ASEA

Type RADSS

Ultrahigh-speed bus differential relay

B03-6010E
Page 1
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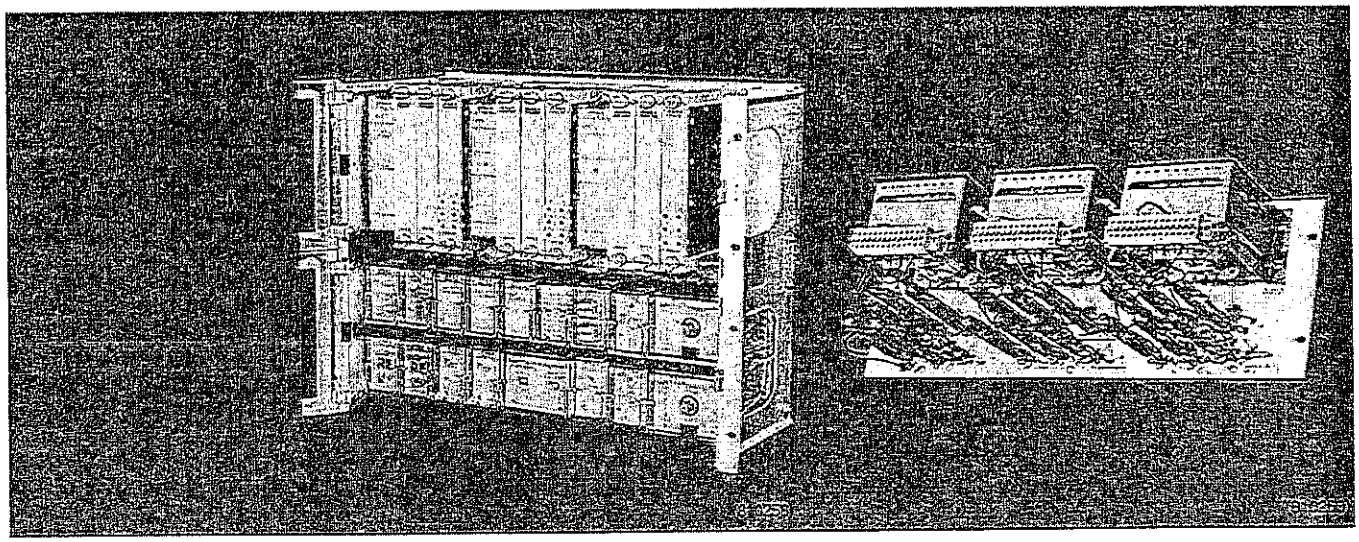
Data subject to change without notice



Abstract

- **Protection for buses or short lines**
- **1-3 ms fault detection, 8-13 ms to trip**
- **Fault sensitivity 20 % of rated current**
- **No maximum fault-current restrictions**
- **No practical limit to number of circuits to the bus**
- **No dedicated or matched CT's required and CT's can be of different ratios and manufacture**
- **Long CT leads acceptable - up to 68 ohms at 5 A or 1705 ohms for 1 A circuits**
- **Moderately-high impedance (165-301 ohms) in diff circuit**
- **Selectable percentage restraint slope, 50 to 85 %**
- **Compact summation CT version available**
- **Adaptable to different bus configurations**

Application

The RADSS relay is a high-speed, sensitive, moderately high-impedance differential relay for phase- and ground-fault protection of buses and short lines. The high sensitivity of the RADSS generally precludes the need for a separate ground-fault relay. The relay is available in both three-phase and single-phase versions. It combines the qualities of high impedance and percentage differential characteristics in one unique operating principle.

Applications are not limited by CT saturation for internal or external faults. The high-speed (1-3 ms) fault-detection makes the relay applicable to any bus. Stability is ensured for external faults, even with CT saturation and secure operation is obtained for internal faults prior to saturation.

The line CT's may have relatively poor characteristics and different ratios. They neither need to be dedicated nor matched; other relays can be used on the same CT circuits. Fully distributed secondary windings are not required. The relay is especially useful in stations where major changes involve old and new breakers with mixed CT types and ratios. Also, additional line circuits can be added to the protected bus without any practical limitations to the relay application.

A high CT secondary lead resistance (over 1700 ohms, for certain applications) can be tolerated. Auxiliary CT's are used to balance the ratios of the main CT's.

An overcurrent starting relay may be used to supervise the measuring unit. The starting relay primary setting may be chosen to correspond to the largest rated line current. This will prevent operation in case of accidental CT secondary open-circuit. The magnitude of the fault current determines the setting of this relay. To enable the tripping of RADSS it is required that both the differential relay d_R and the start relay S_R operate simultaneously.

The single-phase version has one summation auxiliary CT for each three-phase circuit to the bus. This enables the use of only one single-phase relay for all phase- and ground-fault protection, at reduced cost compared to the other versions.

The summation CT version as well as the three-phase version can be used in pilot-wire differential protection schemes.

Application (cont'd)

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 A to 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 1-zone

The most simple and reliable installation is the single bus 1-zone arrangement (Fig. 1). In this case it can also be permitted that a bus seciton switch (S) is opened at certain times to split the bus in two parts. As long as there is no internal fault the RADSS diff relay rémains 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.

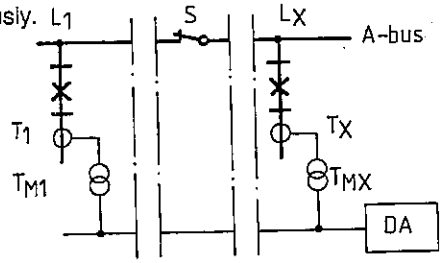


Fig. 1 Single bus. 1-zone with bus section switch normally closed

2-zones with Bus Section Switch

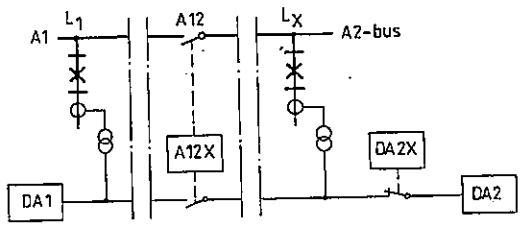


Fig. 2 Single bus, 2-zones with bus section switch normally open

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 change-over relay and RXMM 1 aux relay. These relay units are arranged to work in a special sequence so that the CT secondary circuits never become open-circuited.

Double-bus with CT-switching

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

1) The bus coupler circuit breaker is closed.

2) The selector switch L1:2 is closed. Its corresponding auxiliary contact in the CT secondary is arranged to close ahead of the main (H.V.) contact.

3) Both selector switches (L1:1 and :2) are now closed and this situation activates a 2-zone to 1-zone auxiliary 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 2Z-1Z unit brings back into service the DB-relay, and separates both the CT interconnection 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 can occur. The diff relay trip circuits are never disconnected so if a fault occurs, one or both, buses will be tripped instantaneously.

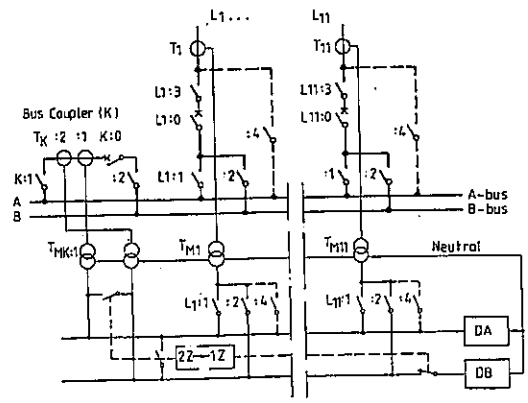


Fig. 3 Double bus, 2-zones with switching of CT secondary cirucits. A bypass switch :4 may be added.

d.c. trip circuit arangements

The basic trip circuit of the RADSS is shown in fig. 4. The SR- and dR-relay contacts must be closed simultaneously, for less than 1 ms, in order to energize the impulse storing device and to make sure that the 107:RXMS1 relay will seal-in via its own contact 14-15.

This quarantees decisive tripping of all circuit-breakers. The seal-in circuit is normally interrupted by the 301:RXKE1 time delay relay after 100 ms. All tripping relays then reset automatically.

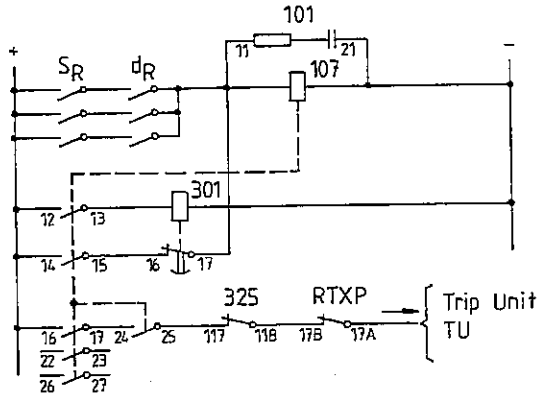


Fig. 4 Simplified auxiliary d.c. trip circuit of RADSS 3-phase, 6-12L, 1-zone

S_R	Start relay (1 ms)
d_R	diff realy (1 ms)
101	RXTCB1 impulse storing
107	RXMS1 aux.tripping relay (3.5 ms)
301	RXKE1 time delay relay (100 ms)
325	RXMVB 2 blocking relay
RTXP 18	Test switch

A typical high speed (3.5 ms) tripping unit (TU) is shown in fig. 5. This takes care of 6 individual trip coil circuits, i.e. six lines when all the three phases of each line are energized by one contact.
Similarly, if only one trip relay contact is required to trip each line, the double bus arrangement may be as in fig. 5. The selector switch (or mirror relay) aux. contacts: 1 and :2 are then used to obtain selective tripping of only the faulty bus.

For the larger and more important H.V. stations, single-pole tripping is often required. One tripping unit (TU) is then installed per line. Also, if two separate sets of trip coils are to be used, six individual trip relay contacts become necessary for every circuit breaker.

The arrangement then used is shown in fig. 7, which also applies to the double bus in fig. 3. In this tripping scheme it is indicated how to include, most easily, a Breaker Failure Relay (BFR).

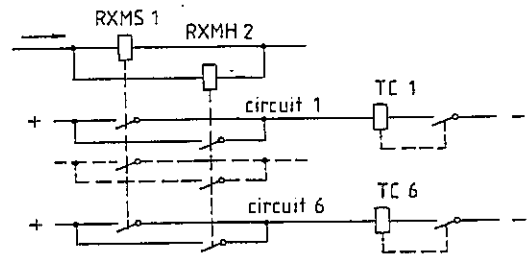


Fig. 5 Typical trip relay unit (TU) with high speed (3,5 ms) contacts and parallel connected reinforcing contacts. For 6 individual trip coil circuits.

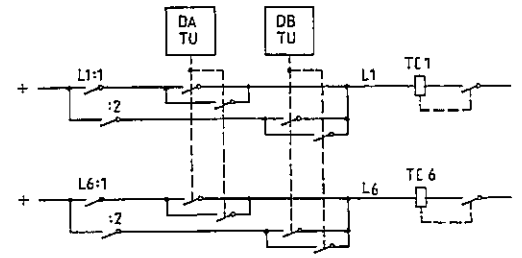


Fig. 6 Tripping of six lines in a double bus scheme, requiring only one trip circuit per line.

If, for example, the BFR for line L2 becomes activated due to a single-line-to-ground fault, the TU for L2 energizes all six trip coils, and if the L2:1 selector switch is closed all lines connected to the A-bus plus the bus coupler, will be tripped in all 3-phases (six trip coils). By this arrangement the BFR's do not need to include an extra set of selector switch auxiliary contacts, nor do they need any additional trip relays.

The diodes shown in the K:1 and :2 trip circuits of fig. 7, are required because during normal AB-bus interconnection K:1 and :2 will normally be closed and the A-B trip circuits should not be interconnected.

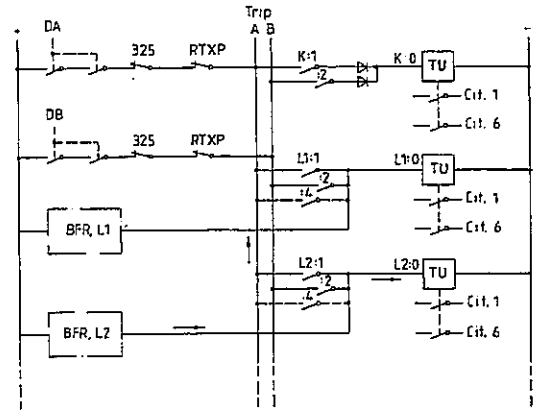


Fig.7 Trip circuit for the double bus shown in Fig. 3 with bypass switch (:4).
Each trip unit (TU) can trip six circuits at high speed. Breaker Failure Relays can easily be included.

Design

All versions are available with 50, 66 , 80 or 85 % slope setting; the slope setting applies only during external faults. During an internal fault, the relay has a different characteristic with a greater operating area. Any value, between 50 and 85 %, may be applied in the field by adjustment of the slide- wire comparator resistors. The relationship between the relay slope, sensitivity and allowable CT secondary resistance is seen from table 1.

Auxiliary CT's are used in each circuit to balance the ratios to the relay. Each input to the relay is limited to 2 amps continously. The overall CT ratio should be selected to limit the total current into the relay to 4 amps.

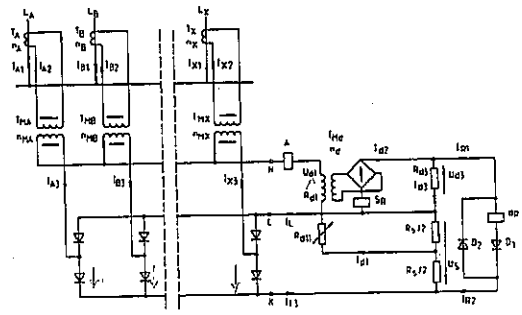
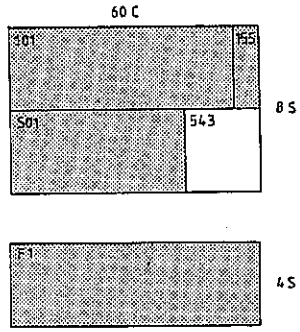


Fig. 8 Schematic diagram for one phase of a single-zone bus differential relay with feeders L_A, L_B and L_x. The current distribution is shown for an assumed positive reference halfcycle. If feeder L_A has the largest primary rating, a secondary rating with I_{A3} = 1 A is normally selected.

A	Alarm relay, RXMT 1 for CT open circuit
S_R	Starting relay
d_R	Differential relay
U_s	Restraint voltage
Ud3	Operate voltage
I_{R1}	Current through d_R-relay
I_{R2}	Blocking current through diode D_2
$T_{MA..}$	auxiliary CT ($n_{MA} = I_{A2}/I_{A3}$)
T_{Md}	$n_d = U_{d1}/U_{d2} = 10$
n_o	Overall CT ratio = $I_{A1}/I_{A3} = I_{x1}/I_{x3}$
R_s R_{d3}	Restraint and differential circuit resistances
R_{d1}	Resistance R_{d3} referred to T_{Md} primary side, $R_{d1} = U_{d1}/I_{d1} = n_d^2 R_{d3}$
R_{d11}	Variable differential circuit resistor
R_{dT}	Total resistance of differential circuit $R_{dT} = R_{d1} + R_{d11} = U_{dT}/I_{d1}$
U_{dT}	Total voltage of differential circuit
I_{d1}	Differential current
I_{T3}	total incoming relay current at terminal K
I_L	Current leaving at terminal L

Versions of RADSS
RADSS 6 or 12L, 3-ph, 1-zone

Version A1



101: Measuring Unit with
3-RTXP18 test switch
3 or 6-RQBA line diodes
3-RQDA S_R + d_R relays

155: Blanking plate

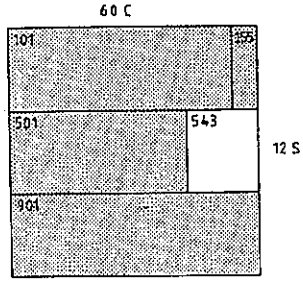
501 Supervision + aux. relay unit
1-RXTCB 1 capacitor + resistor
1-RXMS 1 aux relay
3-RXMT 1 alarm relays
1-RXSP 14 flag indicator
1-RXTNT 1 push-button with lamp
2-RXKE 1 time lag
2-RXMM 1 aux relay
1-RXMVB 2 aux blocking relay
1-RXME 1 aux relay

543 Space for trip relays

F1 Loose transf + comparator unit with:
3-T_{Md} aux.transformers
3 x 6-Resistors, each 50 W

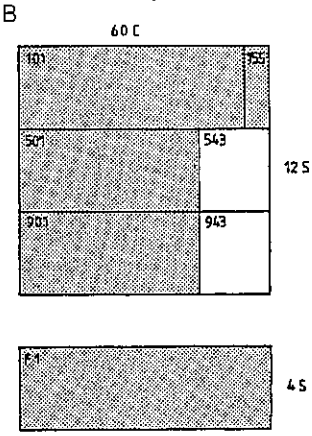
The F1-unit is normally mounted on the B-(back) plane of the cubicle and 3 x 8 = 24 wires must be made by purchaser to the (101 + 501) unit.

Version A2



As version A1 but all the units are fully interconnected and mounted together in one 12S equipment frame.

RADSS 18 or 24L, 3-ph, 1-zone
Version B



101 As 101 in version A1

501 Extension unit for 6L or 12L with:
3-RTXP18 test switch
3 or 6-RQBA line diodes

543 Space for trip relays

901 As 501 in version A1

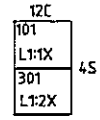
943 Space for trip relays

F1 As F1 in version A1

Switching relay units (ref. Fig. 9)

Switching line CT's to DA, DB

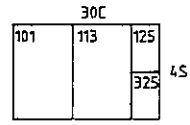
5075



101,301 RXMVB 2 latching relay

Bus Coupler CT disconnection

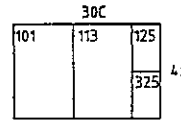
5074



101,113 RXMVB 4 latching relay
125 RXKE 1 time-lag relay
325 RXMM 1 aux relay

Bus Interconnection
(2-zone to 1-zone)

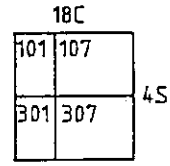
5074



101,113 RXMVB 4 latching relay
125 RXSF 1 aux flag indic.
325 RXKF 1, delayed alarm, 5 min

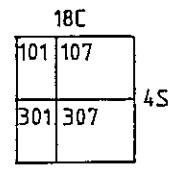
Trip relay units

5076



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

5076



101,301: RXMS 1 with 6 NO contacts
107,307: RXMH 2 with 8 NO contacts

Technical data

Rated frequency	25-60 Hz
Rated curent	2 A per input
Maximum continuous current:	
restraint circuit	4 A
differential circuit	0.5 A
Short time current differential circuit	
50 seconds	1 A
1 second	7 A
Dielectric tests	
current circuits	50 Hz, 2.5 kV, 1 min
remaining circuits	50 Hz, 2.0 kV, 1 min
Impulse voltage test	1.2/50 µs, 5.0 kV, 0.5 J
1 MHz burst test	2.5 kV, 2 s
Auxiliary dc voltage	48, 110, 125 or 250 V
Permitted ambient temperature	−5 to +55°C
Input diode rating	10 A rms, 1200 V PIV

Operate time (S_R+d_R) to trip	1-3 ms 8-13 ms to trip

See Relay data table B03-1003E and B03-1503E for specific information.

Auxiliary CT's:
Three different types may be used depending on required rated secondary current. For example:

1) Type SLCE 12:
   5/0.7 A, 140/1000 t, 0.3/16 ohms,
   Knee-point (at 1.6 T) = 410 V rms

2) Type SLCE 16:
   5/1 A, 160/800 t, 0.4/10 ohm,
   Knee-point (at 1.6 T) = 416 V rms

3) Type SLXE 4:
   5/2 A, 240/600 t, 0.4/3.5 ohm,
   Knee-point (at 1.6 T) = 400 V rms

Note:
The given current ratios correspond to the continuous thermal rated current.
The number of secondary turns for each type is always kept constant so as to obtain a certain secondary knee-point voltage. Different ratios are therefore obtained by varying the number of primary turns.

Table 1 RADSS settings and approximate operating values

Slope S	R_{d3} ohm	$R_{s/2}$ ohm	K A	R_{se} ohm	P_n W	I_{d1} min(A)	R_{d11} ohm	R_{dT} ohm	R_{LX} ohm	U_{T3} dR)V	I_d (S_R)A	U_{T3} (S_R)V
0.2	1.10	1.2	0.107	0.76	12	0.13	136	301	75	63	0.88	310
0.5	"	3.66	0.10	0.96	16	0.20	"	"	301	86	"	"
0.66	"	5.50	0.096	1.0	16	0.30	"	"	602	118	"	"
0.80	"	7.30	0.092	1.02	16	0.46	"	"	1204	171	"	"
0.85	"	8.15	0.091	1.03	16	0.61	"	"	1705	221	"	"

To order

Specify:
- RADSS - Lines, 3-ph, 1-Zone
- Number of Lines: 6 or 12, 18 or 24L
- Slope (S): 0.5 or 0.66 or 0.80
- Start relay I_{d1} (SR) = 0.88 A (standard)
- R_{d11}: 0 or 136 ohms (max)
- Auxiliary dc supply voltage
- Ordering Number (if available)

Type of auxiliary CT's:
- Current ratios and
- Turns ratios

Mounting and connection:
- See B03-9301E

Note:
When you need assistance to select the most suitable setting please send us a simple single line diagram of the bus(es), indicating: (1) Current rating of bus conductor, (2) Number of line circuits, (3) CT-ratios of all lines, (4) Rated load current of all lines (required only when load current is much less than CT-rating), (5) Requested primary operating current.

Having received these information we will advise: (1) Slope setting, (2) R_{d11} setting, (3) Start relay setting, (4) Permissible maximum loop-resistance as seen from relay R_{LX}, (5) Max permissible loop-resistance in line CT-secondary circuit R_{A2}...R_{X2} (which includes CT-winding resistance, dc resistance of extra burden or relays and pilot-wire 2-way resistance), (6) Required line CT-secondary knee-point voltage U_{A2}...U_{X2}.

Ordering tables

RADSS 3-phase, 1-zone

Version	For number of lines	Transformer and comparator	Ordering no
A1	6 or 12	Loose	RK 637 016-AB
A2	6 or 12	Mounted in the equipment frame	RK 637 016-CB
B	18 or 24	Loose	RK 637 016-BB

Switching and trip relay units

Version	Application	Relays included	Ordering no
Switching relay units	Switching line CT's to DA, DB	RXMVB 2	5651 131-A
	Bus interconnection (2-zone to 1-zone)	RXMVB 4, RXSF 1, RXKF 1	5651 131-SA
	Bus coupler CT disconnection	RXMVB 4, RXKE 1, RXMM 1	5651 131-RA
Trip relay units	For each zone or for each line	RXMS 1, RXMH 2	5651 260-A
	For each zone or for each line	RXMS 1, RXMVB 2	5651 261-A

Sample specification

The bus differential relay shall be a moderately high-impedance differential relay for phase-and ground-faults. The relay shall have a percentage restraint characteristic that is effective for external faults, only. Instantaneous saturation shall not cause maloperation on external faults. Different ratios of the main CT inputs corrected by using auxiliary CT's. The operating time shall be 8-13 ms for all tripping outputs. The relay shall be suitable for 19" rack-mounting.

Reference

Buyer's Guide	No.	Information	No.
Auxiliary current transformer type:		Description of RADSS	RK 637-300E
SLCE 12	B03-9280E	Checking of operating and restraint characteristics	RK 637-104E
SLCE 16	B03-9281E	Commissioning:	
SLXE 4	B03-9282E	single bus system	RK 637-101E
Test system COMBITEST	B03-9510E	double bus system	RK 637-105E
Mounting and connection	B03-9301E	Maintenance test	
Dimensions	B03-9382E	double bus system	RK 637-105E
		Bus coupler CT's disconnection	RK 637-301E
		Auxiliary CT's	RK 637-302E
		Schematic diagram for 2-zones	RF 637 359

Switching schemes

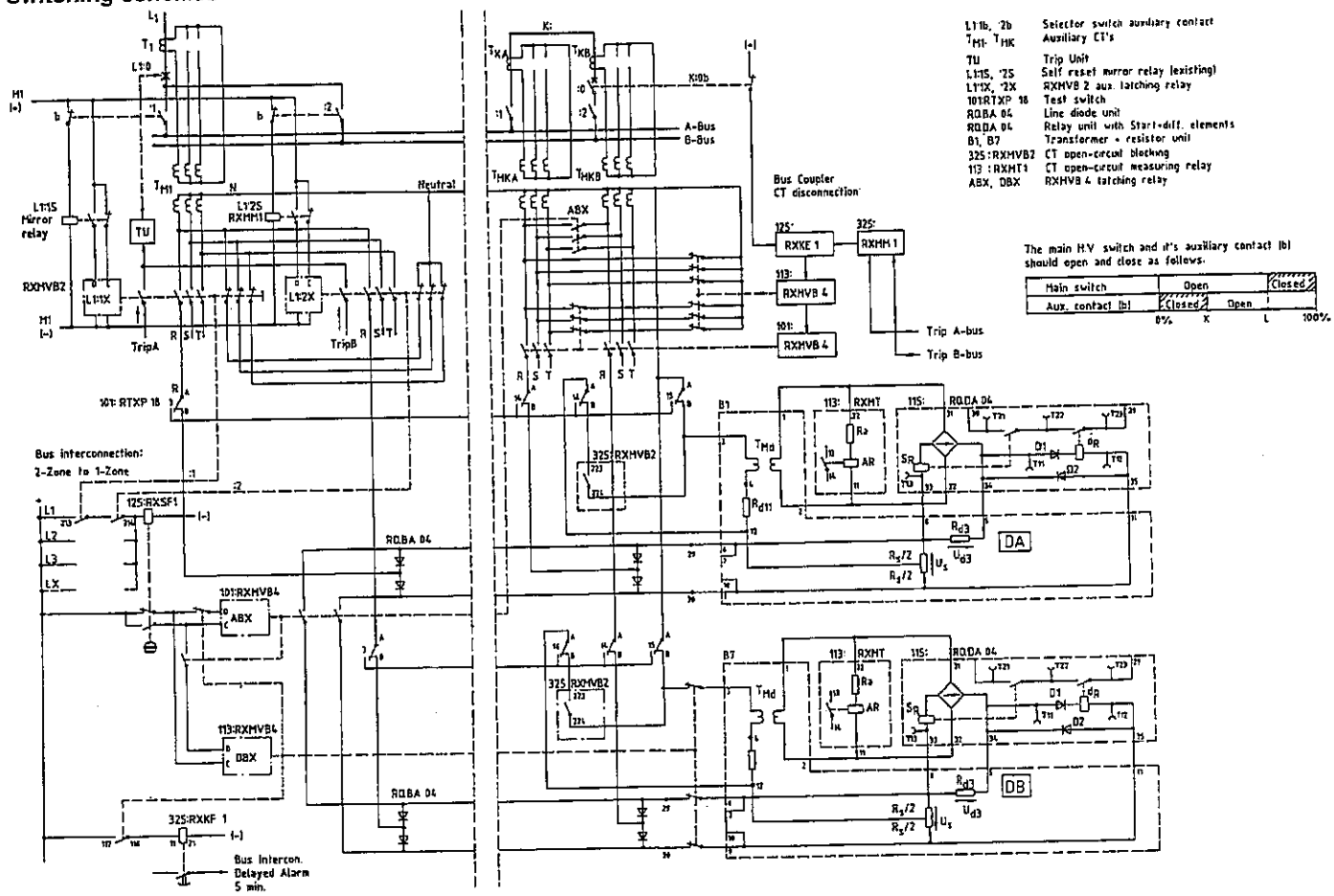


Fig. 9 Bus diff relay for 11-Lines, 1-Bus coupler 3-ph, 2 zones

The line CT's (T1) may be switched to the DA or DB diff relays. In most stations a mirror relay (L1:1S) is available and arranged to be enrgized when the (L1:1) selector switch is open. The auxiliary contact (L1:1b) must open and close as shown in fig. 9.

When both selector switches (L1:1 and :2) are closed simultaneously it is an advantage to interconnect the DA- and DB-line diodes and disconnect the DB-measuring circuit.

If the dc-supply to a mirror relay should become inadvertently interrupted the two relay zones may be switched to one overall zone. This situation can be supervised by a time-lag relay, sounding an alarm after 5 min. Switching a line from one bus to the other normally takes less than 5 min. and no alarm will then be obtained.

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

1) When the BC breaker K:O is open a fault which occurs between the CT's and the breaker will be disconnected instantaneously by the correct bus diff relay.
2) If this fault occurs when K:O is closed the wrong bus will be tripped instantaneously and the faulty bus, say 150 ms later.
3) If the K:O fails to open for a proper bus fault the adjacent bus will be tripped, say 150 ms later.