Generator protection

COMBIFLEX

1MRK 502 003-BEN
Page 1
Issued June 2004
Revision: A
Data subject to change without notice

(SE970128)

Features

- Great flexibility in mounting and wiring
- Can be delivered as prewired and factory tested protection assemblies or as individual relays
- Complete range of protection, covering all types of generator faults and other critical situations
- Each protection relay is independent with its own dc supply and secondary testing facilities
- Possibility of custom specified integrated modular multifunction package RAGCX

Application

COMBIFLEX generator protection can be applied to any generator or other rotating ac machines. They are particularly suitable as a complement to integrated protection terminals or to obtain measuring characteristics not met by integrated schemes or where great flexibility in application is desired. Individual relays can be used complementary to other protection families or packages. For large machines, subdivision into dual schemes e.g. main I and main II can easily be made.

Besides the generator protection described here, a great number of protection of multipurpose type are available (see References).

Product overview

	Relay type	Features
Stator faults		
Phase short circuit	RADHA	3-ph high impedance differential*)
	RADSC	3-ph low impedance differential*)
	RADSB	3-ph low impedance differential, with power transformers within the zone*)
	RAZK	Impedance measurement*)
Phase inter-turn fault	RAIDK	Current measurement*)
Earth fault	RAGEK	Variants for 95% and 100% coverage
Excitation/Rotor faults		
Loss of excitation	RAGPK	Reactive current measurement
Rotor earth fault	RAIDK RAHL	AC injection in the rotor, low rotor capacitance*) AC injection in the rotor, high rotor capacitance*)
Bearing insulation	RARIC	With separate shaft current transformer*)
System faults		
Stator overload	RAVK	Thermal*)
Reverse power	RAPPK	Setting 0,3-15%*)
Unbalanced load	RAIIK	Negative sequence current detection*)
Accidental stator energizing	RAGIK	Voltage controlled overcurrent measurement
Over/under frequency	RAFK	Measure f and df/dt*)
Out-of-step operation	RAZK	Impedance measurement*)
Over/under voltage	RAEDK RALK	Voltage measurement*) V/Hz*)

*)Some multi-purpose products are described in detail in separate documents, where also some ordering data will be found. See References on page 20.

Stator short-circuit protection
Differential protection is commonly used. Depending on the earthing system, earth faults may also be detected.

The **RADHA** is a three-phase high impedance differential protection. This protection is used when 10-20 ms tripping times are acceptable and where dedicated CT's are available.

The **RADSC** is a three-phase low impedance percentage differential protection relay with up to six through current restraint inputs. It can be used for all kinds of generators and motors. Operating time is typically 15 ms.

The **RADSB** is a three-phase low impedance percentage differential protection relay with up to six through current restraint inputs. It has 2nd ant 5th harmonics detection for current inrush resp. overexcitation security. It can be used for all kinds of power transformers and include a generator winding and an auxiliary transformer in the protection zone. Operating time is typically 30 ms.

The **RAZK** is a microprocessor impedance measuring protection with one measuring element in each phase, and each one zone. At a nearby fault the impedance locus will move to low R- and X- values inside the zone and is detected by the relay. If the short circuit is not cleared by other protection relays within a set time delay the RAZK will act as back-up protection.

Phase inter-turn protection
Modern machines are usually designed with one turn per phase and slot. For these machines inter-turn currents can only flow at two earth faults, and normally then detected by the stator earth fault relay. For generators with split neutrals a phase inter-turn protection scheme can consist of a low set time delayed overcurrent relay, which senses the current flowing between the neutrals of the

parallel windings. However, due to difficulties to distinguish between normal and abnormal unbalance currents this protection relay is often omitted.

The **RAIDK** is a microprocessor based time-overcurrent protection which, provided with a filter option for damping the third harmonics influence, can be used to detect an inter-turn fault.

Stator earth-fault protection

The common practice to earth the generator neutral through a resistor limits the earth current to 5-10 A. The COMBIFLEX stator earth-fault protections are based on detection of the fundamental and third harmonic voltages in the neutral (or broken delta).

The **RAGEK 95%** stator earth-fault protection is set at 5% of maximum neutral voltage at solid earth faults. At this setting 95% of the stator winding and also the generator bus and ancillaries up to the next step-up transformer are protected.

The **RAGEK 100%** stator earth-fault protection covers 100% of the stator winding and consists of a 95% measuring relay and an additional relay covering as a minimum the remaining 95-100% of the winding. It can be used for generators which produce about 1% or more third harmonic voltage under all service conditions.

When more than the minimum 1% third-harmonic voltage exists, the operating zone of the third harmonic 95-100% protection can be further extended and the set operating value of the 95% protection can be increased. A reduction in the operating time for the 95% protection is then feasible without any loss in security.

The third-harmonic relay is supervised by either a generator phase-to-phase voltage, or generator current. The third-harmonic relay setting is determined from the amount of generator neutral third-harmonic voltages. Calculations can be based on machine specifications and equipment capacitance or on field measurements.

Loss-of-excitation protection

The **RAGPK** protection gives an alarm for generator underexcitation conditions and provides tripping for loss-of-excitation. A fault condition is detected by the protection when the generator accelerates and draws reactive power from the system in order to maintain the active power output as received from the prime mover. The resulting induced currents in the rotor may cause dangerous overheating, particularly for cylindrical rotor turbo-generators. The magnitude of reactive power drawn from the system is a function of the machine reactance and the system source impedance. The resultant current will not be steady, but is pulsating, and conventional time delayed overcurrent relays cannot adequately protect the generator; therefore, special loss-of-excitation protection is required to ensure tripping.

The RAGPK protection can also be used where parallel machines maintain the terminal voltage above 0,85 p.u. on the machine having lost excitation. The protection includes a current detector set at 1,1 p.u. current. The current received by the machine is generally in the order of 2-5 times rated, at lost excitation.

The RAGPK protection is suitable for all types of synchronous machines. The operating characteristic is normally set as close as possible to the thermal capability curve for the underexcited machine.

Rotor earth fault protection

The field circuit is normally kept isolated from earth. A single earth fault is therefore not of immediate danger. A second fault can cause serious damage. Signalling and alarm or delayed tripping of the first earth fault is therefore sufficient. A voltage injection unit is connected to one of the poles of the generator field winding, and to earth.

The microprocessor based time-overcurrent protection **RAIDK** and **RAHL** are used to detect the level of insulation by measurement of the injected AC current. The RAIDK can be applied on rotors with up to 1 µF leakage capacitance, the RAHL on rotors with up to 5 µF leakage capacitance. Typical setting levels are 1-10 kohm. The RAHL can in addition be used as 2 phase back-up protection relay for the stator winding or the field exciter.

The injection unit can be supplied as stand-alone or included in certain variants of the RAIDK, resp. RAHL assemblies.

Shaft current protection

If the bearing insulation on rotating machines breaks down, the induced voltage between shaft ends from machine dissymmetries creates a shaft current that can damage the bearings or other vital parts. The damage depends

on the shaft-current magnitude and duration. It is therefore desirable to provide sensitive protection that can detect shaft currents of 1 A or less. The shaft-current measuring principle enables more sensitive protection than shaft-voltage measurements or vibration-monitoring. Vibration monitors only operate after the bearing is damaged. By applying the shaft current protection **RARIC**, the machine can be tripped and the cause of the bearing insulation breakdown can often be eliminated before the bearing is damaged.

A shaft-current transformer type ILDD is required for measurement of the shaft current. It is available for shafts with diameters 160 to 3000 mm.

Stator overload protection
When load currents exceed the rated values there is an imminent risk that conductors and insulation will be damaged due to overheating.

The RAVK is a microprocessor thermal overcurrent measuring relay with time constants from 2 to 62 minutes. It is available with 1, 2 or 3 measuring modules RXVK, each with single phase measurement, one thermal stage and one time overcurrent stage.

Reverse power protection
The purpose of the reverse power protection is basically to prevent damage on the prime mover (turbine).

When the input to the prime mover is lost, the generator operates as a synchronous compensator. This may lead to damage of the turbine blades, bearings or in case of motors, insufficient lubrication. Especially for turbo generators, the active power supplied to a machine running as synchronous compensator may be as low as 0,5% of the generator rated power.

Depending on the excitation level, the small active power to the machine may be combined with a substantial reactive current. In order to secure operation in this case, the angular error of the total measuring circuit (voltage and current transformers plus relay) must be extremely small. Correction of the angular error may be required when the reverse power is less than 2% of rated generator power.

The **RAPPK** reverse power protection is based on single-phase measurement of the active power component of the generator current. The operation can be selected to be based either on overcurrent in the reverse power direction or on undercurrent in the forward power direction. The operate value can be set as low as 0,3% of rated current. The protection has two settable time stages for delayed tripping up to 4 and 30 s respectively and settable angle error correction up to ±3°. The power consumption in the voltage and current circuits are extremely low.

Negative sequence current protection
When the generator is connected to balanced load the phase currents are equal in magnitude and displaced electrically by 120°.

The **RAIIK 400** provides protection against excessive rotor heating that may occur due to unbalanced phase currents.
Single-phase and two-phase faults, phase rupture or asymmetric loading on the system can give rise to unbalanced currents, hence negative sequence currents.

Dead machine protection
Accidental energizing of generators at standstill or on turning-gear can lead to catastrophic failures of the generator and other related power station equipment. Generally, the time to damage the generator stator from the high in-rush currents received during energizing at stand still is in the order of a few seconds. The bearing, however, may be damaged more quickly due to the lack of oil pressure. Since conventional protections do not provide adequate protection when the generator is out-of-service, a dedicated high-speed protection is recommended by most major equipment manufacturers.

The **RAGIK** protection prevents damage due to accidental energizing to the network. Tripping time is about 30 ms.

Over/under frequency protection
Minor frequency deviations may be harmful to the mechanical parts of generators and motors, and an abnormal frequency deviation can be a symptom of harmful over-speed due to faults in the exciting system or turbines.

The **RAFK** is a microprocessor frequency protection with two time delayed frequency stages per measuring module. The stages can independently be set for under- or over-frequency. Standard assembly variants with up to three modules are available

Out-of-step, or loss of synchronism protection

Loss of synchronism may be harmful to a rotating machine if not detected already after a few pole slips and the machine is disconnected from the network. Detection may be by counting over-current pulses or by watching the load apparent impedance. The impedance locus would typically perform circles in the impedance plane, from low impedance (180 degrees out-of-step) to high impedance.

The **RAZK** is a microprocessor impedance measuring protection with a one-phase measuring element and one zone. It detects when the impedance locus enters the zone and leaves the zone. If this takes place on opposite sides of the X-axis an out-of-step condition is detected.

Over/under voltage protection

Detection and signalling/tripping at an abnormal stator voltage level can be required from several reasons. A loss of feeding voltage to a motor, followed by a return (autoreclose) within 1 second may cause high stresses to the mechanical parts since the rotor at that instance may be out of synchronism, resulting in a very high inrush current. Over-voltage may be a reason for a fault in the voltage regulation system.

The **RAEDK** is a microprocessor voltage measuring protection with two time delayed voltage stages per measuring module. The stages can independently be set for under- or over- voltage. Standard assembly variants with up to three modules are available

The **RALK** is a microprocessor Volt/Herz measuring protection with two independent setting stages that is primarily protecting the generator transformer from overexcitation during starting and stopping of the turbine.

Design

General

Generator protection in the COMBIFLEX family is mainly built up of standard plug-in units and offer the following advantages:

- Great flexibility in mounting and wiring, hence, easily adapted to user's practice regarding included relays and the number of output functions. The user's requirement on contacts for tripping and external signalling as well as indicating flags or light emitting diodes (LED's) for start and tripping functions, etc. are easily met.
- Modifications and extension can easily be made.
- Pre-wired and factory-tested equipment in cubicles assures easy installation and reduces commissioning work to a minimum.
- Static relays with low power consumption in the measuring circuits reduce the burden on CT's and, hence, the risk of saturation.
- Built-in testing system COMBITEST simplifies the testing.
- The number of spare parts is reduced by using the same type of plug-in unit in several protection relays.

The protection can be delivered by ABB in cubicles or as stand-alone units and, when desired, combined with relays from other ABB relay families or according to the user's choice.

The COMBIFLEX protection is supplied complete for connection to the station battery. The trip and signal contacts of medium duty type generally have sufficient making and breaking capacity for direct connection to trip coils and other external equipment.

Relays are in some cases available with or without internal visual signalling. This opens the possibility to group signals together in a common rack or outside the protection cubicle. Generally, several potential free contacts are available for external function.

A protection cubicle (system) would normally include:

- Dc supply supervision with flag relays for the whole cubicle
- Individual protection relays according to requirements
- Signalling, either in each relay or grouped together in the cubicle
- Grouping of trip signals and separately mounted (in the cubicle) tripping relays type RXME, RXMH or RXMVB, all with heavy duty contacts and with free choice of number of trip contacts.
- Test switch RTXP for individual protection relays or common for several protection relays.
- DC supply ($\pm$24 V) unit RXTUG for individual protection relays or common for several protection relays.

Where division into two protection groups is required, relays can freely be placed in separate cubicles, due to redundancy requirements. For a systematic approach, please contact your local ABB office.

Each protection relay is equipped with a test switch, type RTXP. This facilitates secondary injection testing and fault tracing (settings are mainly performed on the front of the relay). Resetting of flag and LED indications are also made on the relay's front.

The relays are supplied on mounting bars, or if specified, in 19" racks. Optionally, 19" racks or cases, type RHGX, can be supplied separately or with the relay mounted.

Products marked with *) in the table on page 2 are described in respective reference document.

RAGEK
95% and 100% Stator earth fault protections

(SE970122)

The **95% stator earth fault protection** (see Fig. 1) consists of a test switch RTXP 18, a dc-dc voltage converter RXTUG 22H, an overvoltage relay RXEDK 2H with band pass filter for measuring fundamental frequency overvoltage and a signal relay RXSF 1 to initiate tripping and alarm when earth fault occurs.

If a fundamental voltage arises in the neutral point, the overvoltage relay (U1) will operate and give a start indication and after set delay the output relay RXSF initiates tripping and alarm for earth fault 0-95% and shows red flag. Alternatively, tripping can be initiated by a second voltage level (U2).

The **100% stator earth fault protection** (see Fig. 2 and Fig. 3) consists mainly of a test switch RTXP 18, a dc-dc voltage converter RXTUG 22H, two voltage relay RXEDK 2H with band pass filters; one for measuring fundamental frequency overvoltage and the other for measuring third harmonic undervoltage, and a voltage limiting unit RXTDA 1 to limit the voltage to the undervoltage relay. A third voltage relay RXEDK 2H or a current relay RXIDK 2H supervises the generator voltage or current, to block operation when the machine is out of service. The relays RXEDK 2H and RXIDK 2H have two measuring stages (U1, U2 and I1, I2 respectively) and built-in timers. A signal relay RXSF 1 is used for initiate tripping and alarm when earth fault occurs. It contains two electromechanical relays with red indicating flags.

If a fundamental voltage arises in the neutral point, the overvoltage relay (119, U1) will operate and give a start indication and after set delay it energizes the signal relay RXSF, which initiates tripping and alarm for earth fault 0-95% and shows red flag.

When the generator voltage has sufficient third harmonic, the undervoltage relay (125, U2) is reset. If an earth fault occurs close to or at the neutral point, when the generator is in service, the protection will after set delay initiate tripping and alarm for earth fault 95-100 % and show red flag.

Setting of operate voltage and time delay are done in the front of the measuring relays.

RAGPK
Loss-of-excitation protection
The RAGPK protection (see Fig. 4) consists of a test switch RTXP 18, a dc-dc voltage converter RXTUG 22H, a directional overcurrent relay RXPDK 21H, a time over/ under-voltage relay RXEDK 2H and a signal relay RXSF 1, containing two electromagnetic relays with red indicating flags. The directional overcurrent relay is connected to current and voltage in the same phase.

The characteristic angle is set to -75°, i.e. the relay measures that component in the current which leads the voltage with 75°. At operation the delayed output of the directional overcurrent relay gives under excitation alarm via a relay in RXSF 1. In combination with overcurrent (the current stage output) or undervoltage (the delayed stage U1 output of the voltage relay RXEDK 2H) the directional relay initiates tripping and alarm for loss-of excitation via the other relay in RXSF 1. Stage U2 of the voltage relay can be used for delayed over- or undervoltage tripping.

RAIDK
Rotor earth fault protection application
The RAIDK protection is described in detail in other documents, see References on page 20 but also see Fig. 5.

A voltage injection unit RXTTE is connected to one of the poles of the generator field winding circuit and earth. Either directly to the winding, or via a protective resistor mounted close to the generator. The latter to minimize consequences of a short circuit on the lead connected to the generator field voltage. The measuring relay RXIDK is connected to RXTTE according to the diagram shown in an other section of this document.

A 40 V 50/60 Hz voltage is injected to the generator field winding circuit. Series capacitors prevent DC current leakage through the injection unit. The AC current flow during normal service is dependent on the leakage capacitance between the field circuit and earth.

The protection RAIDK/RXIDK measures, via a current transformer in the injection unit, the AC current. This current increases when the isolation resistance of the field winding circuit decreases.

The relay has two current stages; the low one with the setting range 15-650 mA and the high one with the setting range 0,02-8 A. For measuring rotor earth-faults, the setting shall be in the range 40-500 mA. Operation will then occur when the isolation resistance to earth is about 0,4-10 kohm. The values are somewhat dependent of the value of the leakage capacitance, see the diagram in technical data section showing typical operate resistance values as a function of the leakage capacitance at different current settings. The low current stage has both an instantaneous output and a delayed output. The high current stage has a delayed output and it can be used

either as a second step in the rotor earth-fault protection or as earth-fault protection for the AC-side. In the latter case it shall be set on approx. 1 A and for disconnection of the excitation voltage.

RAHL 421
Rotor earth fault protection application
The RAHL protection is described in detail in other documents, see References on page 20 but also see Fig. 6.

A voltage injection unit RXTTE is connected to one of the poles of the generator field winding circuit and earth. Either directly to the winding, or via a protective resistor mounted close to the generator, the latter to minimize consequences of a short circuit on the DC-side or an earth-fault on the AC-side of the field exciter. Further the RXHL 421 is connected to RXTTE according to the diagram shown in an other section of this document.

A 40 V 50/60 Hz voltage is injected to the generator field winding circuit. Series capacitors prevent DC current leakage through the injection unit. The AC current flow during normal service is dependent on the leakage capacitance between the field circuit and earth. This current is mainly capacitive, i.e. the current is leading the injected voltage by about 90°.

The protection RAHL/RXHL 421 measures, via a current transformer in the injection unit, the component of the current which is in phase with the injected voltage. This component increases when the isolation resistance of the field winding circuit decreases. The relay has the setting range 20-200 mA, which is equal to the active component of the earth-fault current when the resistance to earth is about 1-20 kohm. The values are somewhat dependent of the value of the leakage capacitance, see the diagram in technical data section showing typical operate resistance values as a function of the leakage capacitance at different current settings. The output relays can be programmed to e.g. give a start signal instantaneously and an alarm or trip signal delayed up to 20 s. In addition the 2-phase current inputs of RAHL 421 can be used as short-circuit and overload protection for the stator winding or the converter.

RAGIK
Dead machine protection
The RAGIK is a three-phase overcurrent protection with voltage supervision. It includes overcurrent relays RXIDK 2H, which are permitted to trip only after the generator voltage has dropped below a set value, e.g. 85% of nominal voltage for a certain set time.

The voltage is supervised by overvoltage relays RXEDA 1 in two phases (separately fused). These relays should both be in reset condition to permit tripping. This prevents a false operation in case of a removed or blown fuse in the voltage circuit.

The voltage relays have settable on-delay time function. It is used to ensure that tripping will not be blocked by momentary generator transients greater than the setting of the voltage relays. A delay of half a second is recommended. During normal start-up, the delay keeps RAGIK in service a little beyond voltage relay operate setting.

The voltage relays control two time relays RXKA 1. One relay (item 337) is used to delay possible tripping when both voltage relays have reset. This time is essential as close-in faults may drop the generator voltage below the reset value, which is about 98% of set operate voltage. Consequently the time setting should be coordinated with existing back-up protection time delay. A two second delay is recommended. The other time relay (item 331) is used to delay fuse failure alarm.

A high speed auxiliary relay RXMS 1 with six make contacts is used as tripping relay. And a signal relay RXSF 1 with two flag relays is used to alarm for tripping and voltage disagreement.

The **RAGCX** modular generator protection packages are based on combination of modern microprocessor protection and measuring relays described earlier in this document. The RAGCX package is mainly intended for small to medium size 5-150 MVA machines.

By combining measuring relays in groups it is possible to reduce number of test switches RTXP and DC/DC converters RXTUG. Additionally, trip and alarm matrix arrangements based on standard auxiliary and time relays can be arranged in the package.

Technical data

Table 1: Common data, unless otherwise specified

Permissible ambient temperature	-5 to +55 °C
Permissible range of auxiliary voltage supply	80-110% of rated value
Output contacts	Reference is made to the output modules described in other catalogues, in general auxiliary relays
Insulation tests: Dielectric test current circuits other circuits	 50 Hz, 2,5 kV, 1 min 50 Hz, 2,0 kV, 1 min
Impulse voltage test	5 kV, 1,2/50 µs, 0,5 J, acc to IEC 255-5
Mounting and connection	The relay are assembled on bars for mounting in 19” racks or cases for flush mounting, unless other specified. Connection is made with COMBIFLEX sockets.

For multi-purpose protection see respective reference document.

Table 2: RAGEK Stator earth fault protection

Rated frequency 50-60 Hz				
Operate data				
Relay	Setting range	Overload capacity 50-60 Hz Cont.	 10 s (1 s)	Power consumption 50-60 Hz (at voltage = lowest setting)
Fundamental RXEDK 2H Ur=50 V	U1 = 5-80 V	175 V	200 V	0,5 mVA
3rd harmonic RXEDK 2H Ur=2 V	U2 = 0,1-1,2 V [1]	20 V	120 V	0,2 mVA
Voltage supervision RXEDK 2H Ur=200 V	U1 = 20-320 V	500 V	500 V	0,5 mVA
Current supervision RXIDK 2H I_r = 1A I_r = 5A	 I1 = 0,075-3,25 A I1 = 0,375-16,25 A	 6 A 20 A	 (100 A) (350 A)	 0,3 mVA 0,5 mVA

[1] Only the scale constants 0,2 and 0,4 are recommended in this application. They give the scale ranges 0,1-0,6 and 0,2-1,2 V. Due to voltage drop in the voltage limiting unit RXTDA 1, the operate voltage is approximately two and three times set scale value respectively.

Time delay		
Fundamental RXEDK 2H	U1	0,05-16,1 s definite time
3rd harmonic RXEDK 2H	U2	0,03-10 s definite time
Supervision relay	U1 or I1	0,05-16,1 s definite time
Filter characteristic: Fundamental RXEDK 2H 3rd harmonic RXEDK 2H	 Rejects 3rd harmonic by 1:40 or more Rejects fundamental frequency by 1:40 or more at lowest setting	
Auxiliary voltage EL UL	 24-250 V dc 24, 48-55, 110-125 or 220-250 V dc	
Power consumption EL UL	 < 12 W < 3 W	
Dimension 95% protection 100% protection	 4U 24C 4U 42C	
Contact data tripping others	 See RXSF 1 See RXEDK 2H and RXMB 1	

Table 3: RAGPK Loss-of-excitation protection

Rated current, I_r	1 or 5 A	
Rated voltage, U_r	120 V, 50-60 Hz	
Auxiliary voltage, UL	24, 48-55, 110-125 or 220-250 V dc	
Current setting ranges Directional overcurrent stage Overcurrent stage	I_r = 1 A 0,074-3,26 A 0,1-40 A	I_r = 5 A 0,3 -16,3 A 0,5-200 A
Voltage setting ranges Undervoltage stage U1 Over/undervoltage stage U2	 20-320 V 10-480 V	
Time setting ranges Directional overcurrent stage Overcurrent stage Undervoltage stage U1 Over/undervoltage stage U2	 0,05-8,1 s and inverse time k = 0,05-1,1 Instantaneously 0,05-16,1 s and inverse time k = 0,05-16,1 0,03-10 s	
Power consumption Measuring circuits Auxiliary voltage	 See RXPDK 21H and RXEDK 2H < 10 W	
Disturbance tests	See RXPDK 21H and RXEDK 2H	
Output relay contact data	See RXSF 1	
Dimension	4U 30C	

Table 4: RAIDK Rotor earth fault protection

Permitted field voltage	Maximum 1200 V DC
Supply voltage	120 or 230 V, 50/60 Hz
Operate earth-fault resistance value	Approx. 0,4-10 kohm, see diagram below
Influence of harmonics in the DC field voltage	No influence of 50 V, 150 Hz or 50 V, 300 Hz
Permitted leakage capacitance	0-2 µF, see diagram below
Permitted shaft earthing resistance	Maximum 200 ohm
Test voltage	5 kV 50Hz
Protective resistor	220 ohm, 100 W, plate 135x160 mm
Other data for RAIDK/RXIDK 2H	See reference document

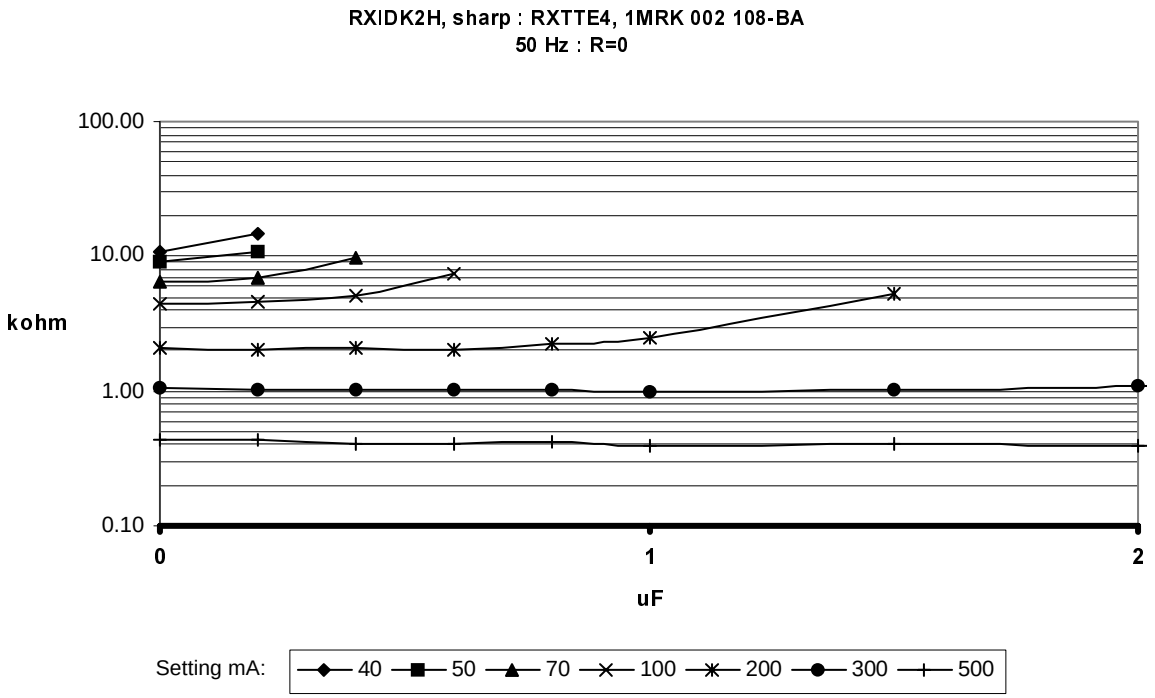

Table 5: RAHL Rotor earth fault protection

Permitted field voltage	Maximum 1200 V DC
Supply voltage	120 or 230 V, 50/60 Hz
Operate earth-fault resistance value	Approx 1-20 kohm, see diagram below
Influence of harmonics in the DC field voltage	Negligible influence of 50 V, 150 Hz or 50 V, 300 Hz
Permitted leakage capacitance	0-5 µF, see diagram below
Permitted shaft earthing resis-tance	Maximum 200 ohm
Protective resistor	220 ohm, 100 W, plate 135X160 mm
Other data for RAHL/RXHL 421	See reference document

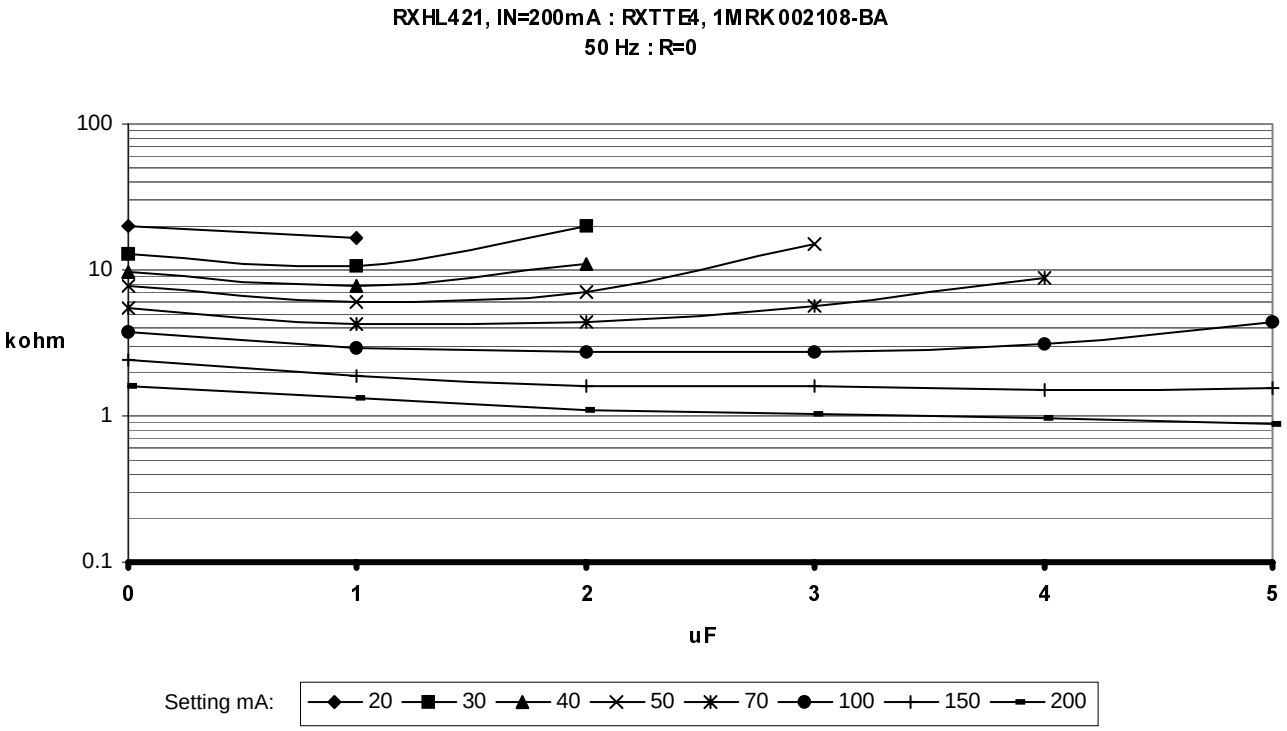

Table 6: RAGIK Dead machine protection

Rated frequency	50 - 60 Hz
Scale ranges Current (RXIDK 2H) Voltage (RXEDA 1) Time (RXEDA 1) Time (RXKA 1)	 0.375 - 16.25 A 15 - 210 V 0 - 10 s 0.1 - 320 s
Operate time	30 ms
Auxiliary voltage	24, 48, 110, 125, 220 or 250 V DC
Dimensions	4U 60C (Four seats free)
Contacts Tripping (RXMS 1) Alarms (RXSF 1)	 6 make 2 make and 1 break

Diagrams

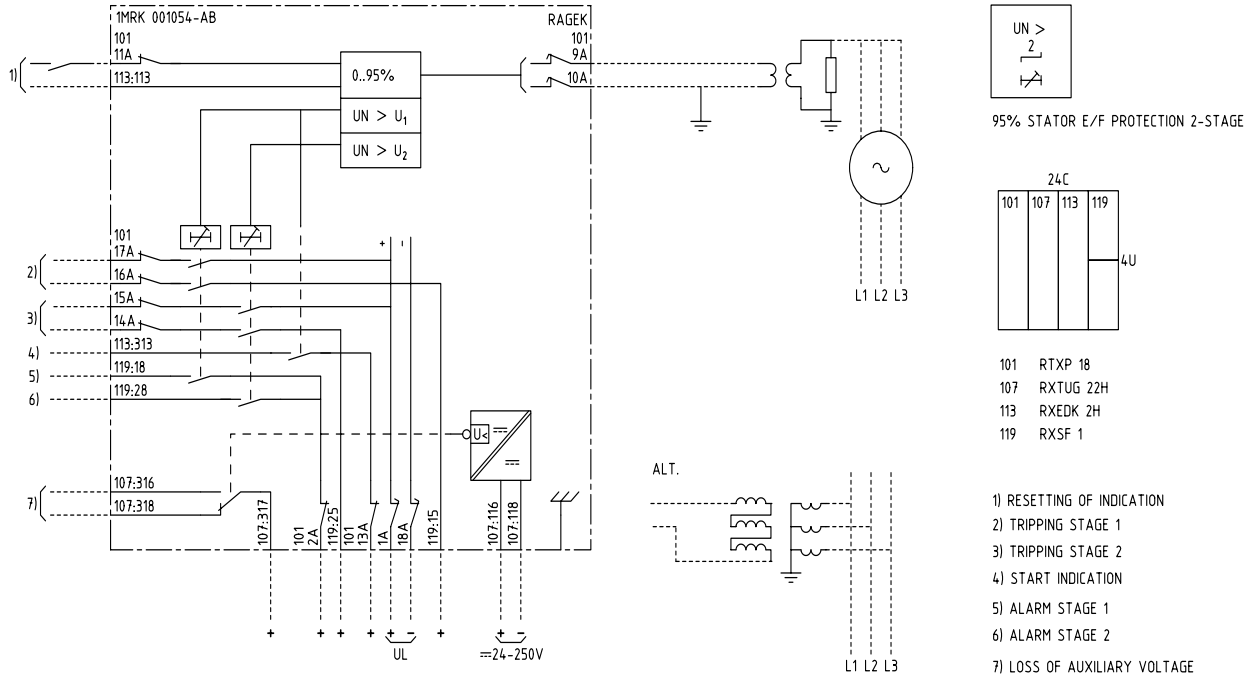

Fig. 1 RAGEK 95% Stator earth fault protection. Terminal diagram 1MRK 001 054-ABA

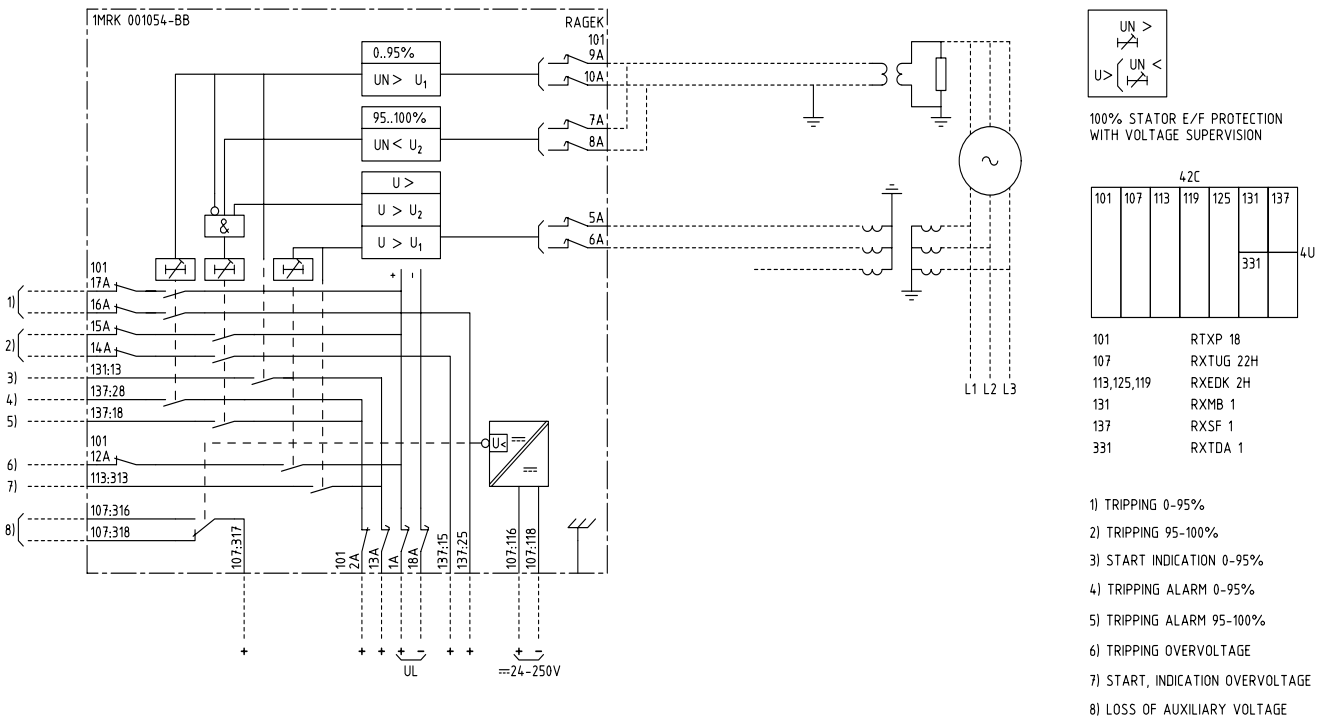

Fig. 2 RAGEK 100% Stator earth fault protection with voltage supervision. Terminal diagram 1MRK 001 054-BBA

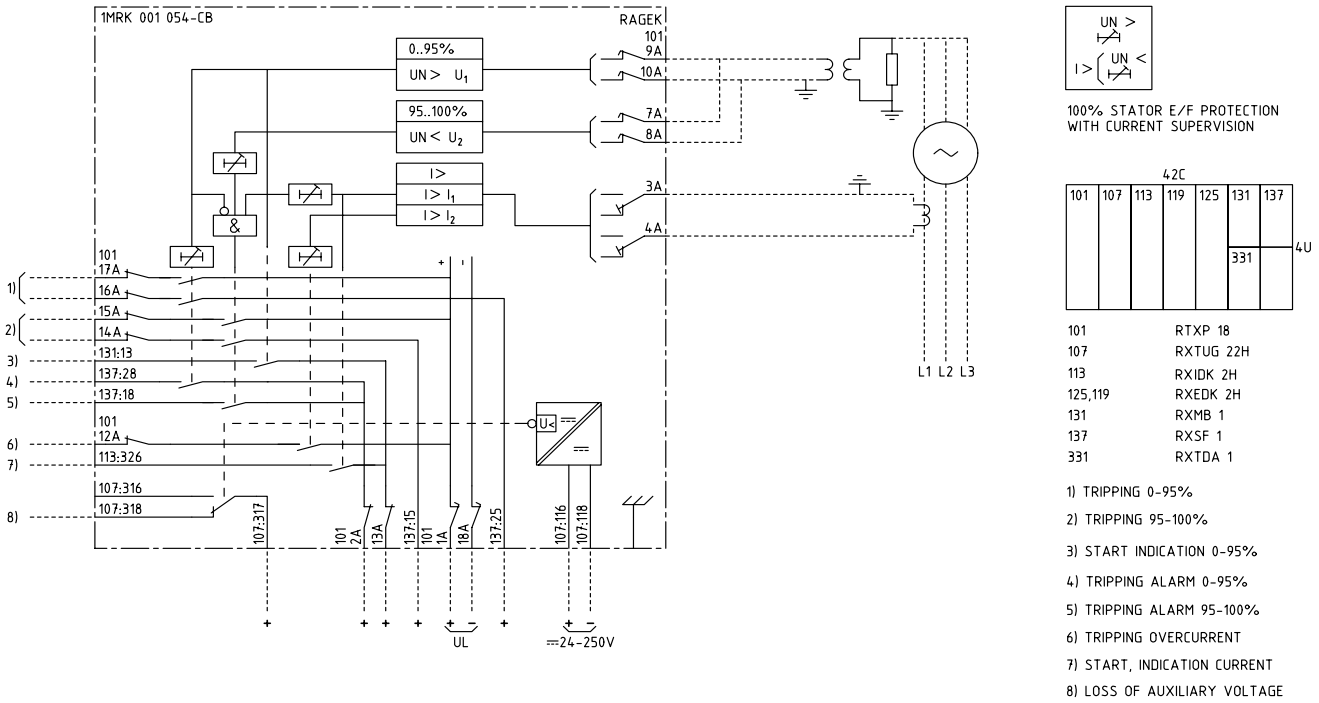

Fig. 3 RAGEK 100% Stator earth fault protection with current supervision. Terminal diagram 1MRK 001 054-CBA

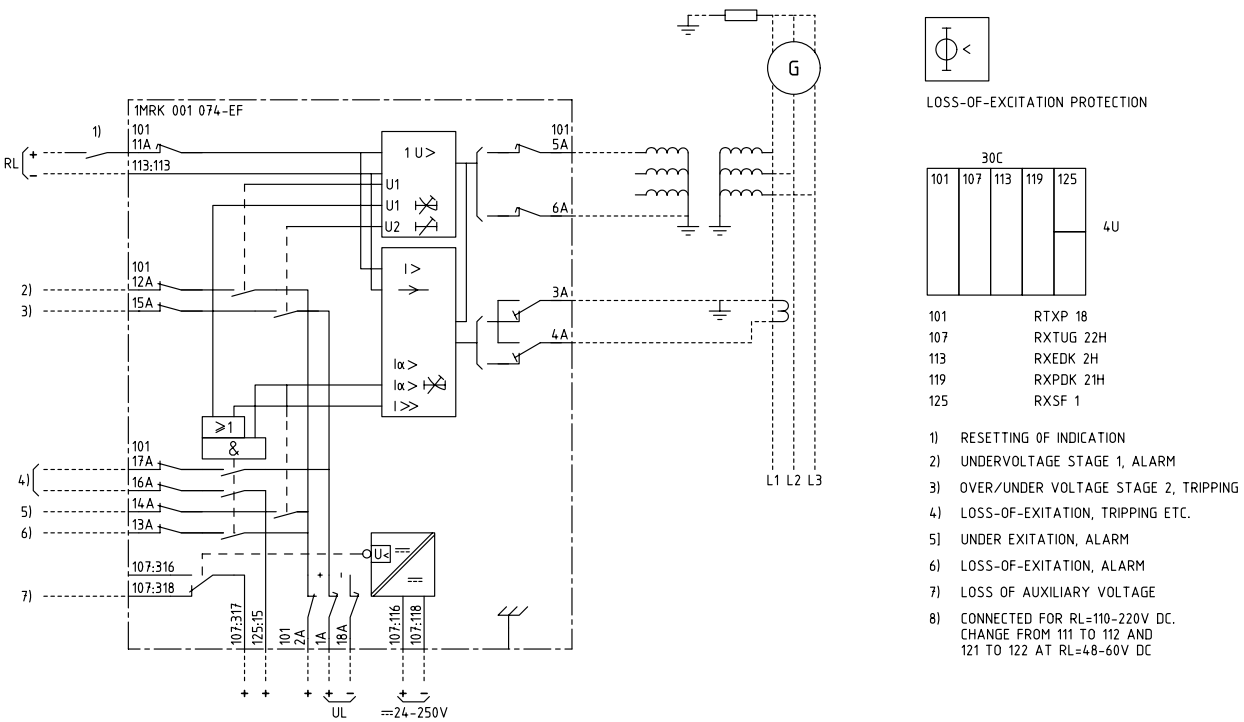

Fig. 4 RAGPK Loss-of-excitation protection. Terminal diagram 1MRK 001 074-EFA

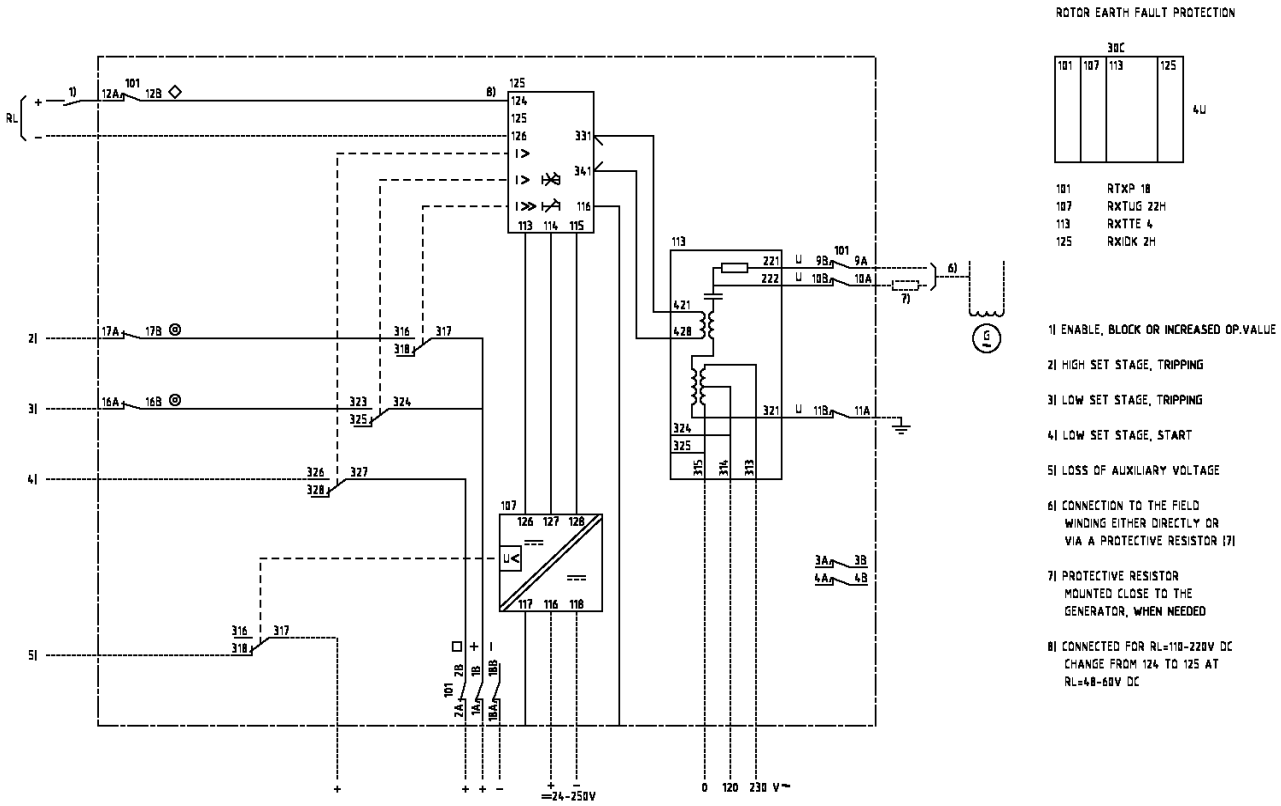

Fig. 5 RAIDK Rotor earth fault protection. Terminal diagram 1MRK 002 398-BA

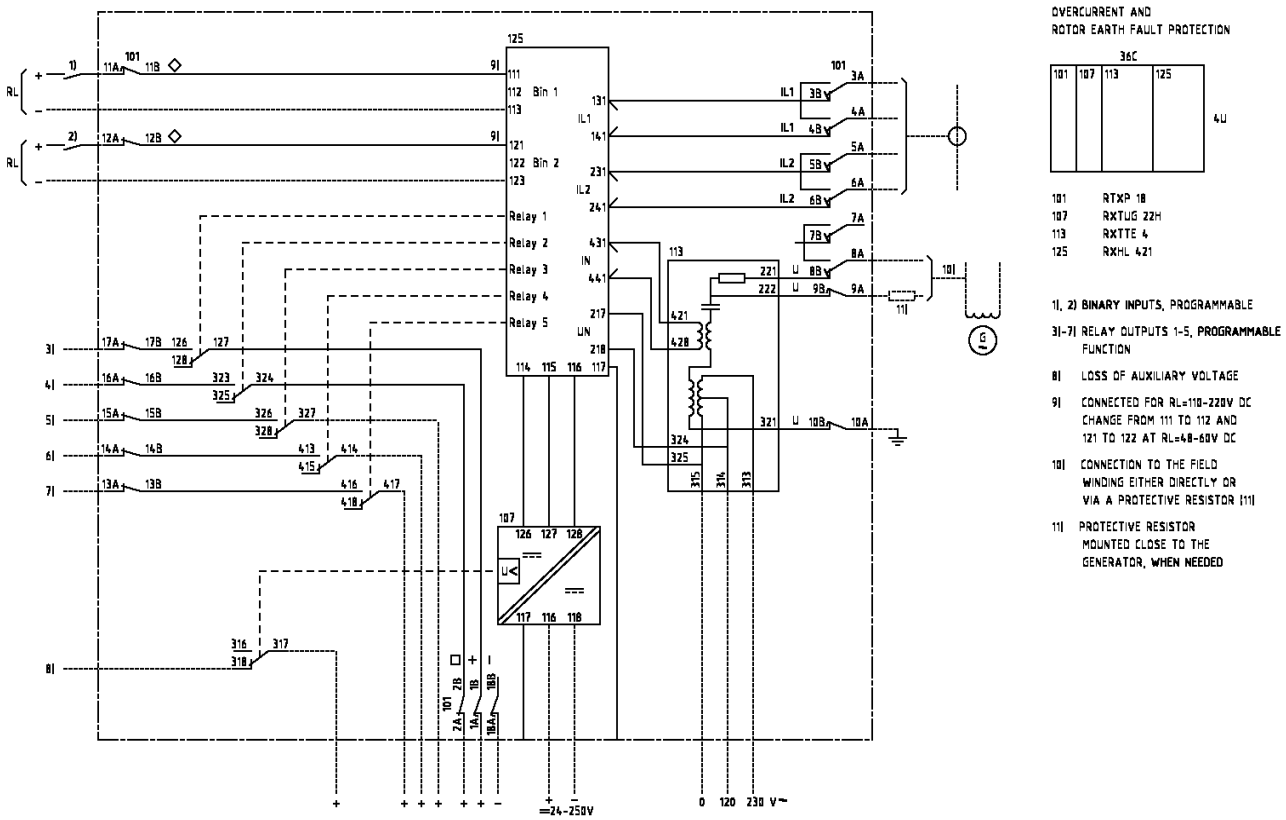

Fig. 6 RAHL Rotor earth fault protection. Terminal diagram 1MRK 002 398-AA

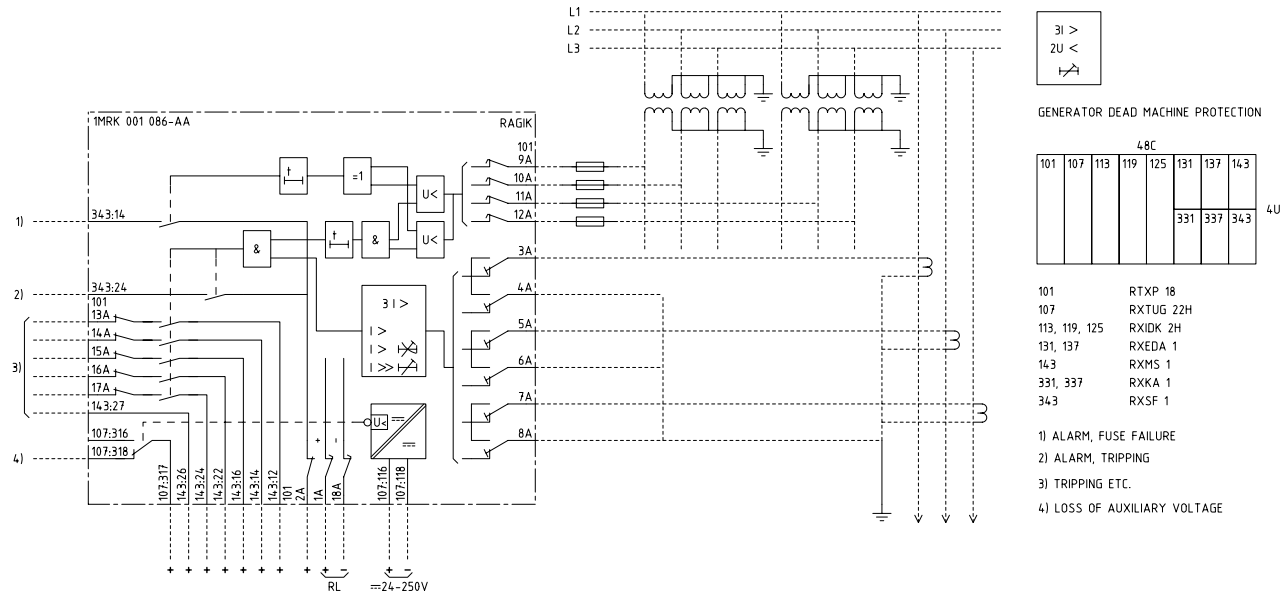

Fig. 7 RAGIK Dead machine protection. Terminal diagram 1MRK 001 086-AAA

Ordering

Specify:

- Ordering No.
- Quantity
- Specify data, see respective product
- Desired wording on the lower half of the test switch face plate max. 13 lines with 14 characters per line.

Designation	Diagrams Terminal/Circuit	Ordering No.	Data to be specified
Phase short circuit			
Differential protection RADHA	–	See References	
Differential protection RADSC	–	See References	
Differential protection RADSB	–	See References	
Impedance protektion RAZK	–	See References	
Phase inter-turn fault			
Time-overcurrent protection RAIDK standard	–	See References	Rated current I_r 50-60 Hz sharp
Stator earth fault protection			
RAGEK 95% protection	1MRK 001 054-AB	1MRK 001 053-AB	Auxiliary voltage UL
RAGEK 100% protection			Rated current I_r for current supervision
with voltage supervision and flags	1MRK 001 054-BB	1MRK 001 053-BB	
with current supervision and flags	1MRK 001 054-CB	1MRK 001 053-CB	
Loss-of-excitation protection			
RAGPK	1MRK 001 074-EFA/-EF	1MRK 001 073-EF	Auxiliary voltage UL Rated current I_r
Rotor earth fault protection			
RAIDK assembly	1MRK 002 398-BA	1MRK 002 397-BA	-
RAIDK standard	See References	See References	1MRK 000 838-GA for Ir=0,2 A 50-60 Hz (sharp)
RAHL assembly	1MRK 002 398-AA	1MRK 002 397-AA	1 A or 5 A phase measurement
RAHL standard	See References	See References	1MRK 000 322-FG for 0,2 A earth and 1 A phase measurement 1MRK 000 322-FM for 0,2 A earth and 5 A phase measurement
RXTTE 4 injection unit (loose delivery without terminal base)	1MRK 002 108-BAA	1MRK 002 108-BA	
Protective resistor on a plate	–	RK 795 102-AD	
Bearing insulation			
Shaft current protection RARIC	–	See References	
Stator overload			
Thermal overcurrent protection RAVK	–	See References	
Reverse power protection RAPPK	–	See References	
Unbalanced load			
Negative sequence current protection RAIIK	–	See References	
Accidental stator energizing			
Dead machine protection RAGIK	1MRK 001 086-AAA/-AA	1MRK 001 085-AA	Auxiliary voltage RL
Time over/under frequency protection RAFK	–	See References	
Out-of -step operation			
Impedance protection RAZK	–	See References	
Over/under voltage			
Time over/under voltage protection RAEDK	–	See References	
Time over excitation protection RALK	–	See References	

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

RADHA	1MRK 509 015-BEN
RADSC	1MRK 509 016-BEN
RADSB	1MRK 504 002-BEN
RXZK/RAZK	1MRK 509 006-BEN
RXIDK/RAIDK	1MRK 509 002-BEN
RXHL 421/RAHL 421	1MRK 509 053-BEN
RARIC	1MRK 502 011-BEN
RXVK/RAVK	1MRK 509 003-BEN
RXPPK/RAPPK	1MRK 509 042-BEN
RXIIK/RAIIK	1MRK 509 045-BEN
RXFK/RAFK	1MRK 509 009-BEN
RXEDK/RAEDK	1MRK 509 004-BEN
RXLK/RALK	1MRK 504 008-BEN
RAGCX	1MRK 502 007-BEN
Auxiliary relays	1MRK 508 015-BEN
Current and voltage relays	1MRK 508 018-BEN
Time relays RXKL, RXKM	1MRK 508 002-BEN
Time relay RXKA	1MRK 508 005-BEN
COMBITEST	1MRK 512 001-BEN
RXTUG	1MRK 513 001-BEN
Connection and installation	1MRK 513 003-BEN
Generator Protection Application Guide	1MRK 502 003-AEN

Manufacturer

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