Directional or non-directional earth-fault relay

REJ 517

1MRS 751131-MBG

Issued: 17.06.1999
Status: Updated
Version: B/08.11.2001
Data subject to change without notice

Features

- Directional or non-directional low-set earth-fault current stage I_0> with definite-time or inverse definite minimun time (IDMT) characteristic
- Directional or non-directional high-set earth-fault current stage I_0>> with definite-time characteristic
- Deblocking zero-sequence voltage stage U_{0b}>
- The two earth-fault current stages configurable to operate alternatively as two voltage stages: a three-stage voltage monitoring operation possible
- Intermittent earth-fault protection
- Circuit-breaker failure protection (CBFP)
- Disturbance recorder
- Two accurate measuring inputs
- Galvanically isolated binary input with a wide input voltage range
- All settings are modified with a personal computer
- Settings are stored into non-volatile memory and remain even in case of power supply failure
- Two normally open power output contacts
- Two change-over type signal output contacts
- Output contact functions freely configurable for desired operation
- Optical PC-connector for two-way SPA-bus data communication
- Continuous self-supervision of hardware and software. At a permanent fault all stages and outputs are blocked
- Rated frequency user-selectable 50/60 Hz

Application

The directional earth-fault relay REJ 517 is a secondary relay that is connected to the voltage and current transformers of an object to be protected. It is designed for earth-fault protection and supervision of distribution substations. Other application areas are protection of generators, motors and transformers.

The relay comprises a zero-sequence voltage unit and an earth-fault current unit. The voltage unit includes a low-set stage $U_{0b}>$ whereas the earth-fault current unit has two stages, a low-set $I_0>$ and a high-set $I_0>>$ stage. The earth-fault current unit may also be programmed to operate as voltage stages, a low-set $U_0>$ and a high-set $U_0>>$ stage.

The earth-fault current and zero-sequence voltage stages of the relay continuously measure the zero-sequence voltage, earth-fault current and phase angle of the system. On detection of a fault the relay starts, trips the circuit breaker, provides alarms, records fault data etc., in accordance with the application and the configured relay functions.

The low-set earth-fault current stage can be given a definite-time or an inverse-time characteristic whereas the high-set earth-fault current stage and the voltage stage feature the definite-time characteristic alone. The operation of the earth-fault current and voltage stages can be blocked by means of an external control signal.

The protection functions are independent of each other and have their own setting groups and data recording. The voltage and current functions use conventional transformer measurement.

Output contact matrix allows any start or trip signal from the protection stages to be routed to the desired output contact.

Design

The relay consists of three protection units: a high-set and a low-set earth-fault current unit, a zero-sequence voltage unit and a circuit-breaker failure protection unit. Further, the relay includes a self-supervision system and a disturbance recorder unit.

Directional or non-directional earth-fault current unit

The directional earth-fault current unit of the relay REJ 517 comprises two earth-fault current stages, a low-set stage I_0> and a high-set stage I_0>> that can be configured as either directional or non-directional. For the directional stages there are two alternative operation characteristics: 1) directional earth-fault with basic angle and 2) directional earth-fault with sin(φ) or cos(φ) characteristics.

1) The operation of the directional earth-fault unit with basic angle is based on measuring the earth-fault current I_0 and the zero-sequence voltage U_0 and further the phase angle φ between the voltage and current. The earth-fault stage starts if the following three criteria are fulfilled at the same time:

- The earth-fault current I_0 exceeds the set starting level of the earth-fault stage. The earth-fault unit has two earth-fault current stages I_0> and I_0>>.
- The zero-sequence voltage U_0 exceeds the set starting level. The unit has one starting level, U_{0b}>, serving both stages in deblocking mode.
- The phase angle φ between the voltage and current falls within the operation sector φ ±Δφ.

The basic angle φ of the network is -90° for isolated neutral networks and 0° for resonant earthed networks, earthed over an arc suppression coil (Petersen coil) with or without a parallel resistor. The operation sector is selectable to Δφ = ±80° or ±88°, both with the addition of a wider operation sector.

2) The operation of the directional earth-fault unit with sin(φ) or cos(φ) characteristics is based on measuring the earth-fault current I_0 and the zero-sequence voltage U_0 and further the phase angle φ between the voltage and current. The sinus or cosinus value for the phase angle is calculated and then multiplied by the earth-fault current. This will give the directional earth-fault current Iφ as a result. The earth-fault stage starts if the following three criteria are fulfilled at the same time:

- The directional earth-fault current Iφ exceeds the set starting level of the earth-fault stage. The earth-fault unit has two earth-fault current stages I_0> and I_0>>.
- The zero-sequence voltage U_0 exceeds the set starting level. The unit has one starting level, U_{0b}>, serving both stages in deblocking mode.
- The phase angle φ between the voltage and current falls within the operation sector of the angle correction factor φ_c=2…7°.

When an earth-fault stage starts, a starting signal is generated and simultaneously the yellow LED on the front panel indicates starting. If the above mentioned criteria are fulfilled long enough to exceed the set operate time, the stage that started initiates a tripping signal. At the same time the red operation indicator on the front panel is lit. The red operation indicator remains lit even if the protection stage resets.

The operation directions, forward or reverse, for the directional earth-fault stages can be selected independently of each other. The directional stages may also be configured separately as non-directional protection stages.

When the earth-fault current exceeds the set start current of the low-set stage I_0>, the earth-fault unit starts delivering a start signal after a preset ~ 70 ms start time. When the set operate time at definite-time operation or the calculated operate time at inverse-time operation elapses, the earth-fault unit operates. In the same way, the high-set stage I_0>> of the earth-fault unit starts delivering a start signal after a preset ~ 60 ms start time when the set start current is exceeded. When the set operate time elapses, the earth-fault unit operates.

The low-set stage of the earth-fault unit may be given a definite-time or an inverse definite minimum time (IDMT) characteristic. When the IDMT characteristic is chosen, six time/current curve groups are available. Four of the groups comply with the standards IEC 60255 and BS 142, and are called “normal inverse”, “very inverse”, “extremely inverse” and “long time inverse”. The two additional inverse-time curve groups are called “RI-” and “RD-curves”.

The inverse-time function of stage I_0> can be inhibited when stage I_0>> is started. In this case, the operate time is determined by stage I_0>>.

If not needed, the stage I_0>> can be set out of operation completely. This state is indicated by “999” when the set start current value is read via serial communication.

The set start current value I_0>>/I_n of stage I_0>> can be automatically doubled in a start situation, i.e. when the object to be protected is connected to a network. Thus a set start current value below the connection inrush current level may be selected for the stage I_0>>. A start situation is defined as a situation where the phase current rises from a value below 12 % x I_0> to a value above 150 % x I_0> in less than 60 ms. The start situation ends when the current falls below 125 % x I_0>.

The reset delay is settable to values 80, 100, 500 and 1000 ms via the switchgroup SGF5. If the resetting time is set to 100 ms or above, the earth-fault stage I_0> operates as an intermittent earth-fault stage.

Zero-sequence voltage unit

The two current stages I_0> and I_0>> can be replaced by two additional voltage stages, making the unit a three-stage zero-sequence voltage module. All the three stages measure the same voltage but can have separate settings both for sensitivity and operate time. The signalling and trip relays can also be selected separately for all the three stages.

When the zero-sequence voltage exceeds the start voltage value set for the low-set stage U_0>, the voltage unit starts delivering a start signal after a preset ~ 70 ms start time. When the set operate time at definite-time operation elapses, the voltage unit operates. In the same way, the high-set stage U_0>> of the voltage unit starts delivering a start signal after a preset ~ 60 ms start time, when the set start voltage is exceeded. When the set operate time elapses, the unit operates.

The low-set and high-set stages of the zero-sequence voltage unit operate on the basis of the definite-time characteristic.

The high-set stage U_0>> may be set out of operation by means of the switch SGF2/3.

CBFP unit

The relay incorporates a circuit-breaker failure protection (CBFP) unit. The CBFP unit generates a trip signal via output PO2 after the set operate time of 0.1…1 s, provided the fault has not been cleared by that time. Normally, the CBFP unit controls the upstream circuit breaker. It can also be used for tripping via redundant trip circuits of the same circuit breaker, if the circuit breaker is provided with two trip coils. The circuit-breaker failure protection unit is activated via a software switch.

Disturbance recorder unit

The relay includes an internal disturbance recorder, which records momentary measured values, external BI signal and states of the internal protection stages. The disturbance recorder can be set to be triggered on operation of stages or on an external BI signal, either on the falling or rising trigger edge.

Self-supervision unit

The relay is provided with a self-supervision system for monitoring internal faults. Once the self-supervision system detects a permanent internal relay fault, the ready indication LED starts blinking. At the same time, the normally operated self-supervision alarm relay drops off and a fault code can be read from the relay. This fault code identifies the fault that has been detected.

Communication capabilities

Relay data, such as events, input data, setting values and recorded information can be read via the optical PC interface. The relay communicates over the SPA bus protocol, data transfer rate 4.8 or 9.6 kbps. For the connection of a PC, an optical connection cable type 1MKC950001-1 is needed.

Auxiliary supply

For its operation the relay requires a secured auxiliary voltage supply. The internal power supply of the relay forms the voltages required by the relay electronics. The power supply is galvanically isolated. A green LED indicator “READY” on the front panel is lit when the power supply module is operating.

Rated voltage ranges:

- AC range 80…265 V ac, rated 110/120/220/240 V
- DC range 38…265V dc, rated 48/60/110/125/220 V

The primary side of the power supply is protected with a fuse located on the printed circuit board of the relay. The fuse size is 2.5 A (slow).

Technical data

Table 1: Energizing inputs

Rated current I_n		0.2 A	1 A
Thermal withstand capability	continuously	1.5 A	4 A
	for 1 s	20 A	100 A
Dynamic current withstand, half-wave value		50 A	250 A
Input impedance		<750 mΩ	<100 mΩ
Rated voltage U_n		100/110/115/120 V	
Maximum input voltage	continuously	2 x U_n	
	for 10 s	3 x U_n	
Power consuption		<0.5 VA	
Rated frequency f_n		50 Hz or 60 Hz ±5 Hz	

Table 2: Measuring range

Measured voltage on phase U_0 as a percentage of the rated voltage of the energizing input	0...400% x U_n
Measured current on phase I_0 as a percentage of the rated current of the energizing input	0...800% x I_0

Table 3: Output contact ratings for power outputs (PO1 and PO2)

Terminals	X2.1/3-4, X2.1/5-6
Rated voltage	250 V dc/ac
Continuous carry	5 A
Make and carry for 0.5 s	30 A
Make and carry for 3.0 s	15 A
Breaking capacity for dc, when the trip circuit time constant L/R ≤ 40 ms, at 48/110/220 V dc	5 A / 3 A / 1 A
Contact material	$AgCdO_2$

Table 4: Output contact ratings for signal outputs and self-supervision output (SO1, SO2 and IRF)

Terminals	X2.1/7-8-9, X2.1/10-11-12, X2.1/13-14-15
Rated voltage	250 V dc/ac
Continuous carry	5 A
Make and carry for 0.5 s	10 A
Make and carry for 3.0 s	8 A
Breaking capacity for dc, when the trip circuit time constant L/R ≤ 40 ms, at 48/110/220 V dc	1 A / 0.25 A / 0.15 A
Contact material	$AgCdO_2$

Table 5: External binary input

External control rated voltage level	U_n = 24/48/60/110/220 V dc
Operative range	18…265 V dc
Typical control current of input circuit	2…25 mA

Table 6: Auxiliary voltage

Rated voltage	U_n = 110/120/220/240 V ac U_n = 48/60/110/125/220 V dc
Operative range	80…265 V ac 38…265 V dc
Power consumption	4…10 W

Table 7: Data transmission

Transmission mode	Optical PC interface
Protocol	SPA bus
Selectable data transfer rates	4.8 or 9.6 kbps

Table 7: Data transmission

Optical connection cable	1MKC 950001-1

Table 8: Dielectric tests

Insulation test according to IEC 60255-5	2 kV, 50 Hz, 1 min
Impulse test according to IEC 60255-5	5 kV, 1.2/50 μs, 0.5 J
Insulation resistance test according to IEC 60255-5	> 100 MΩ, 500 V dc

Table 9: Electromagnetic compatibility tests

The EMC immunity test level fulfills the requirements specified in the generic standard EN 50082-2		
1 MHz burst disturbance test, class III (IEC 60255-22-1)	common mode	2.5 kV
	differential mode	1.0 kV
Electrostatic discharge test, class III (IEC 61000-4-2)	for contact discharge	6 kV
	for air discharge	8 kV
Radio frequency interference test	conducted, common mode (IEC 61000-4-6)	10 V (rms), f = 150 kHz…80 MHz
	radiated, amplitude-modulated (IEC 61000-4-3)	10 V/m (rms), f = 80…1000 MHz
	radiated, pulse-modulated (ENV 50204)	10 V/m, f = 900 MHz
	radiated, test with a portable transmitter (IEC 60255-22-3, method C)	f = 77.2 MHz, P = 6 W; f = 172.25 MHz, P = 5 W
Fast transient disturbance test (IEC 60255-22-4 and IEC 61000-4-4)	ac/dc ports	4 kV
	binary inputs	2 kV
Surge immunity test (IEC 61000-4-5)	power supply, ac/dc ports	4 kV, common mode 2 kV, differential mode
	I/O ports	2 kV, common mode 1 kV, differential mode
Electromagnetic immunity tests (IEC 61000-4-8)	power frequency magnetic field	100 A/m
Voltage dips and short interruptions	IEC 61000-4-11	30% / 10 ms 60% / 100 ms >95% / 5 000 ms
Electromagnetic emission tests (EN 55011 and EN 50081-2)	conducted, RF emission (mains terminal)	EN 55011, class A
	radiated, RF emission	EN 55011, class A
CE approval	complies with the EMC directive 89/336/EEC and the LV directive 73/23/EEC	

Table 10: Mechanical tests

Vibration test, sinusoidal (IEC 60255-21-1)	class I
Shock and bump test (IEC 60255-21-2)	class I

Table 11: Environmental conditions

Climatic environmental tests	dry cold test	according to IEC 60068-2-1
	dry heat test	according to IEC 60068-2-2
	damp heat test, cyclic	according to IEC 60068-2-30
Enclosure class	front side	IP54 (flush-mounted)
	rear side, connection terminals	IP 20
Weight of the relay		~3.0 kg

Block diagram

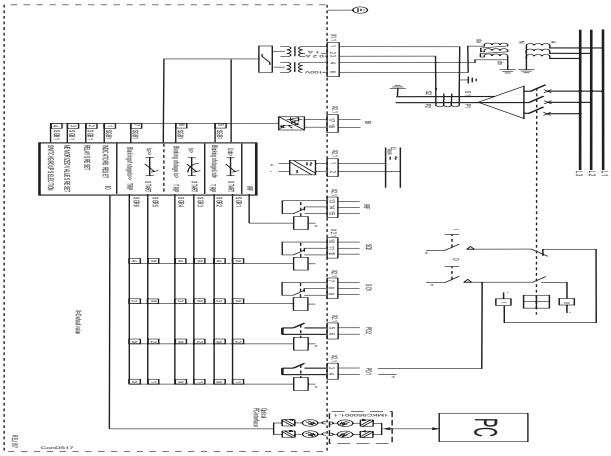
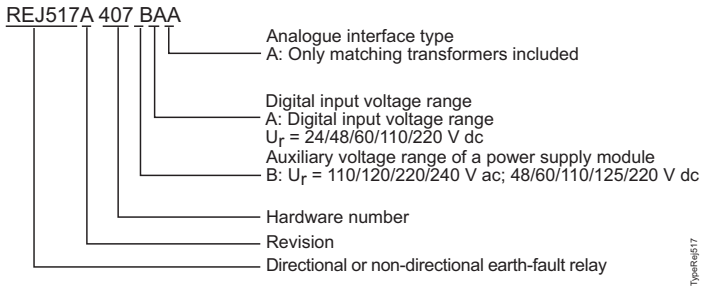


Fig. 1 Block diagram of the directional or non-directional earth-fault relay

Ordering

The order number identifies the hardware as described below.

This number is labelled on the marking strip on the front panel.



When ordering, please specify:

Ordering information:	Ordering example:
1. Type designation and quantity	REJ 517, 5 pieces
2. Order number	REJ517A 407-BAA
3. Optical connection cable	1 piece (1MKC 950001-1)

Order numbers

Optical connection cable	1MKC 950001-1
Protective cover for rear connectors	1MRS060132
Flush mounting kit	1MRS050209
Semi-flush mounting kit	1MRS050253
Wall mounting kit	1MRS050240
Side-by-side mounting kitl	1MRS050241
19” Rack mounting kit	1MRS050257

References

Additional information

User’s Guide	1MRS 750615-MUM

ABB Oy

P.O. Box 699
FIN-65101 Vaasa, Finland
Tel +358 10 224 000
Fax +358 10 224 1094
www.abb.com/substationautomation