Modular multifunction generator protection

RAGCX

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Page 1
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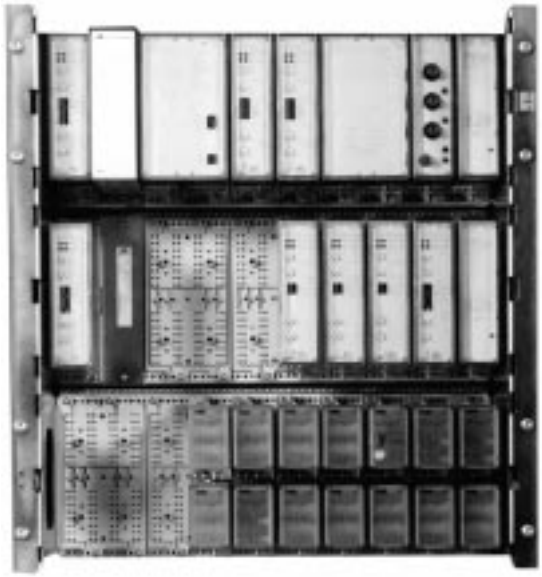

(SE970186)

Features

- RAGCX is a modular generator protection that enables selection of the desired protection in a standardized package with or without prespecified options.
- Stand-alone modules for high dependability
- Suitable for small to medium size gas, steam and hydro generator applications
- Standard recommended minimum protection and optional protection functions
- Optional test switches
- Protection functions included in the standardized RAGCX package;

Basic functions

- Generator differential 87G
- Neutral point voltage 59N
- Loss of excitation 40
- Rotor earth-fault 64R
- Reverse power 32
- Negative sequence overcurrent 46
- Non-directional earth-fault 50N/51N
- 2-Zone under impedance 21
- or voltage restrained overcurrent 51V
- Over and under voltage 51

Optional functions

- Block differential 87GT
- Directional earth-fault 67N
- or Restricted earth-fault 87N
- Out of step 78

Application

The RAGCX family of generator protection assemblies is intended for small to medium (5-150MVA) size generators of different design. The packaging allows for subdivision of the included protection functions into dual schemes, each having separate DC supplies for redundancy reasons. The package lends itself to easy adaptation to varying specifications of protective elements to be included, depending on the generating plant requirements. Standard plug-in elements are used together with optional functions. It is also possible to specify main protection of different operating principle for the primary and back-up functions used. For example; current based differential (RXDSC 4) or voltage restrained overcurrent (RXISK 2H) or under-impedance protection (RXZK 21H or 22H) for single or two zones of protection may be used for generator stator short-circuit detection. I.e., when specifying the impedance relay function, one instantaneous zone and a second time-delayed zone may be included or one time-delayed zone only used as a back up function to the differential relay. Similar considerations can be taken care of by proper selection of optional protective elements included and in the settings of the elements chosen.

Design

The RAGCX is housed in a 19” equipment frame having a height of 12U (533 mm) and is suitable for panel mounting. All external connections are made with standard COMBIFLEX terminal sockets. Individual doors may be provided for each rack tier.

RAGCX can be supplied with the test switches type RTXP or with screw terminal connections or both.

The two basic RAGCX packages have been designed based on the requirements for ABB STAL gas turbines and steam-turbines typically in the 5 to 150 MVA range. It is also possible to use this concept for hydro-generators and other machines.

The protection modules used in the basic RAGCX configuration

Loss of excitation (40)

The directional time-overcurrent relay, type RXPDK 21H, is a static microprocessor based relay. The relay consists mainly a start and trip of low set (directional) stage and trip of high set stage, and three output units which provide separate change-over contacts for start of low set stage and trip of low set and high set stages. The relay has a memory for voltage. The relay has both a choice of different inverse time characteristics and definite time delay settable 50 ms - 8,1 s. Start and low set operate values are set on the scale marked Iα> on the front of the relay. The relay operates when $I \times \cos(\varphi - \alpha) > I_{set}$. The characteristic angle, α, is settable in two ranges between -12° to +12° or -120° to +120°.

Generator differential (87G)

The RXDSC 4 is a high speed low impedance differential protection with a through current percentage restraint function. The relay is insensitive to the DC component. By including additional input restraint modules, up to maximum of 6 three-phase inputs can be connected.

The percentage restraint characteristic provides the required restraint for external faults. The characteristics are designed to provide excellent internal fault sensitivity.

The RXDSC 4 relay also has an unrestrained instantaneous function which responds to the total differential current (less any dc component). This will provide redundant operation for severe internal faults.

Rotor earth-fault (64)

The RXPDK 22H relay is similar to the RXPDK 21H relay which is described earlier, but has higher current sensitivity and no voltage memory function. It consists mainly a start and trip of directional stage and trip of neutral point voltage, and three output units which provide separate change-over contacts for start and trip of directional stage with settable definite time delay 60 ms-10 s and trip of voltage stage. The relay is equipped with a filter for third harmonics suppression.

Start and low set operate values are set on the scale marked I_{α}> on the front of the relay. The relay operates when $I \times \cos(\varphi - \alpha) > I_{set}$ and $U_N > U$>. The characteristic angle, α, is settable 0° or -90°. The relay can also be programmed for uni function or bidirectional function, and the characteristic angle is set with the programming switch on the front of the relay.

Reverse power (32)
The single phase RXPPK 2H relay is used for reverse and low forward power applications mainly for generators. The reverse power setting range of 0,3% to 15% of rated power allows for sensitive settings that may be required in cases of steam turbine plants etc. The relay may also be used for measuring forward power in cases where the reverse power measurement is unreliable.

RXPPK 2H has an angular compensation setting for eliminating phase angle errors from the instrument transformers of +/- 3 degrees.

Two different definite time delay stages.
- Trip t_1 = 0 - 4 s or Trip t_2 = 0 - 30 s.

Trip t_2 function is supported with a stand by time-hold function, with the settings 0 or 5 s. When a Start I_s has occurred, the t_2 timer will not reset until the hold time has expired, regardless if the Start I_s has been reset.

Negative sequence overcurrent (46)
RXIIK 4 comprises mainly of three functional units, a measuring unit, HMI unit and transformer unit, transformer unit contains 3 input transformers one for each phase current.

RXIIK 4 has five programmable relays, which can be selected through HMI for I_Start, I_Alarm, I_Trip and Thermal blocking of start function independently.

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 with definite time = 0-100 seconds.

Thermal memory for block and trip function with the settable cooling time up to 200 minutes.

Under impedance (21)
Applications include single and dual zone impedance protection of transformers, generators, lines and cables. The relays include a directional element which is provided with a memory function upon loss of voltage during the fault. As an alternative the RXZK 21H with one impedance zone may be used. It has a built-in timer, individual R&X settings and a directional element. See the RXZK 21H Buyer's Guide for more details.

The quadrilateral impedance reach characteristic is independently adjustable in the reactive and resistive direction. Forward, reverse and non directional functions are available.

Micro-processor based 2-zone RXZK 22H impedance relay with R and X settings for operates value and built in time delay functions. Directional function with settabel characteristic angle 0° to 120°. Definite time delay settable 0-5 s on second measuring stage.

Voltage restrained overcurrent (51V)
RXISK 2H is used as a short-circuit protection for generators. The voltage restraint function is linear between a set voltage value and 25% of that setting. The set overcurrent operating value is then reduced linearly with the reduced voltage as a result of the fault. The resulting fault current sensitivity is thus a function of the measured input voltage to the relay.

Standard IEC inverse characteristics as well as fixed time delays may be selected via the switches on the front of the relay.

Neutral point voltage (59N)
The over/undervoltage relay, type RXEDK 2H, is a static microprocessor based relay with two delayed stages. The relay consists mainly a start and trip indications and three output units which provide separate change-over contacts for start and trip of stage 1, and trip of stage 2. Operate values for both stage 1 and 2, are set with the potentiometers and programming switches marked with U_s. Both measuring stages can independently be programmed for over/under function. Operation occurs for a voltage equal to or larger than the product of set scale value and the selected scale constant.

The start function output is energized immediately after the measured value exceeds or falls below the set start voltage level.

Stage 1 can be set for definite-time or inverse-time delay 50 ms-16,1 s while stage 2 only has definite time delay up to 10 s.

Design (cont'd)

Non-directional earth-fault (50/51N)
The time-overcurrent relay, type RXIDK, is a static microprocessor based relay with a high set definite delayed stage and a low set, definite or inverse time, delayed stage. The relay consists mainly a start and trip indications and three output units which provide separate change-over contacts for start, trip and high set stage.

Start and time-overcurrent operate values are set on the scale marked I>. Operation occurs for a current equal to or larger than the product of set scale value and the selected scale constant (I_s). The scale constant is selected on the programming switch on the front of the relay.

The start function output is energized immediately after the measured current exceeds the set start current level.

For definite-time delayed operation the time overcurrent output operates after the set time delay settable 50 ms-8,1 s. High set stage can be delayed up to 1 s.

The protection modules used in optional RAGCX configurations

Block differential (87GT)
The RXDSB 4 is a differential relay intended for all types of three-phase power transformers. By including additional input restraint modules, up to 6 transformer windings or restraining inputs can be connected. The relay is well suited for generator and step-up transformer overall protection, often including the auxiliary transformer in the protected zone.

The non-linear percentage restraint characteristic provides the required restraint for external faults. This makes the relay suitable for use with multi-winding transformers, autotransformers or in a system where one transformer winding is directly connected to two or more breakers. The characteristics are designed to provide excellent internal fault sensitivity.

The RXDSB 4 relay also has an unrestrained instantaneous overcurrent function which responds to the total differential current (less any dc component).This will provide redundant hight speed operation for severe internal faults.

Out of step (68)
RXZK 23H is intended for detecting out of step conditions for tie-lines and synchronous generators and motors. It includes a current reversal logic in order to set up a trip condition. This ensures that the relay will not trip on stable swing conditions, i.e. swings not resulting in a current reversal.

The characteristic angle is settable 0° to 90°. Definite time delay settable 0-5 s on second measuring stage.

Additional functions
Additional protection functions, such as 100% stator ground fault protection (RAGEK), dead machine protection (RAGUA), frequency relays (RXFK 2H) and overexcitation relays (RXLK 2H), thermal overcurrent protection (RXVK 2H), shaft current protection (RARIC) and an excitation machine diode failure relay (RXIDK 2H) may also be specified and engineered into the protective scheme. See also Generator Protection Product Selection Tables in 1MRK 501 010-BEN for further guidance.

Standard configuration

Example of a typical layout

Rack1	101	107	113		125	131	137		149	155
Rack 2	501	507	513		525	531	537	543	549	555
Rack 3	901	907	913	919	925	931	937	943	949	955
				1119	1125	1131	1137	1143	1149	1155

Rack 1

101	RXPDK 21H	Loss of exct. 40
107	RTQTB 060	Gen. diff. 87G
113	RXDSC 4	Gen. diff. 87G
125	RXPDK 22H	Rotor E/F 64R
131	RXPPK 2H	Reverse power 32
137	RXIIK 4	Neg. seq. 46
149	–	SPARE
155	RXTUG 22H	DC/DC converter

Rack 2

501	RXEDK 2H	Neutral point 59N
507	RTQTB 060	Block. diff. 87GT Option
513	RXDSB 4	Block. diff. 87GT Option
525	RXIDK 2H	E/F 67N, 50N/51N Option
531, 537, 543	RXISK 2H/ RXZK 22H	Voltage restrained overcurrent 51V/ Under imped. 51
549	RXEDK 2H	U>/U< 59/27
555	RXTUG 22H	DC/DC converter

Rack 3

901	RXPDK 22H/ RXPDK 21H	Restricted E/F 87N Option
907	RXZK 23H	Out of step Option
913	RXPPK 22H	Reverse power 32 Spare
919-955	RXMB 1	
1119	RXMB 1	
1125	RXMB 1	
1131	RXKL 1	
1137	RXKL 1	
1143	RXMB 1	
1149	RXMB 1	
1155	RXMB 1	

Subsystem 1

Rack 1

Loss of excitation protection	RXPDK 21 H
Generator differential protection	RXDSC 4
Rotor earth fault protection	RXPDK 22H
Reverse power protection (1)	RXPPK 2H
Negative sequence overcurrent protection	RXIIK 4
Spare space	
DC/DC converter power supply	RXTUG 22H

Subsystem 2

Rack 2

Neutral point voltage protection (stator earth fault) or resistedearth fault relay	RXEDK 2H
Block transformer differential	RXDSB 4 Option
Non-directional earth-fault overcurrent	RXIDK 2H Option
Voltage restrained overcurrent protection	RXISK 2H
(Alt. underimpedance	RXZK 22H)
Over/undervoltage protection	RXEDK 2H

Rack 3

Auxiliary trip and signalling relays	RXMB 1
Timers	RXKA 1 RXKL 1

Optional modules

Restricted earth-fault protection/ Directional earth-fault overcurrent	RXPDK 22H/ RXPDK 21H Optional
Out of step protection	RXZK 23H Optional
Extra reverse power relay (for steam turbines)	RXPPK 2H
Extra trip auxiliary	RXMB 1

Wiring for all the option protections are included

Standard configuration (cont'd)

Alternatives

One or two zone impedance protection instead of voltage restraint over-current protection	RXZK 21H or RXZK 22H
Equipment frame mounting with or without terminal blocks and wiring	
VSH cubicle mounting	

Technical data

Table 1: Current and voltage function

Standard rated AC current, I_r	1 A or 2 A or 5 A
Standard neutral AC current, I_N	0,05 A or 0,2 A
Standard rated AC voltage, U_r	110 or 240 V
Standard neutral AC voltage, U_N	110 or 240 V
Rated frequency	50 or 60 Hz
Standard DC supply voltage	24-250 V

Table 2: 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 3: 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

Table 3: Electromagnetic compatibility(EMC), immunity tests

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

Test	Severity	Standard
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 4: Electromagnetic compatibility(EMC), emission tests

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

Table 5: Isolation 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 6: 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 7: Temperature range

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

Please refer to the Buyer´s Guide for each individual relay module for further details.

Ordering

Specify:

- RAGCX generator protection
- Quantity
- Ordering number, see below
- Rated current
- Rated voltage
- Auxiliary voltage
  - DC supply
  - Auxiliary relays
- Optional protective relay modules to be included
- Method of mounting
  - A. 19" equipment frame 12U high without doors as standard - optional doors
  - B. VSH cubicle mounting
- Optional terminal blocks with wiring
  - length ca. 2.4 m
  - additional price for 12U equipment frame version only

Table 8: Ordering table

RAGCX Product	Circuit diagram	Terminal diagram	Ordering No.
Generator protection, Gas turbine	1MRK 001 054-PA	1MRK 001 054-PAA	1MRK 001 053-PA
Generator protection, Steam turbine	1MRK 001 054-RA	1MRK 001 054-RAA	1MRK 001 053-RA

References

COMBIFLEX Generator Protection - Application Guide	1MRK 502 003-AEN
COMBIFLEX Generator protection	1MRK 502 003-BEN
COMBIFLEX Installation and connection details	1MRK 513 003-BEN
COMBIFLEX Dimensions	1MRK 514 004-BEN
COMBITEST	1MRK 512 001-BEN
VSH 200 relay and control cubicle	1MRK 514 002-BEN
RXIDK 2H and RAIDK, RXIDG 21H and RAIDG	1MRK 509 002-BEN
RXIDK 4 and RAIDK	1MRK 509 035-BEN
RXEDK 2H and RAEDK	1MRK 509 004-BEN
RXPDK 2H and RAPDK	1MRK 509 007-BEN
RXZK 21H, 22H, 23H and RAZK	1MRK 509 006-BEN
RXISK 2H and RAISK	1MRK 509 033-BEN
RXPPK 2H and RAPPK	1MRK 509 042-BEN
RXKA 1	1MRK 508 005-BEN
RXKL 1 and RXKM 2H	1MRK 508 002-BEN
RXMB 1, RXMB 2 and RXMC 1	1MRK 508 006-BEN
RADSB	1MRK 504 002-BEN
RADSC	1MRK 509 016-BEN
RXTUG 22H	1MRK 513 001-BEN

Manufacturer

ABB Automation Products AB
Substation Automation Division
SE-721 59 Västerås
Sweden
Tel: +46 (0) 21 34 20 00
Fax: +46 (0) 21 14 69 18