Bus differential relay

REB 103
3-phase

1MRK 505 007-BEN
Page 1
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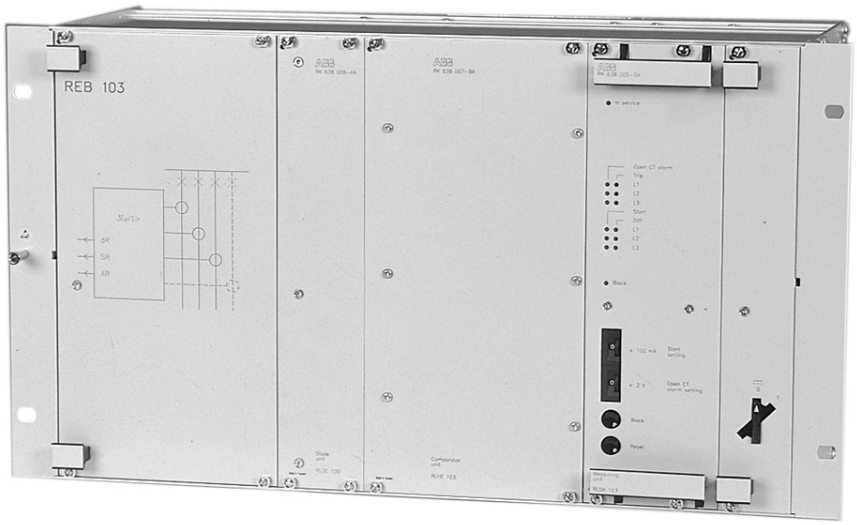
Data subject to change without notice



(SE970146)

Features

- Percentage restrained differential relay for phase-to-phase and phase-to-earth faults.
- Very high E/F-sensitivity of the differential relay element in directly earthed networks.
- Primary fault settings of the differential relay element: 1 percent of the largest main CT rating.
- High speed of operation, detecting an internal fault within 1 ms and sending an output trip signal within 6 to 9 ms.
- Fully stable in the event of faults outside the protected zone, even with infinite fault-MVA and completely saturated line CT's.
- Line CT's may be of standard design, with different CT-ratios, with large internal resistance and a small knee-point voltage.
- Other relays may be connected to the same CT core.
- Very sensitive CT-Open-Circuit Alarm feature.
- Starting Relay element adjustable in the range: 1 to 150 percent of the largest line CT rating.
- A separate and sensitive Earth Fault relay scheme is available when the network is resistance earthed.

Application

The REB 103 bus differential relay is a very fast percentage restrained differential relay. The operating time for an internal bus fault is 1-3 ms and trip impulse is sent to the breakers within 6-9 ms. The high speed of operation ensures power system stability also for busbar faults with very high fault currents.

The REB 103 bus differential relay is suitable for all types of bus configurations: 1, 2, 3 and 6-zones, with switching of CT secondary circuits. Full stability is guaranteed during the switching operations, owing to the method of reconnecting the circuits and, also, by the percentage operating and starting relay features.

When SF6 gas insulated buses are protected, externally mounted single-phase, slip-over cable CT's may be used with great advantage, particularly if these are made with the most suitable ratio. The auxiliary CT's may then be of the same design (ratio) for all feeders and the complete gas insulated bus construction may be included within the zone of the bus differential relay.

In some cases, when a large generator feeder is connected to a bus, its CT's may be located some distance away, for example in the bushings of the step up power transformer. These CT's may be included in the bus zone protection if the feeder is considered to be a major part of the busbar.

Application (cont'd)

If the distance of the pilot-wires is large (>1 km), isolating auxiliary CT's may be installed at both ends.

In the case of a double bus, it is recommended that the main bus coupler CT's have two separate cores, one for each bus zone, so as to avoid any interference from one zone to the other. If only one core is available, two auxiliary CT's have to be included to feed individually each bus zone. The knee-point voltage of the main CT should in such a case, preferably be higher than the knee-point voltages of the two auxiliary CT's put together.

Auxiliary CT's are used for ratio correction and also for reducing the 1 Amp and 5 Amp rated current to a 0.5 A relay current. The auxiliary CT's may be mounted close to the REB 103 relay, but in some special cases, they may be placed relatively close to the line CT's, so as to reduce the burden of the line CT secondary circuit.

Busbar arrangements

The arrangements of power system buses vary widely depending on the magnitude of the through going load current, the number of line circuits and the need for splitting up the station in several zones subsequent to an internal bus fault.

The normal rating of a bus conductor is from 1000-3000 A and a typical number of lines to a certain bus zone is 6-12 L. For the largest installations 2, 4 and 6 relay zones may be installed.

Single bus one-zone

The most simple and reliable installation is the single bus one-zone arrangement (Fig. 1). In this case it can also be permitted that a bus section switch (S) is opened at certain times to split the bus in two parts. As long as there is no internal fault the REB 103 differential relay remains stable. This applies even when the two bus sections are working asynchronously, e.g. at different frequencies; however, when an internal fault occurs, both sections will always be tripped simultaneously. When the bus selection switch is open, the two sections must be supplied radially, i.e. internal fault currents to one section must not pass through to the other section.

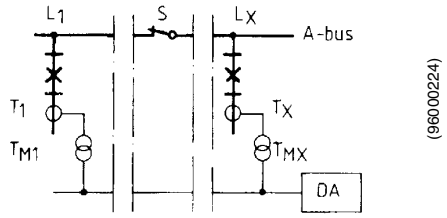


Fig. 1 Single-bus, one-zone with bus section switch normally closed

Single bus two-zones with bus section switch

When the bus section switch (A12) in Fig. 2 is kept open during longer periods of time, it may be an advantage to include two differential relays. The two sections may then work independently and when a fault occurs only the affected section is tripped.

When the A12 switch is closed, all the input circuits will be connected to the DA1 relay and the DA2 relay is disconnected. The operating sensitivity is then determined only by the DA1 relay. If both relays should be kept in service at the same time the total relay operating current becomes twice as large.

The relay units shown in the drawing, A12X and DA2X, consist of RXMVB 4 changeover relay and RXMM 1 auxiliary relay. These relay units are arranged to work in a special sequence so that the CT secondary circuits never become open-circuited.

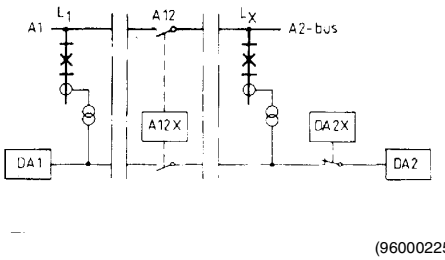


Fig. 2 Single-bus, two-zone with bus section switch normally open

Double-bus with CT switching

One of the most common arrangements is the double-bus, with one bus coupler and one circuit-breaker per line (Fig. 3). When line L1, connected to the A-bus (L1:1 closed), is to be switched to the B-bus, the following sequence is used:

1) The bus coupler circuit-breaker K:0 is closed.

2) The selector switch L1:2 is closed. Its corresponding auxiliary contact in the CT secondary is arranged to close earlier than the main (HV) contact.

3) Both selector switches (L1:1 and :2) are now closed and this situation activates a bus interconnection relay unit, which interconnects the CT circuits of the A- and B-zones and disconnects the DB-relay.
   The operating sensitivity then becomes controlled by only one relay, instead of two relays in parallel. Also, the two trip circuits are interconnected so that both buses are tripped for a fault on one bus.

4) The selector switch L1:1 is then opened and the bus interconnection unit brings the DB-relay back into service and separates both the CT and the trip circuit interconnection.

It should be noticed that during this switching operation the CT secondaries are never open-circuited so no dangerous voltages ever will occur; if a fault occurs, one or both buses will be tripped instantaneously. In the case of double-buses it is recommended that the main bus coupler CT has two separate cores, one for each bus zone so as to avoid interference from one zone to the other.

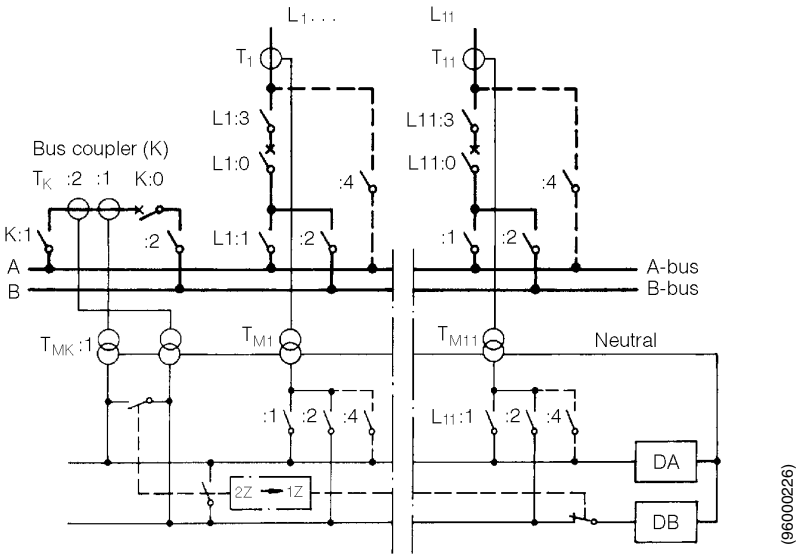


Fig. 3 Double-bus, two-zones with switching of CT secondary circuit. A bypass switch may be added.

Design

REB 103
The REB 103 differential relay measuring circuits are provided in modern microprocessor technology, enhancing the functionality and including self-supervision for high availability.

SR
The start relay is used as current detector and is normally set higher than the rated current for the largest current transformer.

It can also be set at a lower value when maximum sensitivity is required. When setting the thumb-wheel to 0, the pick-up will be approximately the same as for the differential relay.

DR
The differential relay is selective and operates only for internal faults. The sensitivity is around 1% of the largest current transformer.

The measuring devices SR and DR operates within 1-3 ms and tripping of the busbar is not initiated until both devices have operated.

The stability (S) i.e. the relation between the differential current ID1 and the incoming current IT3 is only applicable for external faults and is around 50%. At internal faults the relay has another characteristic with a larger operating area.

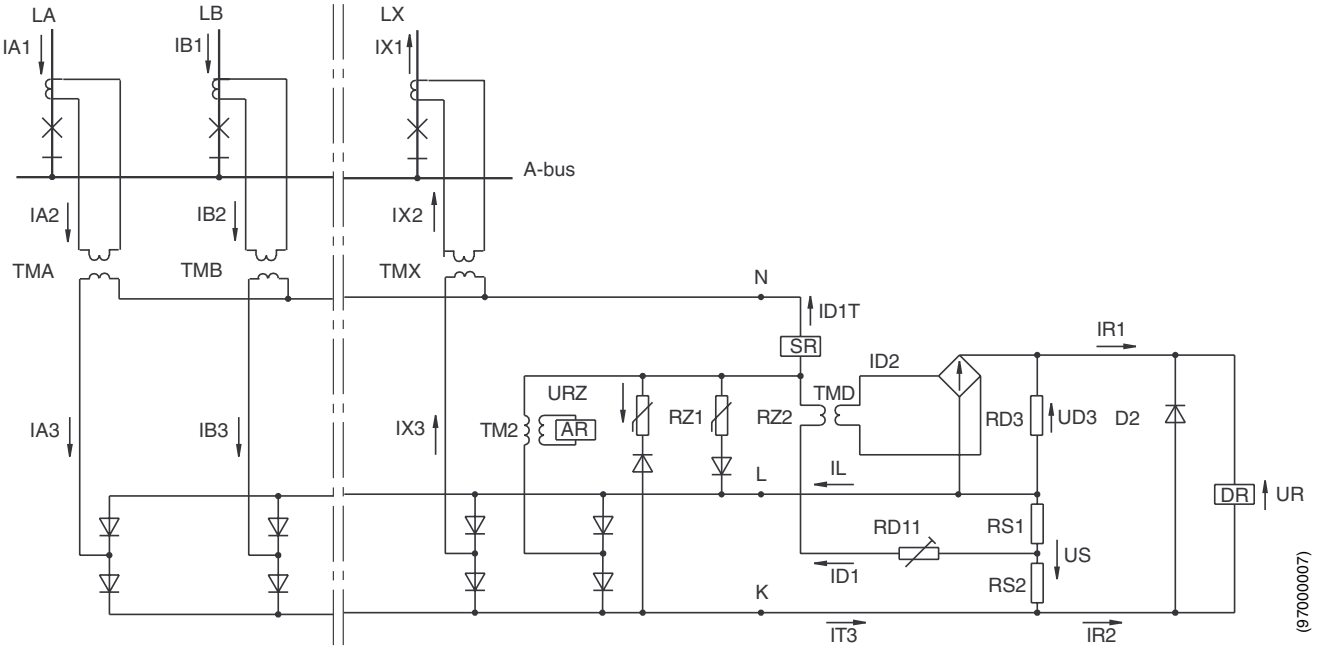
AR
The alarm relay operates for the differential voltage caused by an open CT-circuit and has a settable operating value. Five seconds after operation of the AR-relay, the tripping circuit is opened and the differential circuit is short-circuited. This function is reset manually.

The total incoming current IT3 (see Fig. 4) enters the relay at terminal K, and the total outgoing current leaves at terminal L. During normal service these currents are basically equal, and the differential current is zero, or in practice less than
0.5 mA.

A restraint voltage US is obtained across the full stabilizing resistor RS, i.e. between the terminals K and L, and this voltage drives a current IR2 through the diode D2 and the resistor RD3, towards the output terminal L. The differential DR element is then securely restrained (blocked) and cannot operate.

When a differential (spill) current ID1 is produced, this passes a variable resistor RD11, the primary winding of an auxiliary CT (TMD) and the starting relay SR, which is used for selecting a suitable level of primary operating current. On the secondary side of TMD, the differential current is passed through a full wave rectifier and the resistor RD3 across which is developed an operating voltage UD3.

A comparison may then be made, between the operating and restraint voltages, UD3 and US. The output from this comparator circuit is fed to the high speed polarized differential relay element (DR). When the operating voltage is larger than the restraint voltage, the output current IR1 is regarded as positive and causes operation of the DR element.



AR	Alarm relay
SR	Start relay
DR	Differential relay
US	Stabilizing voltage
UD3	Operate voltage
IR1	Current through differential relay
IR2	Block current through diode D2
IT3	Total incoming current at terminal K
IL	Current outgoing at terminal L
TMA	Intermediate current transformer
TMD	Ratio, nd = 10
n_0	Overall current transformer ratio = IA1/IA3 = IX1/IX3
RS	Resistance in stabilizing circuit RS = RS1 + RS2
RD3	Differential circuit resistor
RD1	Resistance RD3 referred to primary side of TMD RD1 = n_d^2RD3
RDT	Total resistance in differential circuit RDT = RD1 + RD11

Fig. 4 Circuit diagram for one phase in a single zone bus differential relay with lines L_A, L_B and L_X

RLDA 103 measuring unit
See Fig. 5

All settings and indications are positioned in RLDA 103. Settings are made with thumb-wheels and indications given by LEDs.

Indication is given with yellow LEDs for:

- Start relay
- Differential relay
- Open CT alarm

Indications for tripping per phase are given with red LEDs.

Indication for blocked relay is given with yellow LED.

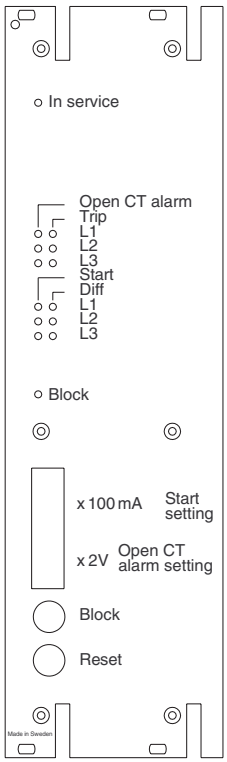
The setting of start and alarm relay are easily accessible in the front. The start relay can be set between 0-1.5 A and the alarm relay between 2 and 30 V.

REB 103 is equipped with self-supervision for:

- low dc/dc-supply
- microprocessor fault

Faults detected by the self-supervision blocks the relay and gives indication in the front.

Design (cont'd)



Indications

In service (green)

Open CT-circuit (yellow)
Tripping (red)
Start relay (yellow)
Differential relay (yellow)
Block (yellow)

Settings

Start relay 0-1.5 A

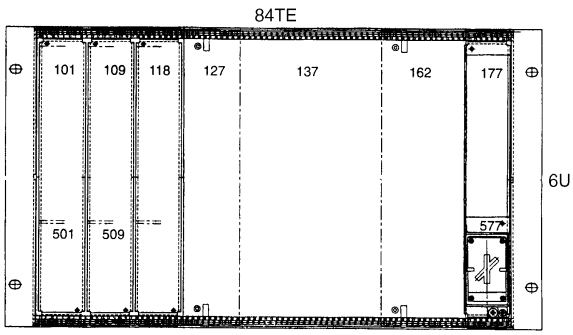
Alarm relay 2-30 V

Block
Reset

(97000008)

Fig. 5 RLDA 103 Measuring unit

REB 103 three-phase differential relay
The three-phase version of REB 103 is arranged for 12 three-phase current inputs and can be added with extension units plus a number of intermediate current transformer units.



REB 103

Basic unit max. 12 lines RK 638 001-AB

101	RXTP 18	Test switch
109	RXTP 18	Test switch
118	RXTP 18	Test switch
127	RLOE 100	Diode unit
137	RLHE 103	Comparator unit
162	RLDA 103	Measuring unit
177	RXTUG 22H	Dc/dc converter
501	RXMD	Block relay
509	RXME	Trip relay
577	577	Switch

Extension unit for up to 12 bays
Ordering No. 1MRK 001 423-AA

42C

RTXP 18	RQBA 040	RQBA 040	RTXP 18	RQBA 040	RQBA 040	RTXP 18	RQBA 040	RQBA 040

Extension unit for up to 6 bays
Ordering No. 7451 299-B

30C

RTXP 18	RQBA 040	RTXP 18	RQBA 040	RTXP 18	RQBA 040

Further extension of bays
If more bays are required for the protection it is only necessary to add the applicable number of above mentioned units.

Auxiliary, intermediate, current transformers
When the primary CTs are identical and having secondary rated current 1 A, aux. CTs may not be required. Conditions on max. currents need, however, to be fulfilled.

Standard ABB aux. CTs are of toroid type (TMA) or C-core type (SLCE). They are used to adapt secondary current of the primary CT circuits to same secondary level, before feeding the measuring circuits. TMAs and SLCEs can be mixed in an application. SLCEs can have up to 4 secondary ratings.

The current from any input to the relay shall not exeed 1 A continously and the ratio shall be chosen so that the total through-going current (IT3) does not exceed 2 A continously.

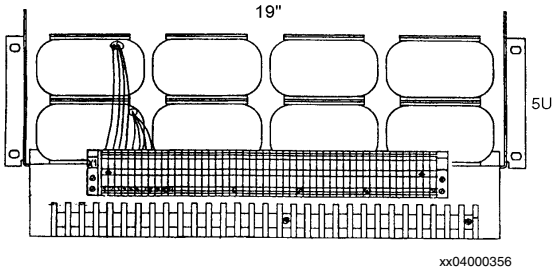
The calculation of aux. CTs for REB 103 is relatively simple. The initial step is normally to calculate the current from the largest primary CT give 0.5 A to the relay. This total ratio received shall be valid for all the other input circuits to the relay. All aux. CT ratios must be as exact as possible, thus without turn corrections, in order not to create unnecessary differential current, requiring alarms to be set on high levels.

For separate delivery

	Rated primary current	Rated secondary current
TMA 25	1, 2 or 5 A	0.025 to 0.250
TMA 50	1, 2 or 5 A	0.250 to 0.500
SLCE 10-1	1, 2 or 5 A	0.025 to 0.500
SLCE 10	1, 2 or 5 A	0.025 to 1.000

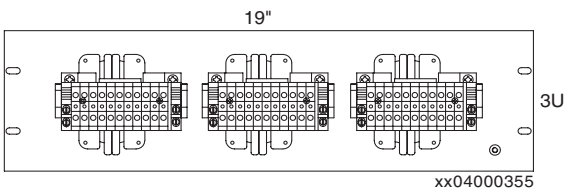
The SLCE 10-1 and SLCE 10 can be delivered with up to 8 taps.

The delivered secondary values will depend on the last full secondary winding turn.



Assembly of toroid transformers TMA

1-4 lines	RK 638 021-BA



Example of SLCE 10-1 mounted on a plate (only available as loose delivery of transformers and plate separately).

Design (cont'd)

Protective panels with REB 103
Busbar protection of type REB 103 can also be supplied ready wired and tested in panels. In order to make a correct design, the following information is required as a base for a quotation for panel supply:

- Bus configuration
- One line diagram with protective zone requirements
- Voltage level
- Short-circuit current
- Continuous current through the station
- Number of lines plus bus couplers
- Current Transformer ratios and knee-point voltages
- Breaker failure protection included or not

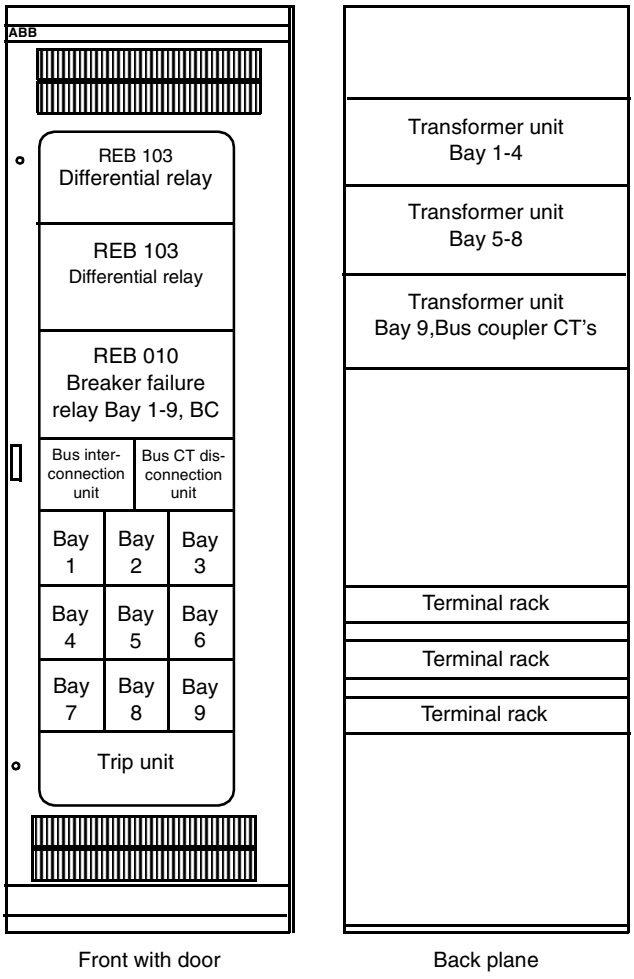
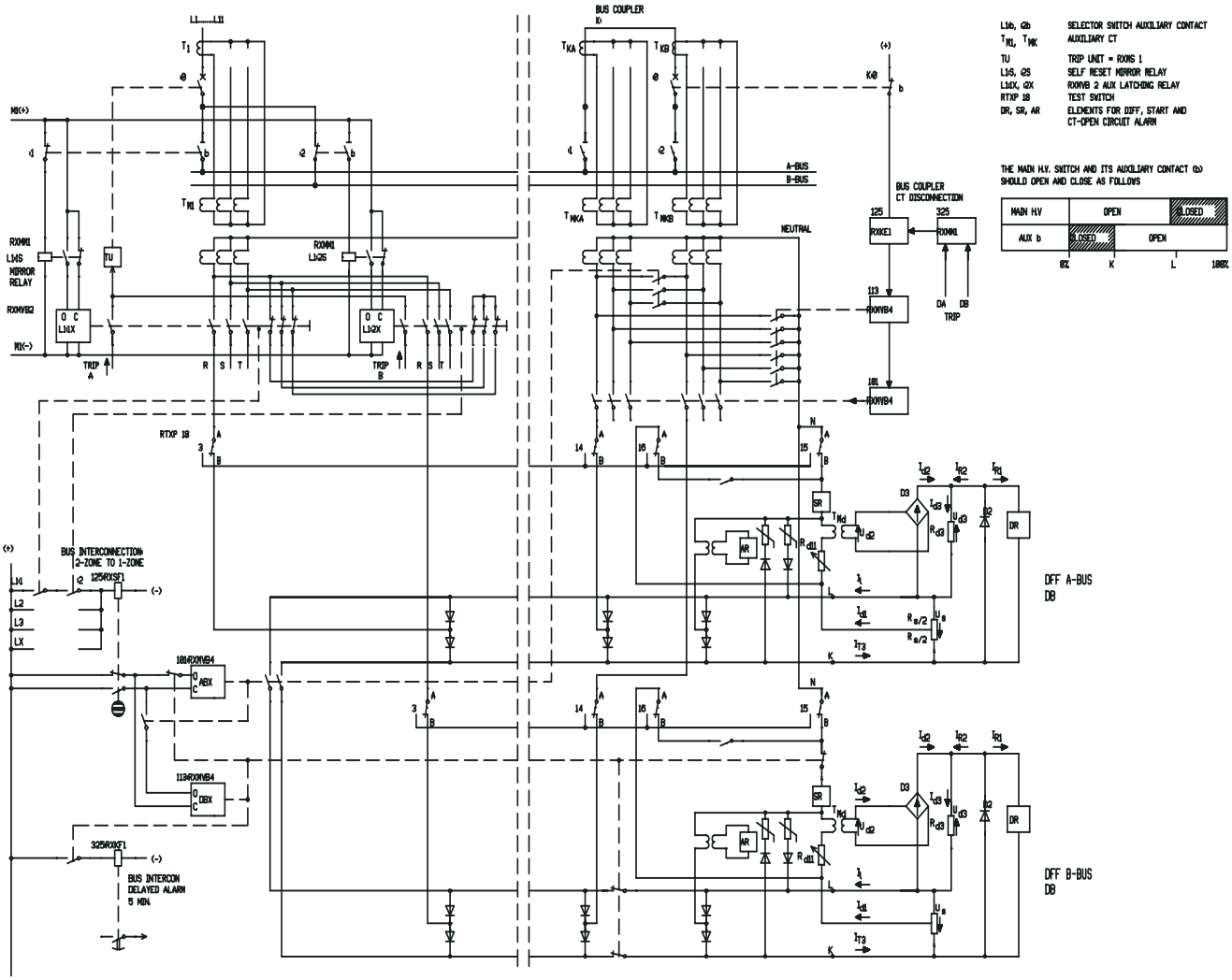


Fig. 6 Example of a REB 103 busbar protection terminal for double-bus with 9 lines and bus coupler with CT switching, including also REB 010 breaker failure relays.



L1:1b, :2b	SELECTION SWITCH AUXILIARY CONTACT
TM1, TMK	AUXILIARY CT
TU	TRIP UNIT = RXMS 1
L1: 1S, :2S	SELF RESET MIRROR RELAY
L1: 1X, :2X	LATCHING RELAY
RTXP 18	TEST SWITCH
DR, SR, AR	ELEMENTS FOR DIFF. START AND CT-OPEN CIRCUIT ALARM

THE MAIN H.V.SWITCH AND ITS AUXILIARY CONTACT (b) SHOULD OPEN AND CLOSE AS FOLLOWS:

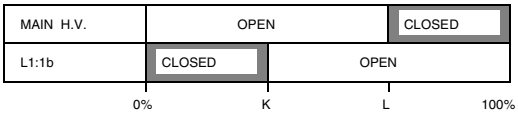


Fig. 7 Bus differential relay for 11-lines, single bus coupler, three-phase, two zones

Design (cont'd)

The line CT's (T1) may be switched to the DA or DB differential relays. In most stations a mirror relay (L1:1S) is available and arranged to be energized when the Main H.V. (L1:1) selector switch is open. The auxiliary contact (L1:1b) must open and close as shown in Fig. 7.

When both selector switches (L1:1 and :2) are closed simultaneously it is advantageous to interconnect the DA- and DB-line diodes and disconnect the DB-measuring circuit. If the dc-supply to a mirror relay should be inadvertently interrupted, the two relay zones may be switched to one overall zone.

This situation can be supervised by a time lag relay RXKL 1, sounding an alarm after five minutes. Switching a line from one bus to the other normally takes less than five minutes and no alarm will then be obtained.

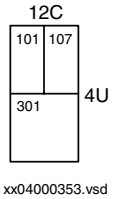
The bus-coupler (BC) CT-disconnection scheme serves the following purpose:

1) When the BC breaker K:0 is open a fault which occurs between the CT's and the breaker will be disconnected instantaneously by the correct bus differential relay.

2) If this fault occurs when K:0 is closed the wrong bus will be tripped instantaneously and the faulty bus, approx. 150 ms later.

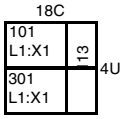
3) If the K:0 fails to open for a proper bus fault the adjacent bus will be tripped, approx. 150 ms later.

Relay units for protective systems
Switching line CT's to DA, DB
Ordering No. 1MRK 002 650-AA



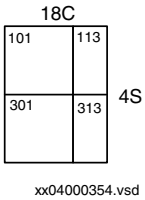
101:	RXMB 1aux. relay
107:	RXMD 1 latching relay
301:	RXMD 2 latching relay

Alternative:
Ordering No. 5651 131-EA



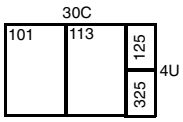
101, 301:	RXMVB 2 latching relay
113:	RXMM aux. relay

Bus coupler CT disconnection
Ordering No. 1MRK 002 650-BA



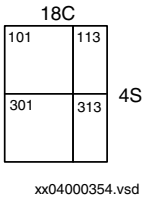
101, 301:	RXMD 2 latching relay
113:	RXMB 1 aux. relay
313:	RXKL 1 time-lag relay

Alternative:
Ordering No. 5651 131-RA



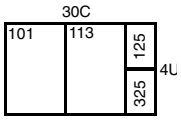
101, 113:	RXMVB 4 latching relay
125:	RXKL 1 time-lag relay
325:	RXMM aux. relay

Bus interconnection (two-zone to one zone)
Ordering No. 1MRK 002 650-CA



101, 301:	RXMD 2 latching relay
113:	RXMB 1 aux. relay
313:	RXKL 1 time-lag relay

Alternative:
Ordering No. 5651 131-SA

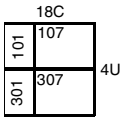


101, 113:	RXMVB 4 latching relay
125:	RXSF 1 aux. flag relay
325:	RXKL 1 delayed alarm relay

Trip relay units for high speed tripping
Trip relay
Ordering: See document 1MRK 508 015-BEN

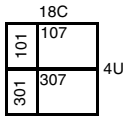
101:	RXMS 1 with 6 make contacts

Rapid operation, strong contacts
Ordering No. 5651 260-A



101, 301:	RXMS 1 with 6 make contacts
107, 307:	RXMH 2 with 8 make contacts

Rapid operation, strong contacts and latching relays
Ordering No. 5651 261-A



101, 301:	RXMS 1 with 6 NO contacts
107, 307:	RXMVB 2 latching relay with 8 make contacts

Technical data

Table 1: REB 103

Rated frequency	50-60 Hz
Rated current	1 A per input
Maximal through-going current differential current	2 A 5 mA
Aux voltage	48, 110, 125 or 250 V
Permitted ambient temperature	-5°C to +55°C
Operating time (S_R+d_R) trip impulse after	1-3 ms 6-9 ms
Insulation tests: Dielectric tests Impulse voltage	 IEC 255-5 and ANSI C37.90 (2,5 kV and 2 kV) IEC 255-5 (5 kV)
Disturbance tests: Power frequency test: Transient test 1 MHz test ESD test Aux. voltage interruption	 SS 436 15 03, section 3,3 SS 436 15 03, section 3,4 and IEC 255-22-4 IEC 255-22-2 IEC 255-11
Settings and estimated operating values (see on page 4)	
Stability factor S	$S = \frac{RS}{\left(n_d \cdot RD3 + \frac{RS}{2}\right)} = 0,5$
RD3	2,2 ohm
RS/2	8 ohm
RD11	3, 6, 9 kohm
RDT	RD11 + 400 ohm
RLX	$RLX = \frac{S}{1-S} \cdot RDT \approx RDT$
U_{T3} (DR)	25-50 V
I_{d1} (SR)	0,005-1,5 A

Note:
When technical assistance is required to choose the most suitable design, please send us a simple one line diagram with the following information:

1 Rated current for the busbar

2 Number of lines

3 Current transformer ratios for all lines

4 Rated current for all lines

5 Required primary operate current

Ordering

Specify:

- Ordering No. RK 638 001-AB
- Quantity
- Auxiliary dc voltage
- Desired wording on the lower half of the test switch face plate max. 10 lines with 10 characters per line.

Accessories:	**Ordering number**	**Quantity**
REB 103 extension unit equipped for 6 or 12 extra lines	1MRK 001 423-AA	
State: 6 extra lines		
12 extra lines		
REB 103 extension unit for 6 lines only	7451 299-B	
Separate small core TMA 25 transformer 1 pc State current ratio	4781 0775-XXX	
Separate large core TMA 50 transformer 1 pc State current ratio	4781 0776-XXX	
Standard variants of TMA 50: 1/0.5 A 5/0.5 A	 4781 0776-150 4781 0776-550	
Assembly of toroid core transformers TMA State number of lines (1/2/3/4) For each line unit the current ratio shall also be stated	RK 638 021-BA	
Separate SLCE 10-1 line unit transformer 1 pc State current ratio	1MRK 000 646-BA	
Separate SLCE 10 line unit transformer 1 pc State current ratio	1MRK 000 646-DA	
Mounting plate for 3 transformers, supplied separate (pre-drilled) for SLCE 10-1, size 3U 19”	2172 0615-44	
for SLCE 10, size 4U 19”	2172 0615-45	
Switching line CT relay unit with RXMB 1, RXMD 1 and RXMD 2 alternative with RXMM 1 and RXMVB 2 State auxiliary dc voltage	 1MRK 002 650-AA 5651 131-EA	
Bus coupler CT disconnection relay unit with RXMD 2, RXMB 1 and RXKL 1 alternative with RXMVB 4, RXMM 1 and RXKL 1 State auxiliary dc voltage in both cases	 1MRK 002 650-BA 5651 131-RA	
Bus interconnection unit with RXMD 2, RXMB1 and RXKL 1 alternative with RXMVB 4, RXSF 1 and RXKL 1 State delayed alarm relay or not State auxiliary dc voltage in both cases	 1MRK 002 650-CA 5651 131-SA	
Trip relay unit with 2 RXMS 1 and 2 RXMH 2 State auxiliary voltage State trip circuit (0/6/12) *see below	5651 260-A	
Trip relay unit with 2 RXMS 1 and 2 RXMVB 2 State auxiliary dc voltage State trip circuits (0/6/12) * see below	5651 261-A	

* 0 = No relays, only wired, 6 = One relay of each type, 12 = Two relays of each type

For our reference and statistics we would be pleased if we are provided with the following application data:

Country: End user:

Station name: Voltage level: kV

References

Connection and installation components	1MRK 513 003-BEN
COMBITEST Test system	1MRK 512 001-BEN
REB 103 Technical Reference Manual	1MRK 505 007-UEN
RXMS 1, RXMH 2	1 MRK 508 015-BEN
RXMVB 2	1 MRK 508 016-BEN
1MRK 513 004-BEN	

Manufacturer

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