Negative sequence overcurrent relay and protection assemblies

RXIIK 4 and RAIIK 400

1MRK 509 045-BEN
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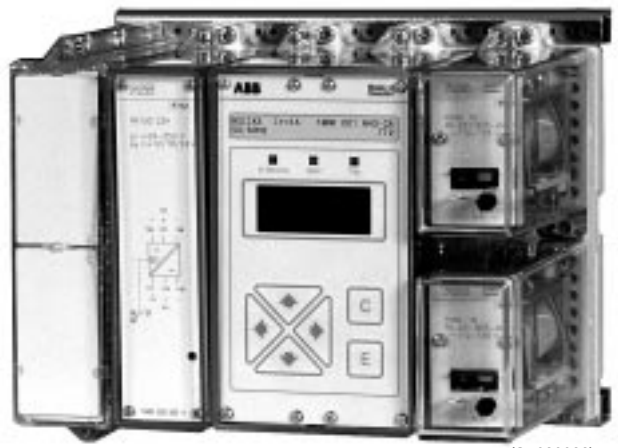
(SE980088)



(SE980083)

Features

RXIIK 4 relay

- Negative sequence overcurrent relays are used to detect unbalanced load on a generator which may cause excessive rotor heating. The relay is also used to detect unbalanced load currents in motors.
- The relay can also be used in the other applications such as:
  - Unsymmetrical load which increase the negative sequence current.
  - Phase interruptions e.g. a broken conductor.
  - Failure on one or two poles of a breaker or disconnect-switch at opening and closing
- Earth-fault detection in solidly earthed system.
- The relay has I_Start, I_Alarm, I_Trip and Blocking functions.
- Three current ranges: I_r = 1 A, I_r = 2 A and I_r = 5 A
- Set range I_Start 4-40% of I_b (machine current) with inverse characteristic

  $t = K \times (I_b / I_-)^2$;

  K= 0-100 seconds or
  definite time = 0-100 minutes.
- Set range I_ Alarm 3-30% of I_b (machine current) with definite time = 0-100 seconds.
- Thermal memory for block and trip function with the settable cooling time up to 200 minutes
- Reset time I_Trip = 0-5 seconds.
- Five independent output relays selectable for In Service, I_Start, I_Alarm, I_Trip, Blocking as well as Group 2 active.
- Easy selectable setting of parameters through the HMI.
- Trip information available via the HMI.
- Two groups of setting parameters are settable and readable through the HMI. The active setting group 1 or 2 can be selected through one of the two binary inputs.
- Selectable binary inputs to block or enable I_Start, I_Alarm, I_Trip, change active group and reset of LED and timer.
- Testing of the output relays and operation of binary inputs can be performed through the HMI.
- Service values are available through the HMI.
- Test switch, DC/DC converter and heavy duty trip relays are available as specified options.

Application

Negative sequence current relays are primarily applied to protect generators and motors but also sometimes used in transmission systems to detect unbalanced conditions and faults. The advantage of the negative sequence current over zero sequence current is that mutually coupled parallel line currents are not influencing the measurement and that only the three phase currents are used as inputs, i.e. the neutral current is not needed.

When a generator is connected to a balanced load the phase currents are equal in magnitude and are 120 degrees from each other. The flux produced by the stator currents rotate synchronously with the rotor and eddy currents are not induced in the rotor parts.

Unbalanced currents give rise to a negative sequence component in the stator current. The negative sequence current produces an additional flux which rotates at synchronously speed in the opposite direction of the rotor. The eddy currents which are induced in the rotor parts will have the double network frequency. During such sustained conditions, the temperature of the rotor may reaches high levels which accelerate the ageing of the insulation and cause mechanical stress on the rotating components.

The heating effect on the rotor is determined by the product:

$$t = K \times \left(\frac{I_b}{I_-} \right)^2$$

where

I_b Rated current of the generator or motor

I_- Negative sequence current in percent of I_b

t Time in seconds

K A constant in seconds that is characteristic for the generator or motor.
This constant represents the time which a generator or motor can permit a negative sequence current which is equal to the rated generator or motor current.

The capability for the machine to withstand continuously unbalanced currents is usually given by the manufacturer as a negative sequence current in percent of rated stator current.

Typical values for generators are given in the table below

The lower values in the table below are typical for large machines.

From the formula above it follows the permissible time for a certain amount of negative sequence current loading is inversely proportional to the square of the negative sequence current. The protect function should have a corresponding operating time characteristic and a thermal memory with a cooling down characteristic that can be set to coincide with the characteristic of the machine.

A short circuit between two-phases will give a large negative sequence current, but these faults are normally cleared by the short circuit protection in much shorter time than the operate time of the negative sequence protection.

The inverse time characteristic is shown in Fig. 1.

A relatively small unbalance in the supply voltage to a motor can give rise to an appreciable negative sequence load current.
A negative sequence voltage of 2% may give rise to a negative sequence motor current of 10-15%.

Negative sequence current protection should be included if there is a risk of uneven loading in exceed of the maximum permissible continuous value.

Type of generator	K-value	Maximum permissible I_- (%)
Cylindrical rotor:		
indirectly cooled	30	10
directly cooled	5 - 10	5 - 8
Salient poles:		
with damper winding	40	10
without damper winding	40	5

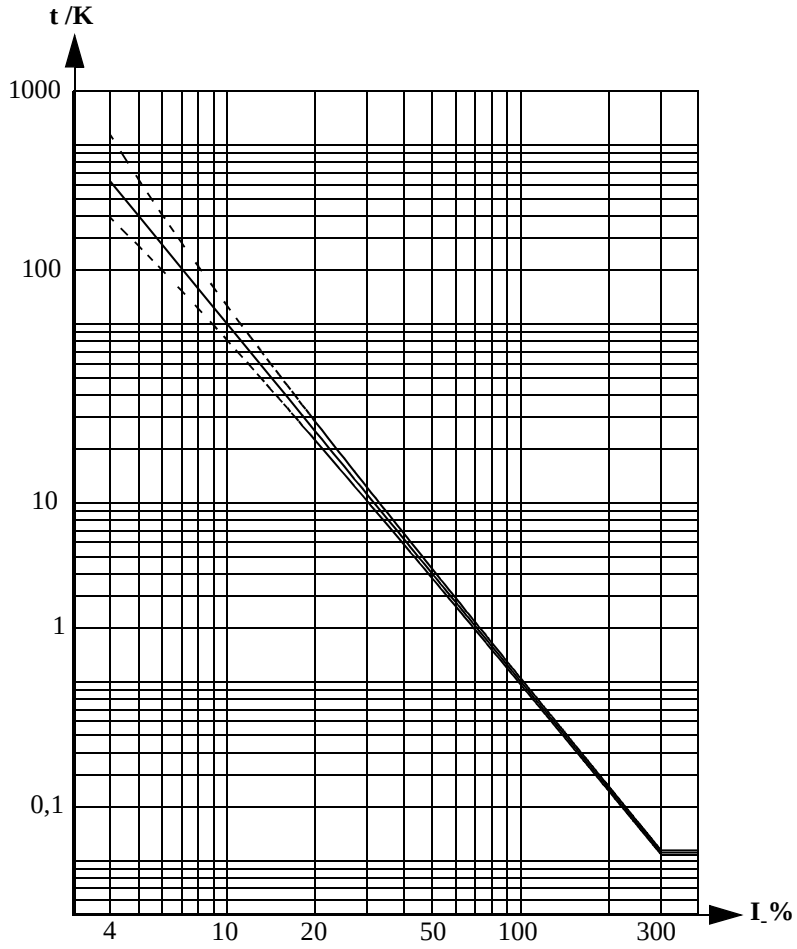


Fig. 1 Inverse time characteristic for RXIIK 4 relay

Principles

The calculated negative sequence current is compared with the set operate value for the I_Alarm and the I_Start function.

A simplified logic diagram of the RXIIK 4 relay is shown in Fig. 2.

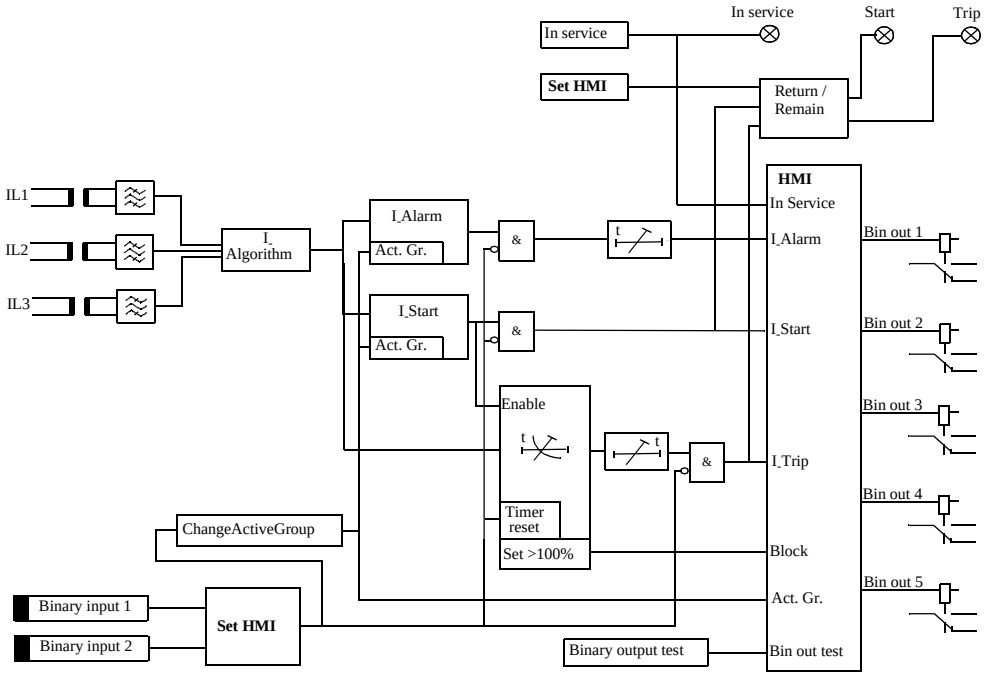


Fig. 2 Functional logic diagram RXIIK 4

Design

RXIIK 4 comprises mainly of three functional units, a measuring unit, HMI unit and transformer unit. The transformer unit contains 3 input transformers; one for each phase.

The circuits are fed with a separate DC/DC converter RXTUG.

RXIIK 4 has five programmable output relays, which can be selected independently through HMI for In Service, I_Start, I_Alarm, I_Trip, Thermal block and Group 2 active.

Setting

Two groups of setting parameters are settable and readable only by menu-structure, self-explanatory HMI software. Different parameters are changeable within the two groups. The selection of an active setting group is also possible via HMI or a binary input.

Normal service

The green LED marked “In Service” is on. If the DC supply voltage is interrupted, the LED will go out.

Start and tripping

The start indication show a steady yellow light when the set operate level for start is exceeded. Resetting of the start indication is done by a binary input or HMI.

Tripping is indicated by a red LED. Resetting of the trip indication is done by a binary input or HMI.

Block or Enable

Block or enable of the functions are done by a binary input.

Technical data

Table 1: Current input

Rated current I_r	1, 2 or 5 A
Basic Current I_b	(0,4 - 1,2) x I_r
Effective current range	(0,03 - 5,0) x I_b
Rated frequency f_r Frequency range	50 / 60 Hz 40 - 70 Hz (outside relay set I_ to 0%)
Power consumption, per phase at rated current I_r = 1 A I_r = 2 A I_r = 5 A	 <30 mVA <60 mVA <150 mVA
Overload capacity for current inputs I_r = 1 A continuously I_r = 2 A continuously I_r = 5 A continuously I_r = 1 A during 1s I_r = 2 A during 1s I_r = 5 A during 1s	 4 A 8 A 20 A 100 A 200 A 350 A (Max 350 A AC for COMBIFLEX)

Table 2: Negative sequence current functions

Function	**I_Alarm**	**I_Start**
Setting range	(3 - 30%) of I_b	(4 - 40%) of I_b
Limiting error for current measuring	Range: 0 - 40% <±1% equivalent I_ Range: 40 - 300% <±4% equivalent I_	
Consistency of set operate value	<±0,2% equivalent I_	
Typical reset ratio	0,5% equivalent I_	
Operate time	<150 ms	
Reset time	<130 ms	
Overshoot time	25 ms	
Recovery time	<130 ms	
Frequency dependence within frequency range 40-70 Hz	<±4% equivalent I_	
Temperature dependence within range -5 °C to +55 °C	<±1% equivalent I_	

Table 3: Time functions for I_Alarm

Time function	**I_Alarm**
Time delay	Definite time
Setting range, definite time	0 - 100 s
Accuracy, definite time	<±0,2% of set time (for settings ≠ 0s)

Technical data (cont'd)

Table 4: Time functions for I_Trip

Time function	I_Trip (initialized by I_Start)
Time delay	Inverse or definite time
Setting range, definite time	0 - 100 min
Setting range, inverse time formula	K = 0 - 100 s $t = K \times (I_b / I_-)^2$
Reset time delay (for trip relay only)	0 - 5 s
Cooling down time	0 - 200 min
Block time	10 - 90% of cooling down time
Accuracy, definite time	<±0,2% of set time (for settings ≠ 0 min)
Accuracy, inverse time	±(1+(I_/I_b))% equivalent I_ and ±200ms

Table 5: Auxiliary DC voltage supply

Auxiliary voltage EL for RXTUG 22H Auxiliary voltage for the relay	24 - 250 V DC, ±20% ±24 V (from RXTUG 22H)
Power consumption at RXTUG 22H input 24-250 V before operation after operation without RXTUG 22H ±24 V before operation after operation Power consumption, back-light.	 < 6,0 W (Back-light off, no output relays act.) < 7,5 W (Back-light off, output relays act.) < 3,5 W (Back-light off, no output relays act.) < 5,0 W (Back-light off, output relays act.) Approximately 2 W

Table 6: Binary inputs

Binary input voltage RL	48-60 V and 110-220 V DC, -20% to +10%
Power consumption 48-60 V 110-220 V	 < 0,3 W / input < 1,5 W / input

Table 7: Output relays

Contacts	5 change-over
Maximum system voltage	250 V AC / DC
Current carrying capacity continuous during 1 s	 5 A 15 A
Making capacity at inductive load with L/R >10 ms during 200 ms during 1 s	 30 A 10 A
Breaking capacity - AC, max. 250 V, cos φ > 0,4 - DC, with L/R < 40 ms 48 V 110 V 220 V 250 V	 8 A 1 A 0,4 A 0,2 A 0,15 A

Table 8: Electromagnetic compatibility (EMC), immunity tests

All tests are performed together with the DC/DC-converter, RXTUG 22H

Test	Severity	Standard
Surge	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	500 V AC	SS 436 15 03, PL 4
Power frequency magnetic field	1000 A/m	IEC 61000-4-8
1 MHz burst	2,5 kV	IEC 60255-22-1, class 3
Spark	4-8 kV	SS 436 15 03, PL 4
Fast transient	4 kV	IEC 60255-22-4, class 4
Electrostatic discharge In normal service with cover on	 6 kV (contact) 8 kV (air) 6 kV, indirect application	 IEC 60255-22-2, class 3 IEC 60255-22-2, class 3 IEC 61000-4-2, class 3
Radiated electromagnetic field	10 V/m, 80-1000 MHz	IEC 61000-4-3, Level 3
Conducted electromagnetic	10 V, 0,15-80 MHz	IEC 61000-4-6, Level 3
Interruptions in auxiliary voltage 24 VDC, no reset for interruptions 110 VDC, no reset for interruptions 250 VDC, no reset for interruptions	2 - 200 ms < 20 ms < 70 ms < 300 ms	IEC 60255-11

Table 9: Electromagnetic compatibility (EMC), emission tests

Test	Severity	Standard
Conducted	0,15-30 MHz, class A	EN 50081- 2
Radiated	30-1000 MHz, class A	EN 50081- 2

Technical data (cont'd)

Table 10: Insulation tests

Test	Severity	Standard
Dielectric Current circuit to circuit and current circuit to earth Circuit to circuit and circuit to earth Over open contact	 2,5 kV AC, 1 min 2,0 kV AC, 1 min 1,0 kV AC, 1 min	 IEC 60255-5
Impulse voltage	5 kV, 1,2/50 µs, 0,5 J	IEC 60255-5
Insulation resistance	> 100 MΩ at 500 V DC	IEC 60255-5

Table 11: Mechanical tests

Test	Severity		Standard
Vibration	Response: Endurance:	1,0 g, 10-150-10 Hz 1,0 g, 10-150-10 Hz, 20 sweeps	IEC 60255-21-1, class 2 IEC 60255-21-1, class 1
Shock	Response: Withstand:	5 g, 11 ms, 3 pulses 15 g, 11 ms, 3 pulses	IEC 60255-21-2, class 1
Bump	Withstand:	10 g, 16 ms, 1000 pulses	IEC 60255-21-2, class 1
Seismic	X-axis: Y-axis: Z-axis:	3,0 g, 1-50-1 Hz 3,0 g, 1-50-1 Hz 2,0 g, 1-50-1 Hz	IEC 60255-21-3, class 2, extended (Method A)

Table 12: Temperature range

Storage	-20 °C to +70 °C
Permitted ambient temperature	-5 °C to +55 °C

Table 13: Weight and dimensions

Equipment	Weight	Height	Width
RXIIK 4 without RXTUG 22H	Approximately 1,3kg	4U	12C

Diagrams

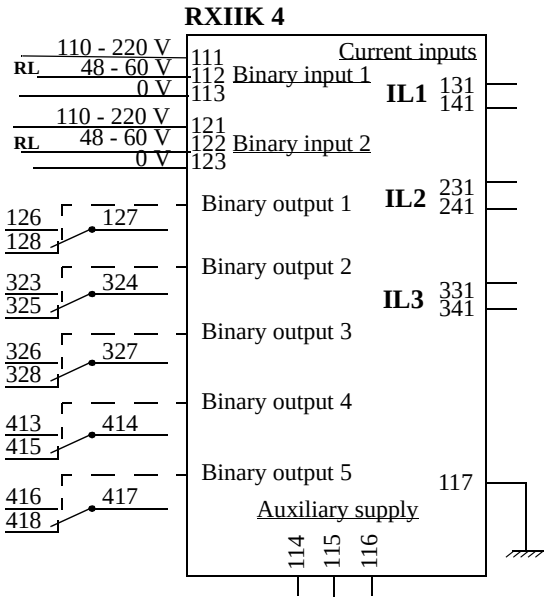


Fig. 3 Terminal diagram

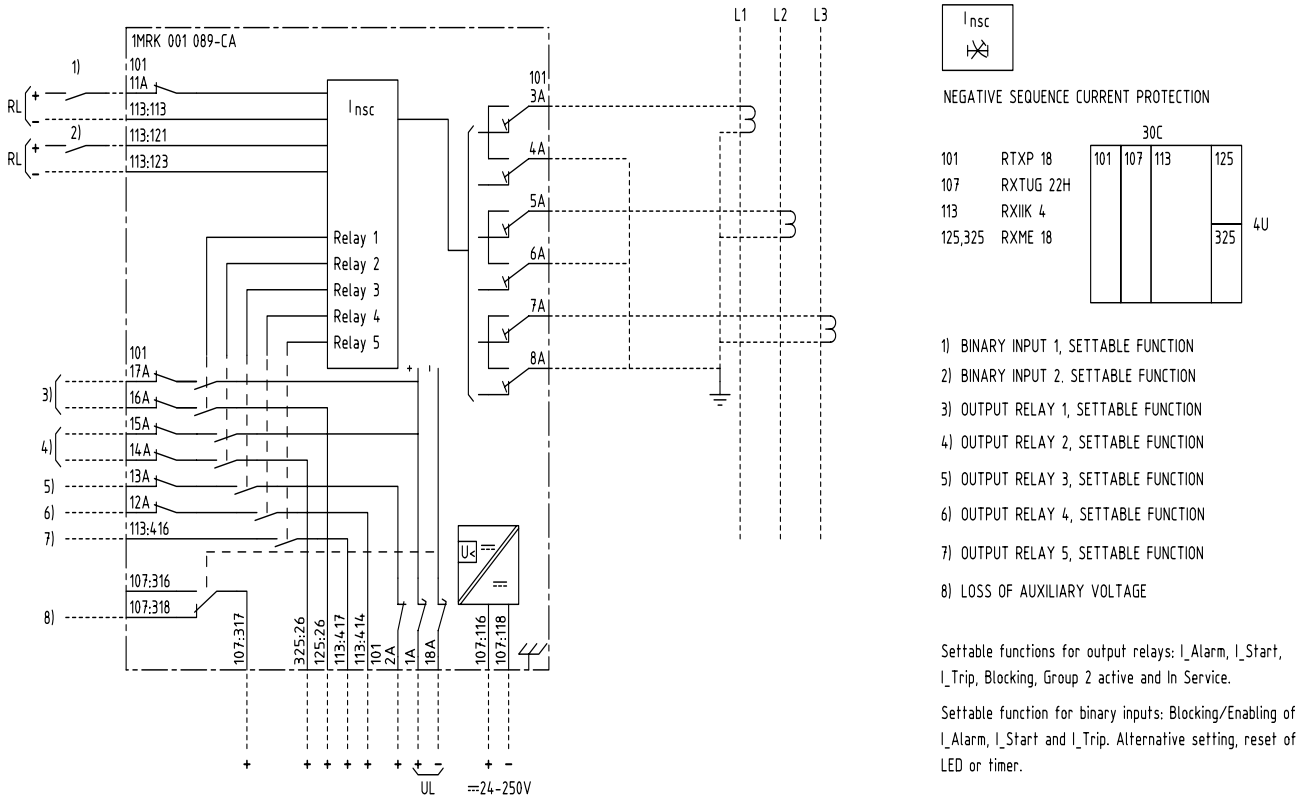


Fig. 4 Terminal diagram 1MRK 001 089-CAA

Protection assemblies

RAIIK 400
Protection assemblies are built up based on the negative sequence current relay RXIIK 4. Test device RXTP 18 and DC/DC converter RXTUG 22H can also be included for specific application requirements. Test device RTXP 18 is a tool for secondary injection functions testing.

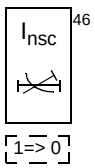
DC/DC-converter RXTUG 22H can be used for a single protection and also to feed additional load up to the rated capacity. With RXTUG 22H all standard requirements concerning disturbance emission and immunity with this RAIIK 400 will be met.

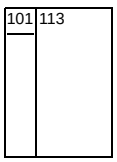
The assemblies have output contacts as specified for the relay RXIIK 4 which in most cases are fully sufficient for start, trip and alarm functions. Protection assemblies are also available with heavy duty relay RXME 18 (RK 221 825-XX) with indicating flag. Output relays are connected to an external auxiliary voltage.

The extremely flexible mounting system COMBIFLEX together with a modern CAD-system enables a unique flexibility for designing assemblies upon customers requests.

The interface voltage for enable or block impulses can be connected to either 48-60 V DC or 110-220 V DC by connecting the voltage circuit to separate terminals. At delivery all relays are connected for 110-220 V DC.

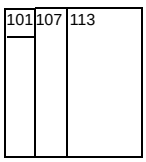
RAIIK 400 Negative sequence overcurrent protection





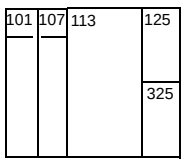
101 RXTUG 22H
107 RXIIK 4

Order No.	Circuit diagram
1MRK 001 088-AA	1MRK 001 089-AA



101 RTXP 18
107 RXTUG 22H
113 RXIIK 4

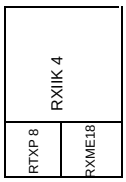
Order No.	Circuit diagram
1MRK 001 088-BA	1MRK 001 089-BA



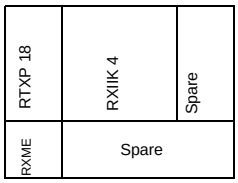
101 RTXP 18
107 RXTUG 22H
113 RXIIK 4
125 RXME 18
325 RXME 18

Order No.	Circuit diagram
1MRK 001 088-CA	1MRK 001 089-CA

The above protections can be supplied in RHGX or RHGS cases
RXIIK 4 can also be supplied in the following mounting alternatives



Ex. Mounting of RXIIK 4 in RHGS 6



Ex. Mounting of RXIIK 4 in RHGS 12

Ex. Mounting of 4 RXIIK 4 in RHGS 30 with dual power supplies RXTUG 22 H

Ordering

Specify RAIIK 400 Protections

- Quantity
- Ordering number
- Code A, H, M
- Desired wording on the lower half of the test switch face plate max.
  13 lines with 14 characters per line.

Specify RXIIK 4 (loose relays)

- Quantity
- Ordering number

Negative sequence overcurrent relay

Type	Rated current Ir	Article No.	Code for phase and neutral
RXIIK4	1 A	1MRK 001 643-AA	☐A1
RXIIK4	2 A	1MRK 001 643-CA	☐A2
RXIIK4	5 A	1MRK 001 643-BA	☐A5

Auxiliary voltage
For included auxiliary relays

	Code
24 V DC	☐H5
48-55 V DC	☐H6
110-125 V DC	☐H7
220-250 V DC	☐H8

Mounting

Mounting alternatives	Size	Article No.	Code
Apparatus bars			☐M10
Equipment frame without door	4U 19”	1MRK 000 137-GA	☐M11
Equipment frame with door	4U 19”	1MRK 000 137-KA	☐M12
RHGX 4	4U 12C	RK 927 001-AB	☐M71
RHGX 8	4U 24C	RK 927 002-AB	☐M72
RHGX 12	4U 36C	RK 927 003-AB	☐M73
RHGX 20	4U 60C	RK 927 004-AB	☐M74
RHGS 30	6U x 1/1 19” rack	1MRK 000 315-A	☐M81
RHGS 12	6U x 1/2 19” rack	1MRK 000 315-B	☐M82
RHGS 6	6U x 1/4 19” rack	1MRK 000 315-C	☐M83

References

Auxiliary relays	1MRK 508 015-BEN
Time relays	1MRK 508 002-BEN
Current and voltage relays	1MRK 508 018-BEN
Connection and installation components in COMBIFLEX	1MRK 513 003-BEN
Relay accessories COMBIFLEX	1MRK 513 004-BEN
Test system COMBITEST	1MRK 512 001-BEN
User’s Guide RXIIK 4	1MRK 509 045-UEN

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