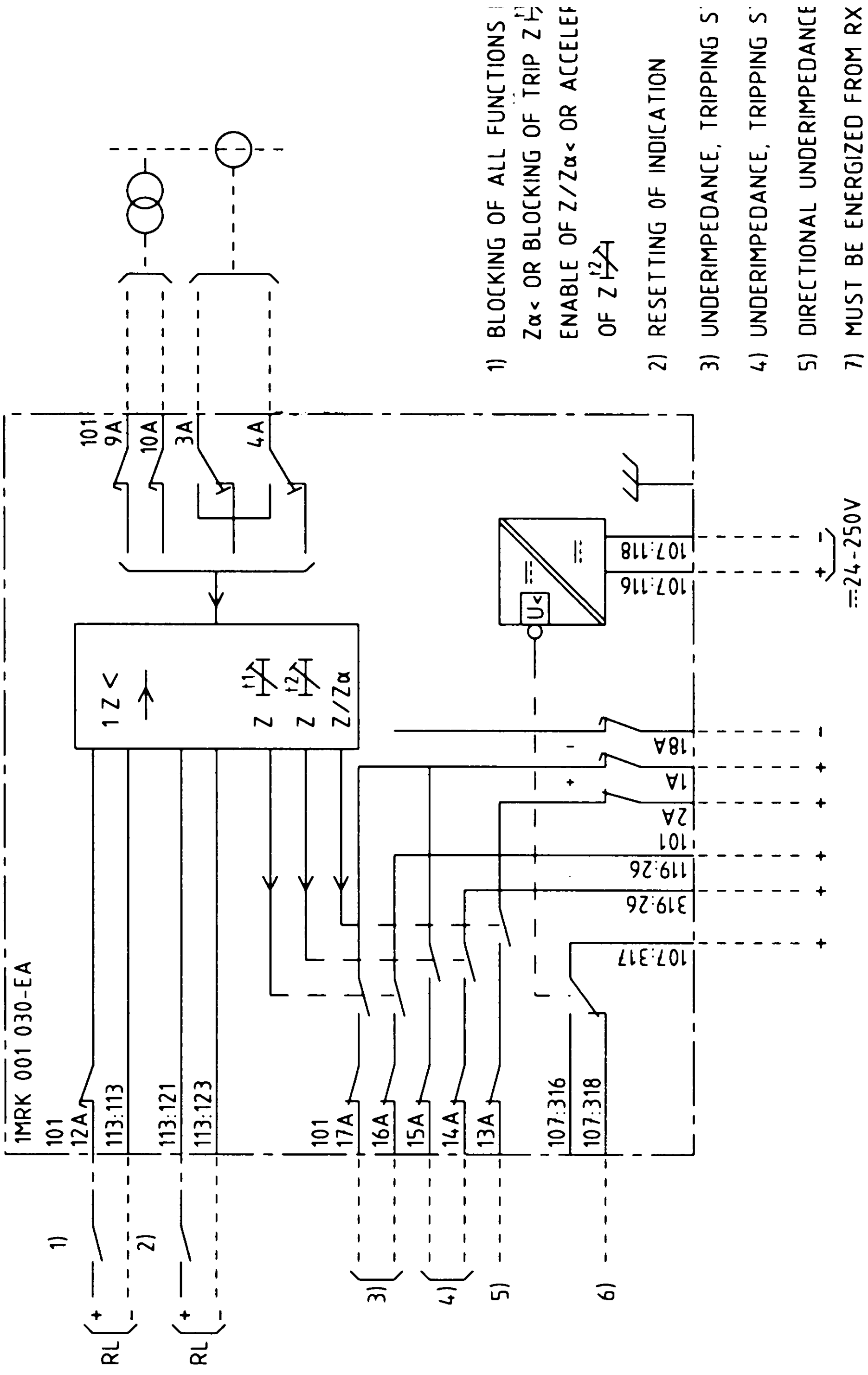


Fig. 42 Terminal diagram 1MRK 001 030-EAA

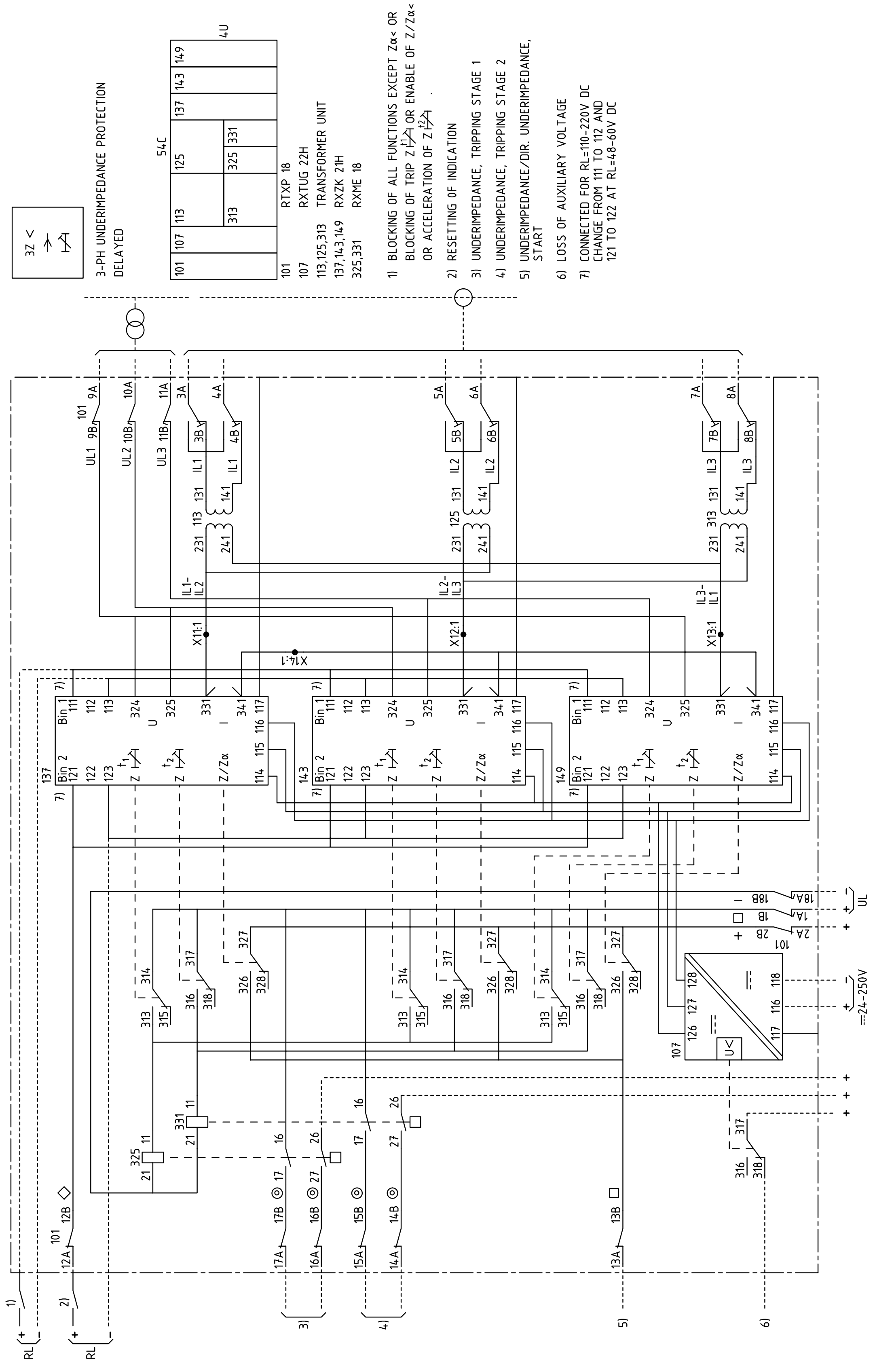


Fig. 43 Circuit diagram 1MRK 001 030-ZB

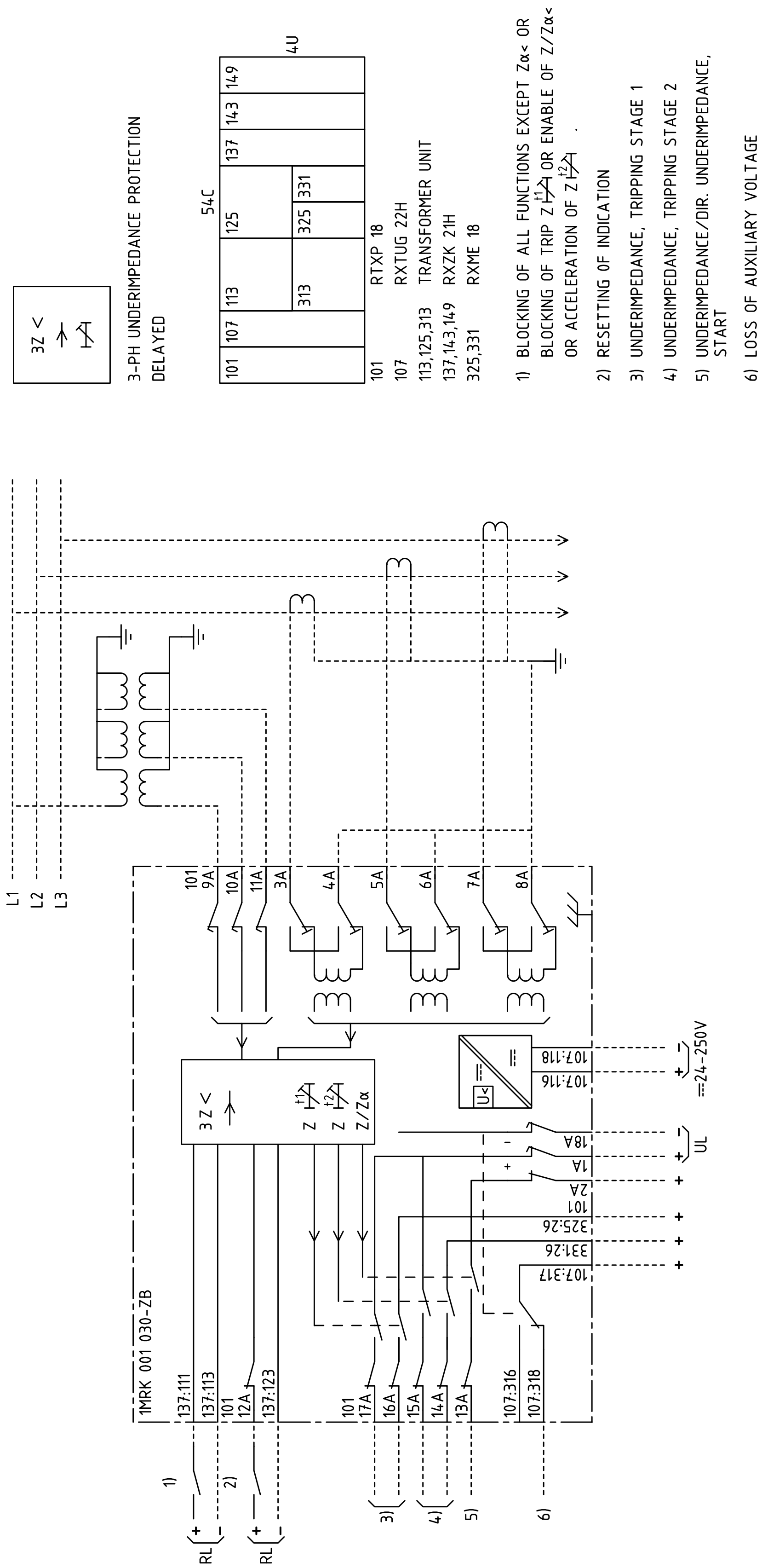


Fig. 44 Terminal diagram 1MRK 001 030-ZBA

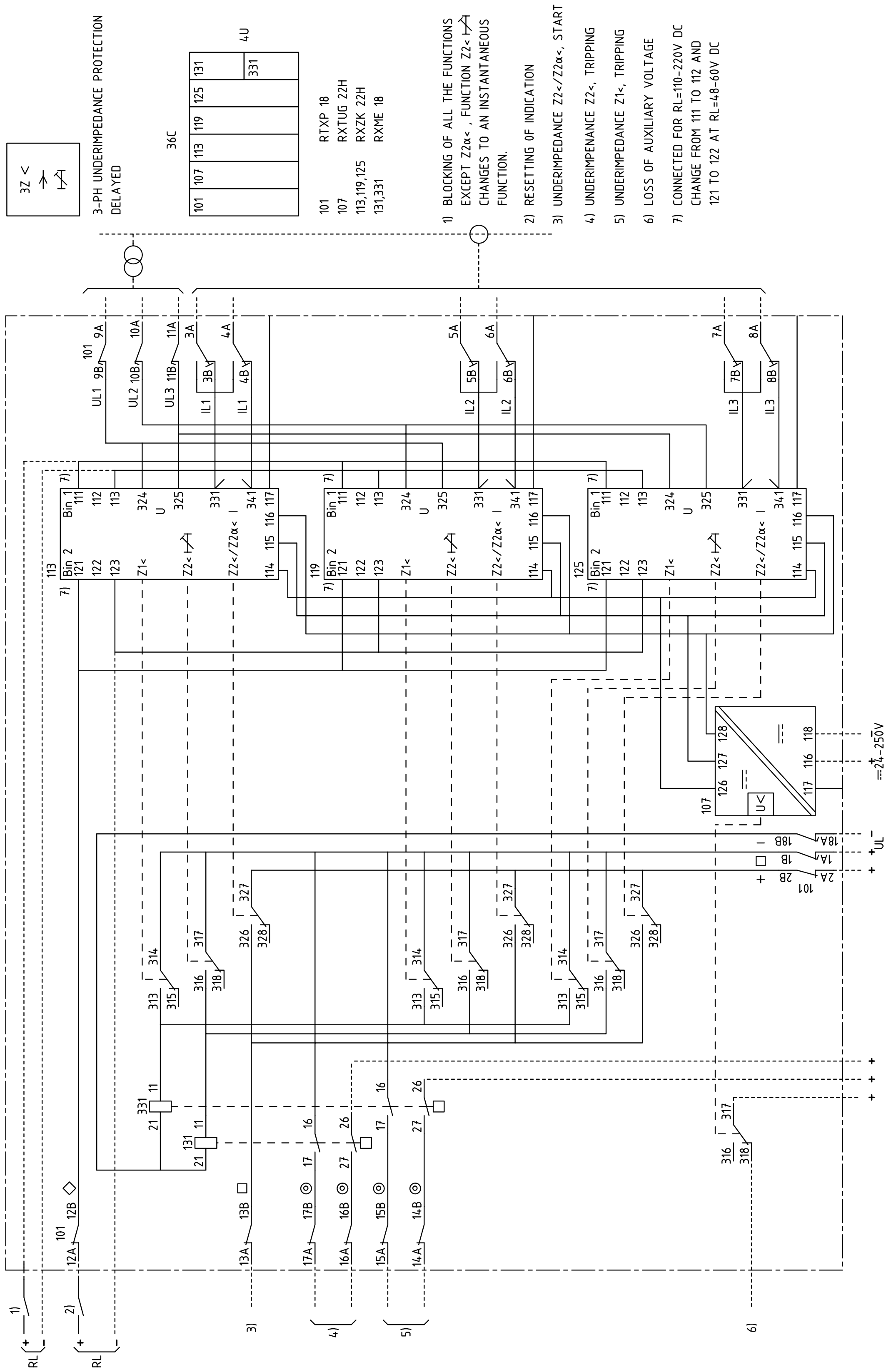


Fig. 45 Circuit diagram 1MRK 001 065-ZA

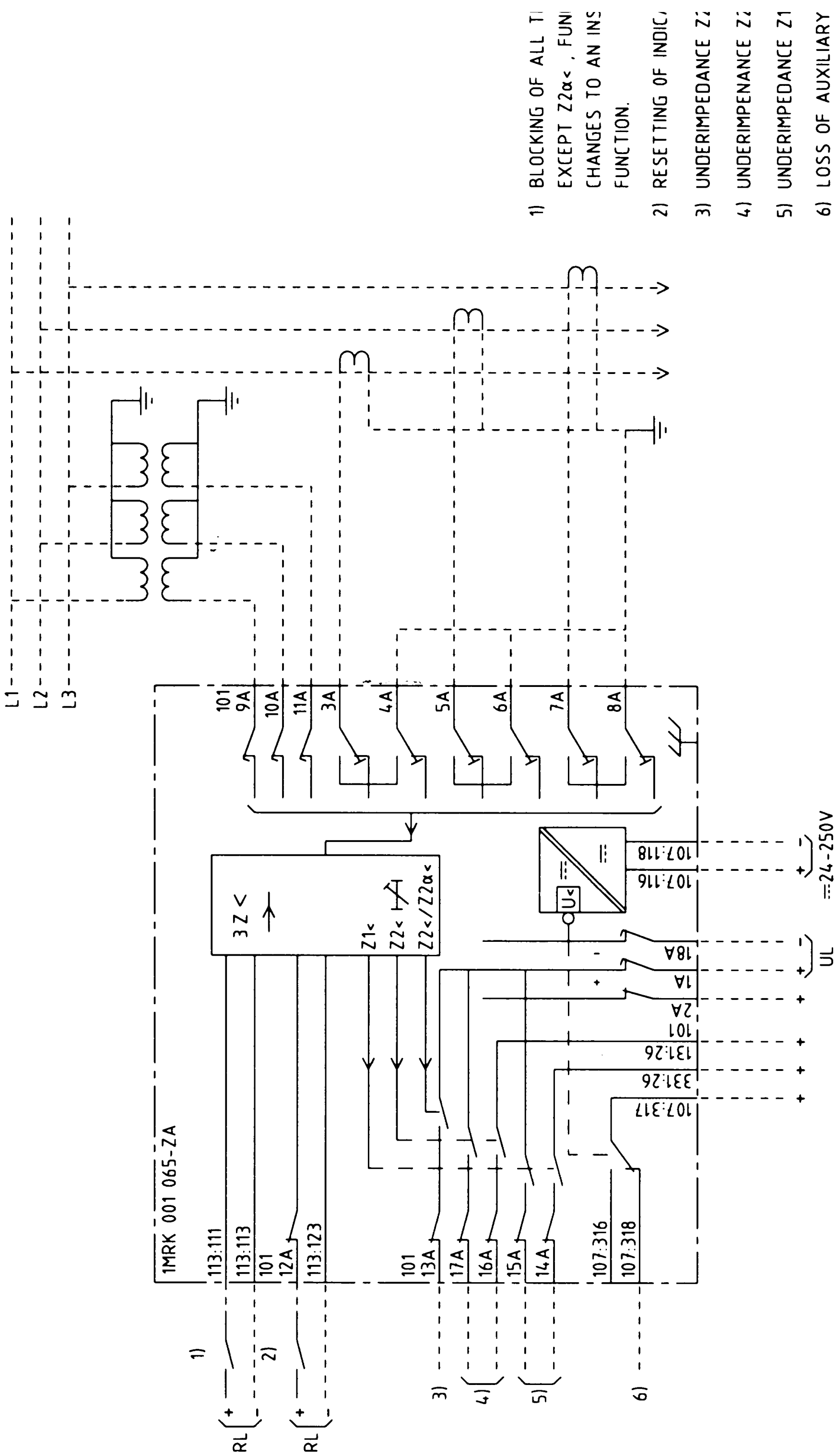


Fig. 46 Terminal diagram 1MRK 001 065-ZAA

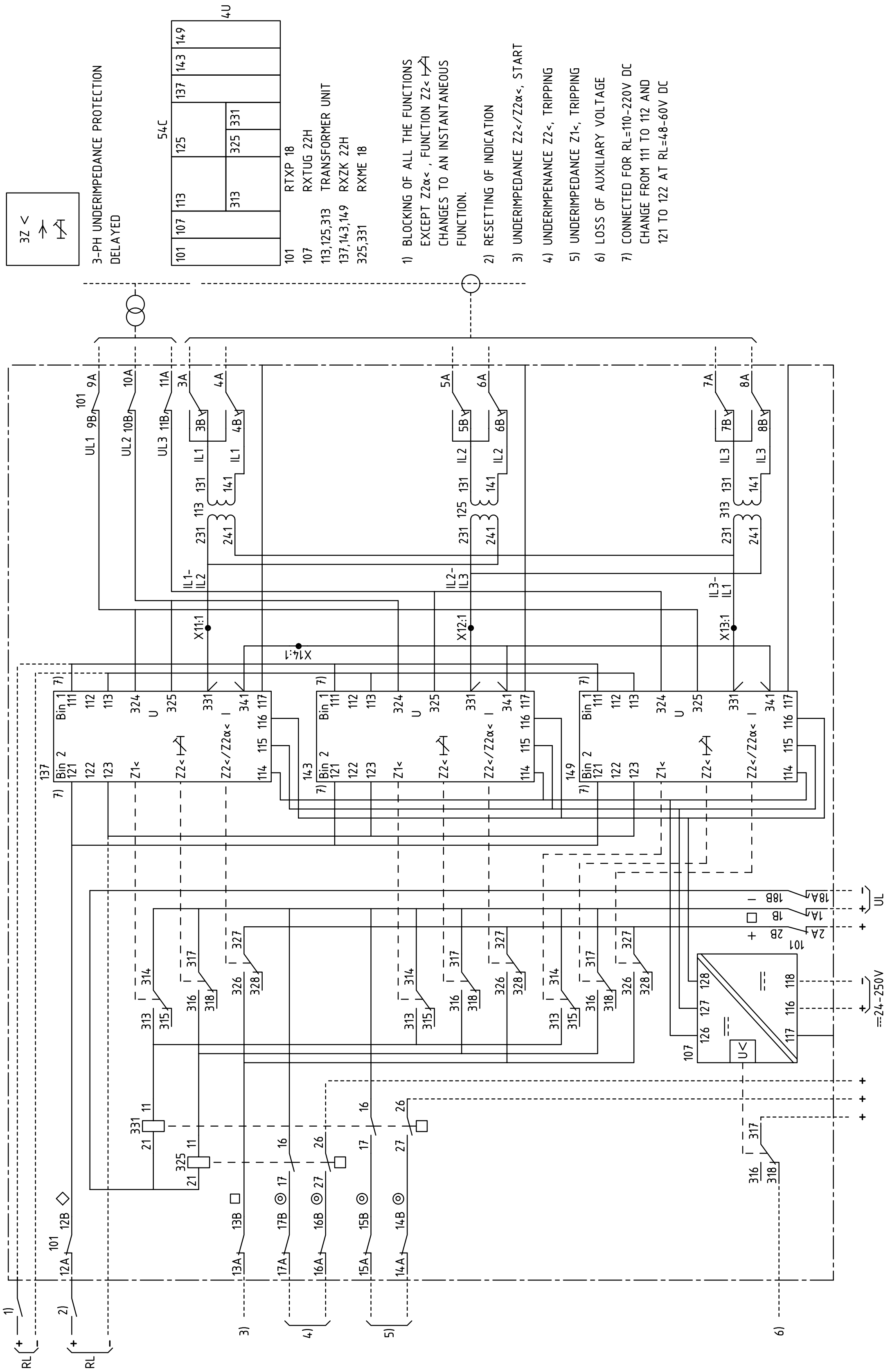


Fig. 47 Circuit diagram 1MRK 001 065-ZB

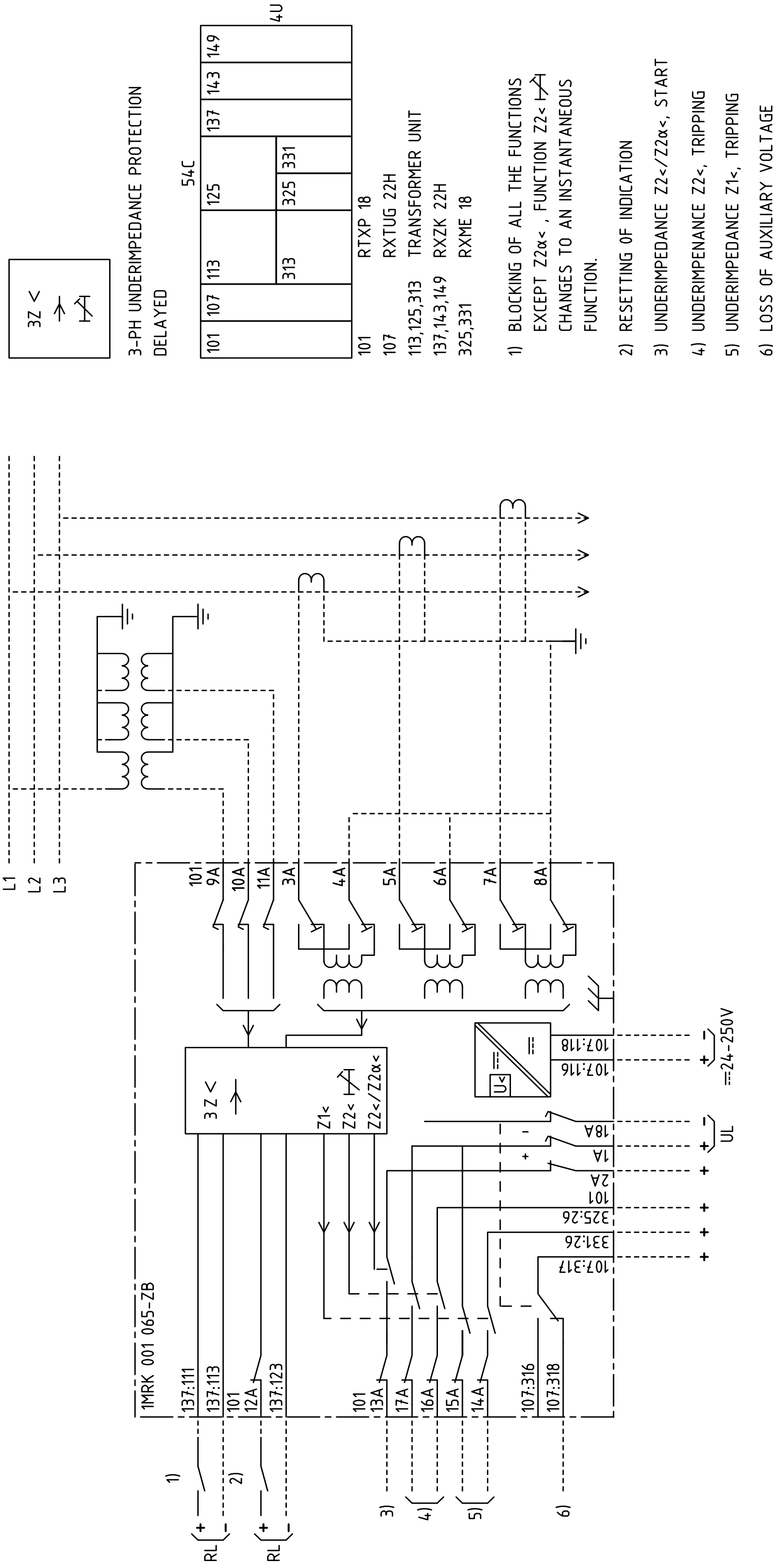


Fig. 48 Terminal diagram 1MRK 001 065-ZBA

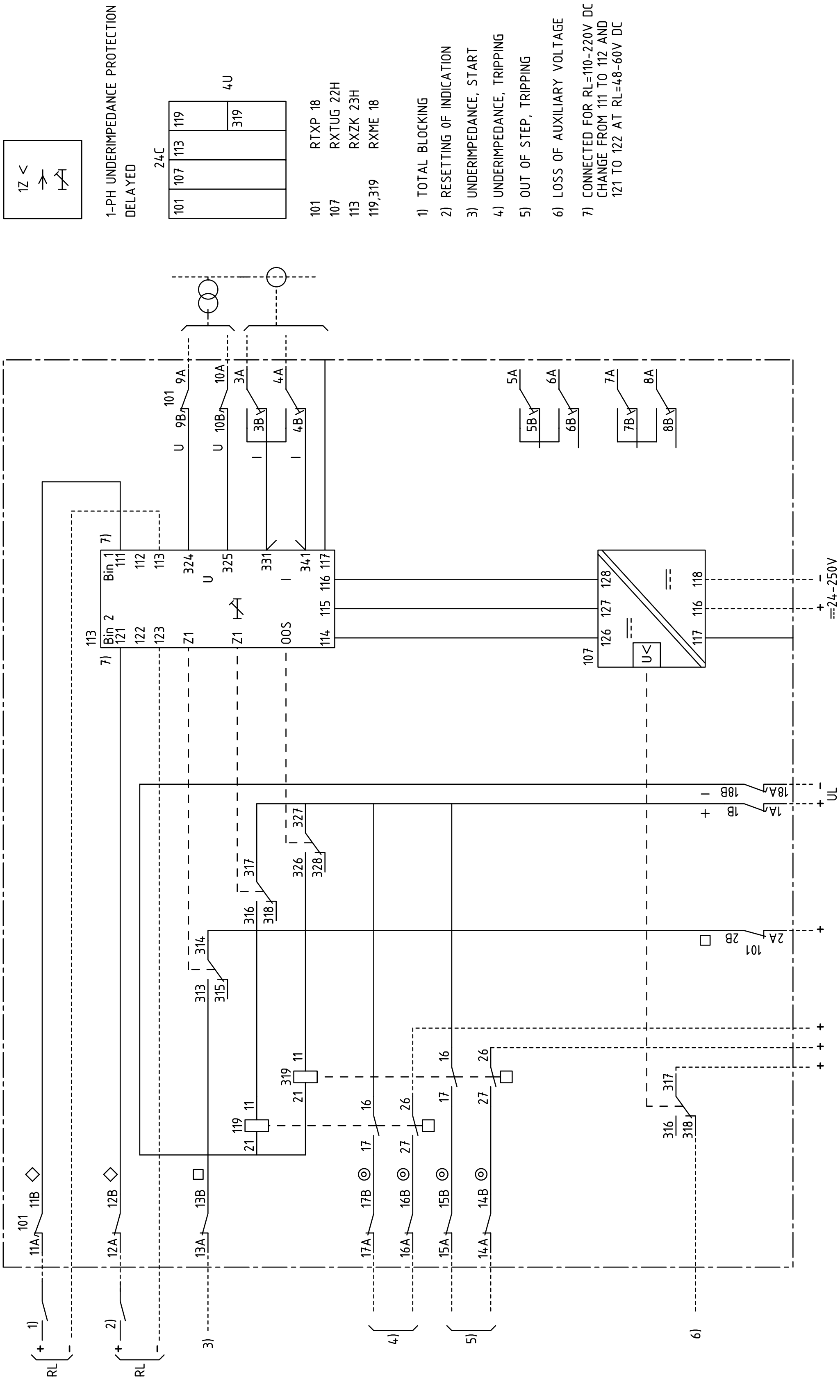


Fig. 49 Circuit diagram 1MRK 001 068-EA

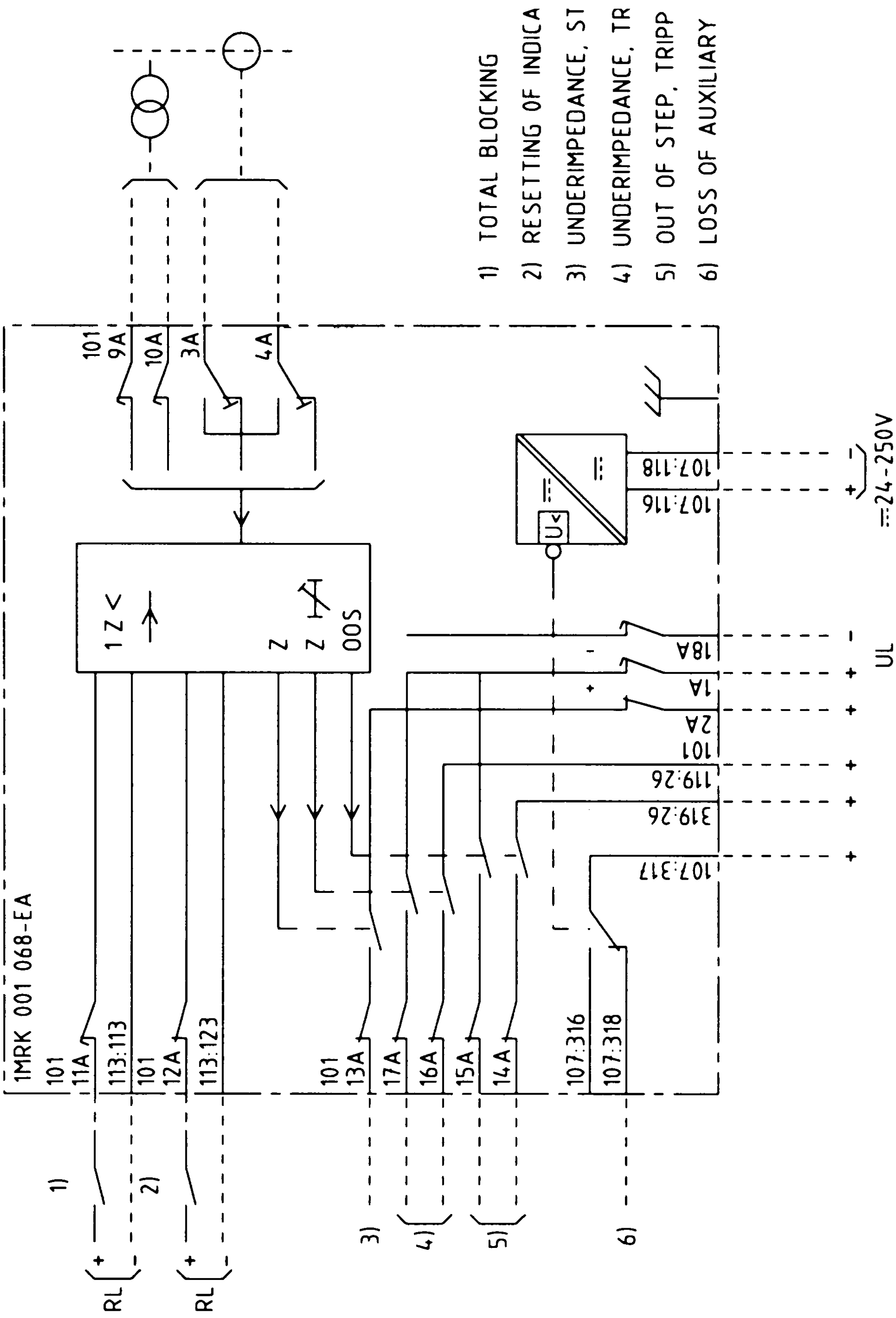


Fig. 50 Terminal diagram 1MRK 001 068-EAA

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