MBCZ 10

Low Impedance
Biased Differential
Busbar Protection

Service Manual

R8059H

CONTENTS

Section 1. INTRODUCTION

The type MBCZ is intended to satisfy the requirements of almost any busbar system. The design is based on a system of standard modules which can be assembled to suit a particular busbar installation, and additional modules can be added at any time if the busbar is extended.

A separate module is used for each circuit breaker and also one for each zone of protection. In addition to these there is a common alarm module, test unit and a number of power supply units.

The modules are coded as follows:

M B C Z XX

- M — Midos modular system of casing
- B — Biased differential system
- C — Current is the measured quantity
- Z — Miscellaneous units
- XX —
  - 11 Bus coupler
  - 12 Feeder breaker
  - 13 Bus section breaker
  - 14 Bus selection isolators
  - 15 Bus section isolator
  - 16 Zone measuring unit
  - 17 Alarm unit
  - 18 Test unit
  - 19 Buswire access unit

MSTZ03/04 – Power supply

Section 2. INSTALLATION

2.1 General

Protective relays, although generally of robust construction, require careful treatment prior to installation and a wise selection of site. By observing a few simple rules the possibility of premature failure is eliminated and a high degree of performance can be expected.

2.2 Unpacking

The relays are either despatched individually or as part of a panel/rack mounted assembly, in cartons specifically designed to protect them from damage.

Care must be taken when unpacking and installing the relays so that none of the parts are damaged or their settings altered and they must at all times be handled by skilled persons only.

Carefully examine the module and case to see that no damage has occurred during transit. Check that the relay serial number on the module, case and cover are identical and that the model number and rating information are correct.

Carefully remove any elastic bands/packing fitted for transportation purposes.

Relays which have been removed from their cases should not be left in situations where they are exposed to dust or damp. This particularly applies to installations which are being carried out at the same time as constructional work.

2.3 Storage

If relays are not installed immediately upon receipt they should be stored in a place free from dust and moisture in their original cartons and where de-humidifier bags have been included in the packing they should be retained. The action of the de-humidifier crystals will be impaired if the bag has been exposed to ambient conditions and may be restored by gently heating the bag for about an hour, prior to replacing it in the carton.

Dust which collects on a carton may, on subsequent unpacking, find its way into the relay; in damp conditions the carton and packing may become impregnated with moisture and the de-humidifying agent will lose its efficiency.

Storage temperature –25°C +70°C

2.4 Site

The installation should be clean, dry and reasonably free from dust and excessive vibration. The site should preferably be well illuminated to facilitate inspection.

An outline diagram is normally supplied showing panel cut-outs and hole centres. For individually mounted relays these dimensions will also be found in the relevant publication.

Publication R7012 is a parts catalogue and assembly instructions. This document will be useful when individual relays are to be assembled as a composite rack or panel mounting assembly.

Section 3. SETTINGS

3.1 CT ratio matching

For the protection to be stable during a through fault there must be an ampere turn balance for the summed inputs. The current circuit of the protection is provided with tapped transformers for each input. The taps are on the primary windings of the input transformer and allow ratio matching in 5% steps from 0.05 to 1.0 for 1A, in 5% steps from 0.05 to 0.5 for 2A and in 1% steps from 0.01 to 0.2 for 5A ct.

3.1.1 Choosing the matching ratio

The actual matching ratio is the sum of the matching ratios between the selected taps (see Figure 1). For example on the 5A input transformer the matching ratio for

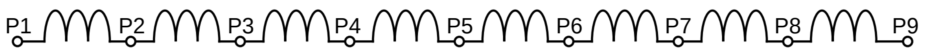
P8 – P4 = 0.01 + 0.03 + 0.03 + 0.03 = 0.1

and for

P1 – P9 = (2 x 0.01) + (6 x 0.03) = 0.2

The current settings of the relay are increased as the matching ratio is reduced such that :

$$\text{Effective setting} = \frac{0.2 + \text{(sum of switch settings)}}{\text{(Matching Ratio)}}$$



In = 1A	0.15	0.15	0.15	0.15	0.15	0.15	0.05	0.05
In = 2A	0.1	0.1	0.1	0.15	0.05	–	–	–
In = 5A	0.03	0.03	0.03	0.03	0.03	0.03	0.01	0.01

Matching ratio = Σ (tap values)

Figure 1 Input transformer primary winding taps.

The busbar rating is related to the circuits with the largest ct ratios and hence the fault settings will be related to these circuits also. Selection of the matching ratio is best shown by example.

Consider the section of busbar shown in Figure 2.

Let 4000/5A ct be connected to P1 – P9 then the matching ratio is 0.2 and the effective setting will be IS as set on the measuring units.

The required matching ratio for the 500/5A ct is then required to be:

$$\frac{0.2 \times 500}{4000} = 0.025$$

The nearest value is 0.03 for P3 – P4 but this will give a ratio mismatch.

$$\text{Ratio mismatch} = \frac{\text{(actual ratio)} - \text{(required ratio)}}{\text{(required ratio)}}$$

The mismatch should be less than the $\frac{\text{(per unit through bias)}}{2}$ (ie. less than 0.1)

For the example the ratio mismatch is $\frac{0.03 - 0.025}{0.025} = 0.2$

and this exceeds the limit. The matching ratio for the 4000/5A ct must therefore be reduced to obtain a better match.

Let the matching ratio for the 4000/5A ct be reduced by 0.04 to 0.16.

Taps P2 – P8. Effective settings will now be $\frac{I_S}{0.16}$

Required matching ratio for 500/5A ct is now $\frac{0.16 \times 500}{4000} = 0.02$ given

by P7 – P9 and matches exactly.

Matching ratio for 1200/5A ct = $\frac{0.16 \times 1200}{4000}$ = 0.048

Nearest ratio is 0.05 given by P6 – P9.

Mismatch = $\frac{0.05 - 0.048}{0.048}$ = 0.04 and is satisfactory as it is less than the limit of 0.1.

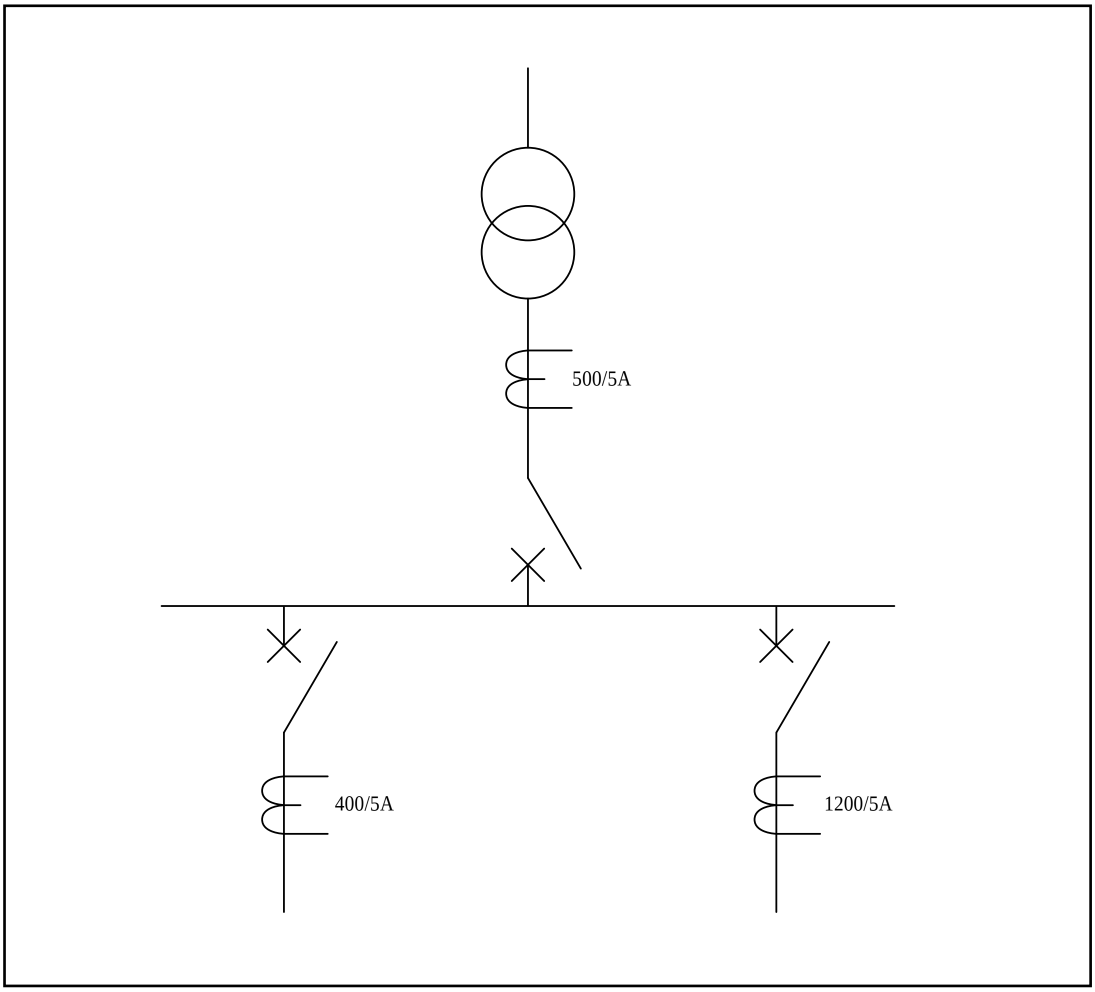


Figure 2 CT ratio matching example.

3.1.2 Adjusting the matching ratio

To adjust the ratio on the input transformers it is necessary to remove the associated circuit breaker module from its case. Remove the cover from the case; there are four retaining screws. Then partially withdraw the module by pulling forward on the top and bottom handles. This module is heavy and must be supported underneath before it is completely withdrawn.

There are six transformers at the right hand side of the module, two for each phase. These should be connected for the same matching ratio unless these are connected to different feeders.

Front of module

0.0.0.0. 1.2.3.4. T 1 5 6 7 8 9 0 0 0 0 0	0.0.0.0. 1.2.3.4. T 2 5 6 7 8 9 0 0 0 0 0	0.0.0.0. 1.2.3.4. T 3 5 6 7 8 9 0 0 0 0 0		
0.0.0.0. 1.2.3.4. T 4 5 6 7 8 9 0 0 0 0 0	0.0.0.0. 1.2.3.4. T 5 5 6 7 8 9 0 0 0 0 0	0.0.0.0. 1.2.3.4. T 6 5 6 7 8 9 0 0 0 0 0		

Trans	Phase	Standard scheme MBCZ/_ _ _ _			Combined function scheme MBCZ12/_ _ _ _ _ _		
		11 BC	12 Fdr	13 BS	301 1 Fdr	302 2 Fdr	303/304 Fdr + $^1/_2$ BS
T1 T2 T3	A B C	Lower Zone	Check Zone	Left Zone	Nil	Fdr. 2 Right	Fdr.
T4 T5 T6	A B C	Upper Zone	Main Zone	Right Zone	Fdr	Fdr. 1 Left	$^1/_2$ BS

Figure 3 Position and function of matching transformers

3.1.3 Reversing polarity of ct circuit

There are two leads to the primary taps on each transformer, one red and one black. The red lead is usually connected to the higher numbered tap. However, the polarity can be reversed if the red lead is connected instead to the lower numbered tap.

NOTE: When refitting the module into its case it should be gently slid in until some resistance is felt. It should then be given a firm push on the bottom and top handles so that it goes completely home. When correctly inserted the front plate will be recessed approximately 1mm below the edge of the metal case.

If there is difficulty inserting the module do not attempt to insert it by sliding it in rapidly as this may damage the rear connectors. Instead try pushing on the lower handle only with two thumbs.

Refit cover and secure with the four fixing screws.

3.1.4 Current transformers with different rated secondary currents

When the ct on separate circuits have different secondary current ratings (1A and 5A) they should be connected to circuit breaker modules of similar rating. However, if the continuous load current is within the continuous rating of the module and a suitable matching ratio is available then a 1A module may be used with a 5A ct.

3.2 Fault settings

3.2.1 Choice of setting

Ideally the fault setting of the protection should be not greater than one third of the minimum fault level. However, when there is only one set of current transformers per circuit and these are arranged to feed both the main and check zones in series; there is an advantage in setting the protection above the normal load current.

These higher settings will ensure that there is no risk of the protection operating during normal load conditions if the current transformers on any circuit become open circuited.

When two sets of current transformers are provided per circuit there will be added security for current circuit faults especially if the wires for the different zones are kept separate. This is because operation of one zone, caused by current circuit faults, will be blocked by the check zone protection.

3.2.2 Adjustment of fault setting

The fault setting (IS) adjustment is provided separately for each phase on each of the zone measuring units. See Figure 4. Setting changes are effected by slide switches on the front of the module. For improved reliability the measuring circuits are duplicated and each switch varies the setting of both the measuring circuits at the same time.

$$\text{The setting } I_S = \frac{0.2 + (\text{sum of the switch settings})}{(\text{Matching ratio})}$$

The primary fault setting will be the effective setting multiplied by the current transformer ratio, and will be the same for all circuits provided there is no mismatch.

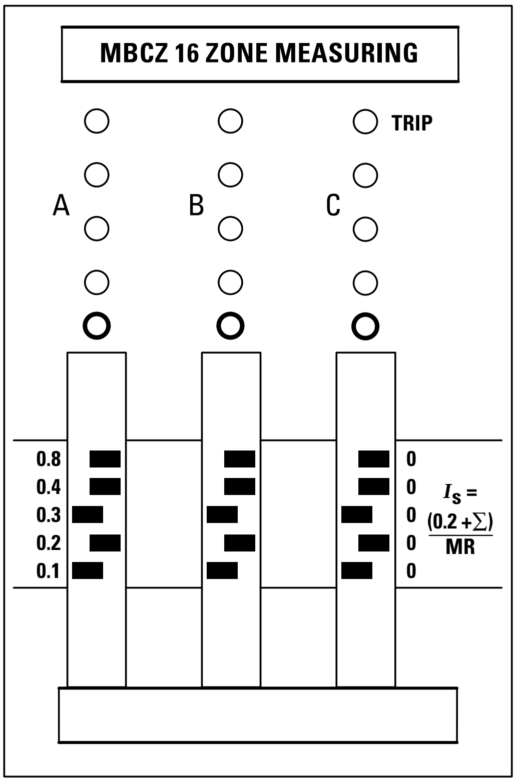


Figure 4 Fault setting controls

3.3 Supervision settings

There is an overcurrent element in the differential circuit of each phase. This element is unbiased and is used to supervise the current circuit. A differential current will result if the secondary circuit of a current transformer becomes open circuited. The amplitude of the resulting differential current will be proportional to the load current flowing in the circuit monitored by the faulty current circuit. Operation of the supervision element gives an alarm and can be arranged to switch the faulty zone out of service.

This element is time delayed for 3 seconds so that operation of the alarm does not occur during faults either internal to or external to the protected zone.

3.3.1 Choice of supervision setting

The supervision setting should be as low as possible but must be greater than the standing differential current due to current transformer ratio mismatch and different magnetising current losses. Typically the setting will be

$$\frac{0.1}{\text{Matching ratio}}$$

3.3.2 Adjustment of supervision setting

The supervision setting ISUPVN adjustment is provided separately for each phase on the zone measuring units. Change of setting is effected by slide switches on the front of the module below the fault setting switches.
See Figure 5.

The setting ISUPVN = $\dfrac{0.1 + (\text{sum of switch settings})}{(\text{Matching Ratio})}$

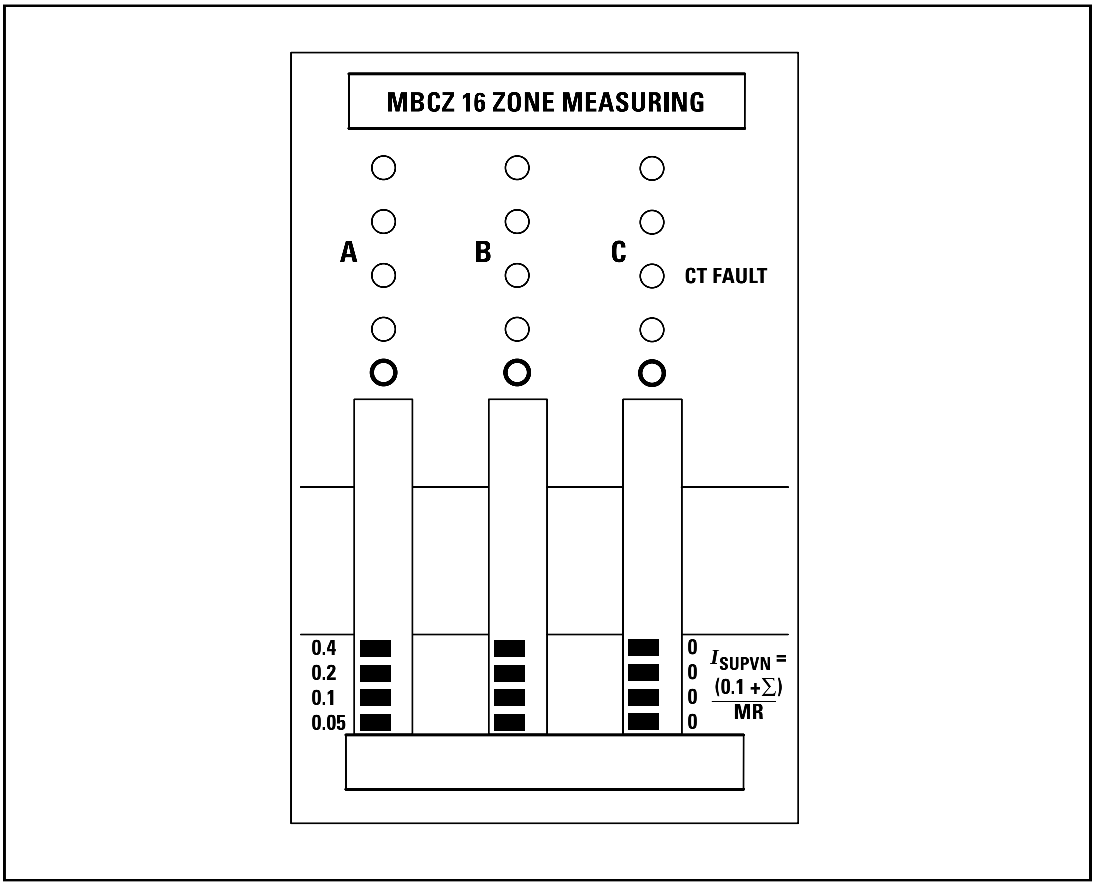


Figure 5 Supervision setting controls

3.4. Control settings on zone measuring units

3.4.1 Auto/manual

When set to “AUTO” the supervision will automatically switch the zone of protection out of service if a fault is detected by the supervision circuits. It will only switch out the protection for the phase where the fault was detected and cover will be maintained for 86% of the possible types of fault by the other two phases. An external alarm is initiated when a unit is switched out of service.

When set to “MAN” the supervision will initiate an external alarm but will not switch the faulty protection out of service. It must, therefore, be manually switched out of service. See Figure 6.

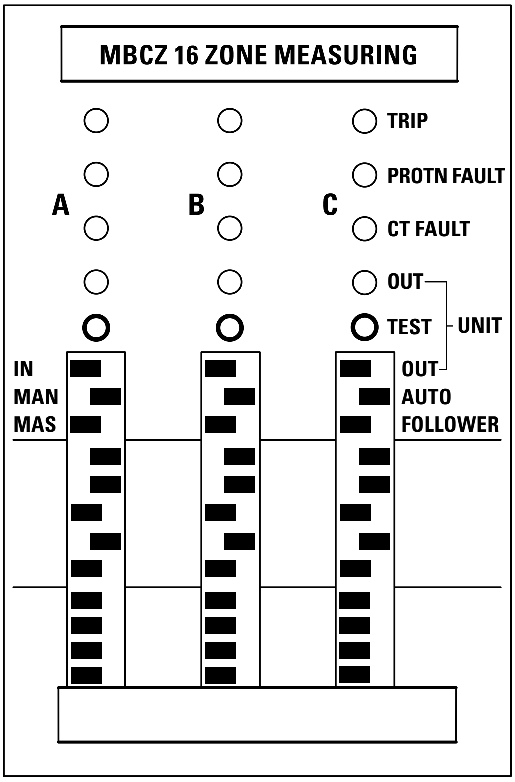


Figure 6 Control settings on measuring unit.

3.4.2 In/out

This switch puts the associated phase of the zone of protection either “in service” or “out of service”. This is a manual control only. When manually switched out of service the alarm is cancelled.

3.4.3 Master/follower

When two sections of busbar are connected together via isolators it will result in two measuring elements being connected in parallel. The fault current will then divide between the two measuring elements in the ratio of their impedance. Thus, for two measuring elements of equal impedance the effective settings will be doubled.

This problem has been overcome by using a MASTER/FOLLOWER arrangement. By making the impedance of one of the measuring elements very much higher than the other it is possible to ensure that one of the relays retains its original setting. Then to ensure that both the parallel connected zones are tripped the trip circuits of the two zones are connected in parallel.

With this arrangement the zone measuring units selected to be MASTERS will have their normal fault settings when they are connected in parallel with FOLLOWER units and the setting of the FOLLOWER unit will increase by a factor of about four.

To make full use of this facility it is necessary to ensure that adjacent zones that may be paralleled by isolators or cb without ct are arranged as MASTER/FOLLOWER/ MASTER as shown in Figure 7.

The selection of this feature is by a slide switch on the front of the measuring unit. All three phases should be set the same. The check zone will normally be set to MASTER.

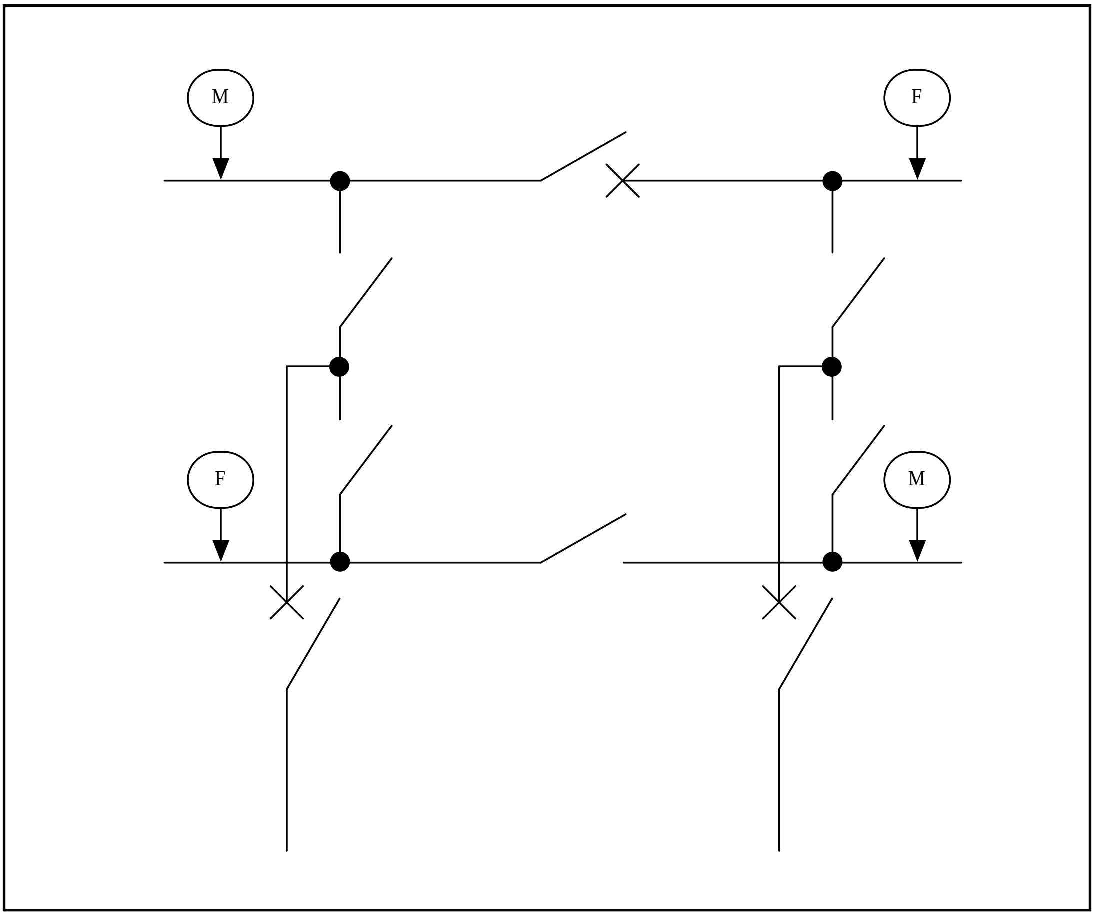


Figure 7 Master/follower/master selection

3.5 Breaker fail/back tripping time delay

With some exceptions, the circuit breaker modules are fitted with a breaker fail or back tripping feature.

On feeder modules made before August 1989 this feature provides a breaker fail function for the feeder protection. When a feeder protection trip is generated contacts are closed to initiate the breaker fail sequence in the feeder module. A timer is started and if when the timer runs out the trip is still present and current is still flowing in the feeder current transformer, a trip signal is applied to all circuit breakers in the busbar main zone connected to the feeder thus clearing the fault.

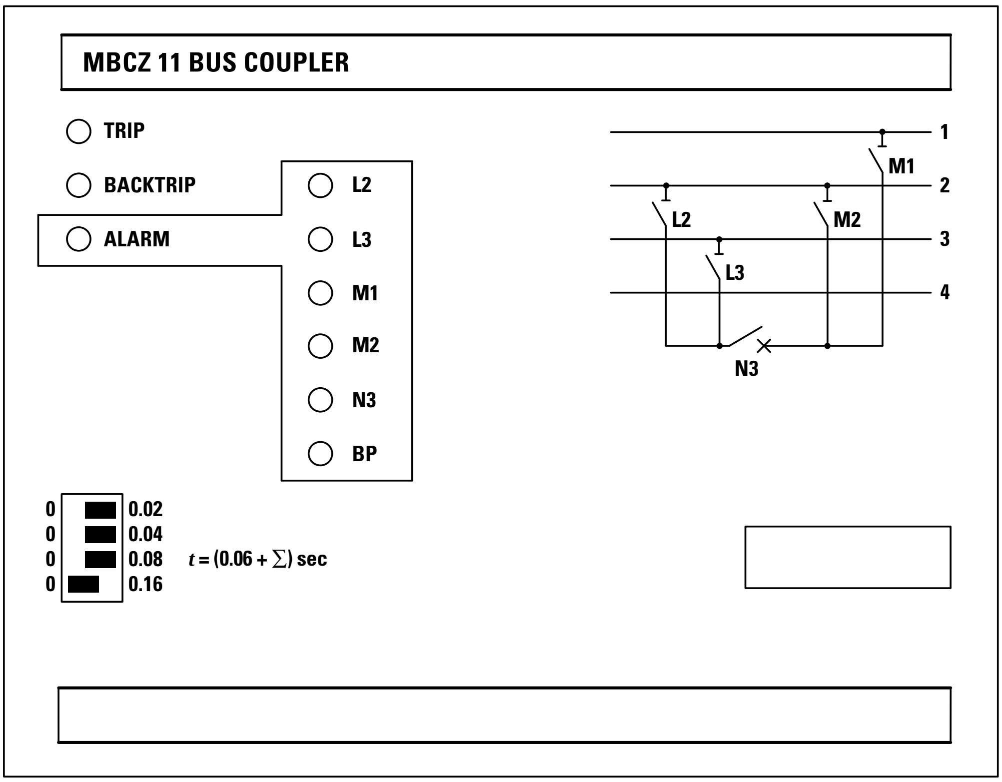
On bus coupler and bus section breaker modules made before August 1989 a similar facility is fitted except that the sequence is initiated not by external contacts but by the occurrence of a trip signal on either of the two main zones on each side of the circuit breaker. A breaker fail situation may arise because either the circuit breaker has failed to trip or in the case where only one set of current transformers is fitted, there is a fault between the circuit breaker and current transformers fed from the healthy zone.

Circuit breaker modules made after August 1989 incorporate both the above features, ie. breaker fail/back trip function may be initiated either by external contacts or by a busbar trip in all three types of module. In addition contacts are provided to indicate that back trip has taken place.

The threshold of the current detector in the breaker fail/back trip circuit is less than the lowest fault setting available on the relay, ie. I_S switch setting/matching ratio.

The time delay is adjustable by means of slide switches on the module front panel. Set time delay is equal to 60 + (sum of switch settings), maximum 200ms for modules made before August 1989, 360ms for those made later.

The breaker fail/back trip feature is not fitted to bus coupler or bus section breaker modules designed for circuit breakers without current transformers, nor to feeder modules designed for bus zone trip. In the latter case breaker fail is incorporated in the feeder protection, and this provides an output which is simply repeated by the feeder module to trip the busbar main zone associated with the feeder.



Note: Pre-August 1989 models have a 3 pole time switch.

Figure 8 Breaker fail/back trip time delay adjustment.

Section 4. ISOLATOR AUXILIARY CONTACTS

Two auxiliary contacts are required per isolator to initiate the isolator repeat relays and set as shown in Figure 9.

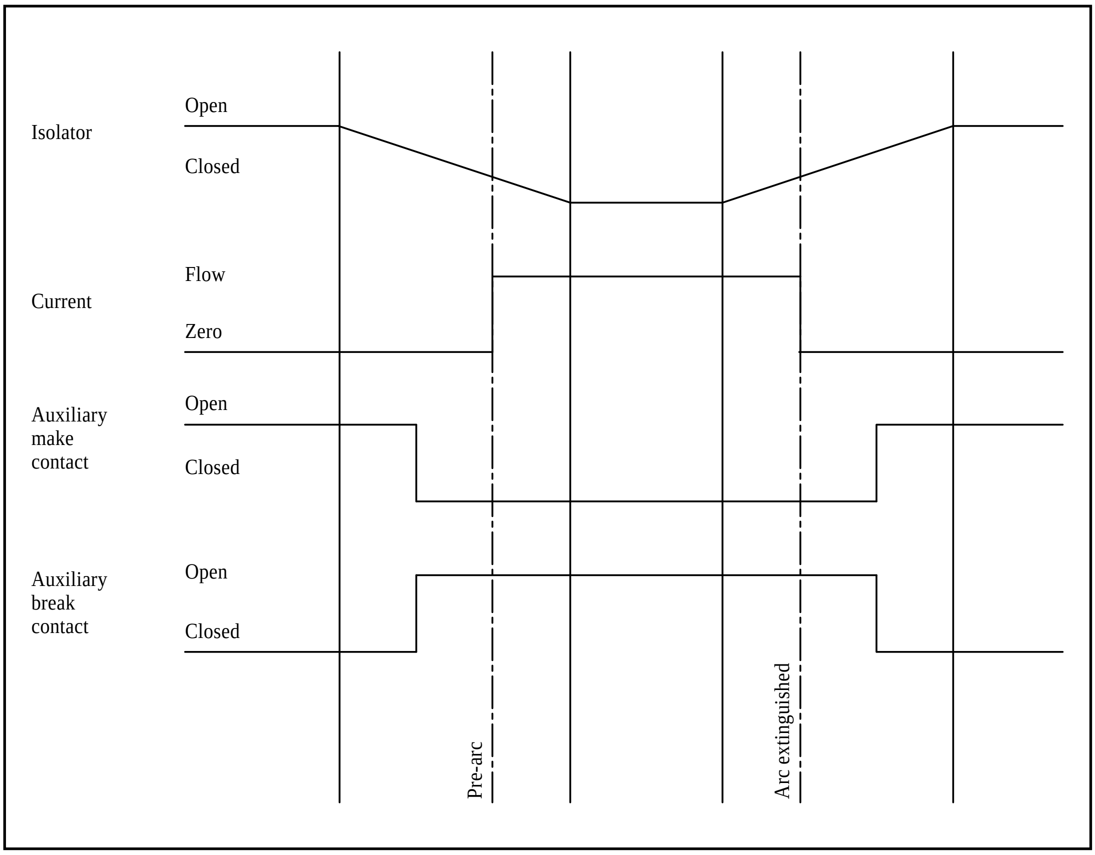


Figure 9 Isolator auxiliary contact operating sequence.

a) Make contact (open when isolator open)

Early make contact. Closes on the closing stroke of the isolator, but makes before the pre-arcing distance is reached. It should open on the opening stroke of the isolator after the arc is extinguished.

b) Break contact (closed when isolator open)

Early break contact. This contact should open on the closing stroke of the isolator before the pre-arcing distance is reached. It should close on the opening stroke of the isolator after the arc is extinguished.

For safety reasons there are normally two isolators connected in series at a bus section. A ‘make’ contact from each isolator should be connected in series to the set coil of the isolator repeat relay, two ‘break’ contacts, one from each isolator, should be connected in parallel to the reset coil. The isolator repeat relay will then only switch as the last isolator closes or the last one opens.

When there is a bus section or bus coupler not provided with current transformers, it is necessary to replicate the circuit breaker in the same way as an isolator, since when it is closed it will connect together the adjacent zones. The auxiliary contacts of the circuit breakers will need to be sequenced in exactly the same way as for an isolator.

Section 5. POWER SUPPLY REQUIREMENTS

The busbar protection requires a supply of ±15V for the protection and –30V for isolator repeat functions. These are provided from Midos power supplies, type MSTZ03/04. The protection can therefore be arranged to operate from any standard auxiliary dc supply via an MSTZ03/04 power supply of the appropriate rating.

These power supply units are of the switch mode type providing isolation from the source. The filtering within these units contributes to the stability of the scheme in the substation environment.

5.1 Protection circuits

Each protection unit requires 3 watts of power in the quiescent state, and each power supply can deliver 60 watts. Therefore, 20 protection units can be fed from one power supply. This is equivalent to one cubicle of equipment. However, this loading is treated as an emergency condition and two power supplies are normally used in parallel to share the load and give a measure of redundancy.

The supply for the protection circuit has the 0V rail earthed in the alarm module.

5.2 Isolator repeat relays

These each take less than 0.75 watts of power; one coil being energised at all times. Unused repeat relays, if fitted, should be energised in the appropriate open or closed state to enable the monitor circuits to function correctly. These are fed from a single power supply that can feed up to 80 repeat relays. The breaker fail input on the feeder breaker units is also fed from this source.

These relays are latched magnetically and will remain in their last set state when the dc supply is lost.

Section 6. CURRENT TRANSFORMER REQUIREMENTS

The general requirements for the current transformers on individual circuits is given by the following expression :

$$VK = K \cdot ICT \cdot [RCT + 2RL + B + Z] \frac{MR_r}{MR_c}$$

Where V_K = knee point voltage of ct

I_{CT} = rated ct secondary current of the circuit with the highest infeed of the bus

R_{CT} = resistance of ct secondary winding

R_L = resistance of a single lead from ct to relay

B = ohmic burden of MBCZ on ct

Z = ohmic burden of other series connected loads (if any)

MR_r = matching ratio for reference circuit (ie. that circuit with the highest ratio ct)

MR_c = matching ratio for circuit under consideration

K = factor for required performance

6.1 Through fault stability

The protection will operate for internal faults and remain stable for external faults with minimum K as follows:

Infeed Circuit X/R	80	40	20	≤10
Minimum K	8	8	4	2.5

However, to ensure high speed fault clearance it is recommended that K is at least 20 for the main infeed circuits to the busbar.

In addition the magnetising current taken by the ct at the knee point should be less than:

$$\frac{V_K}{20\ [R_{CT} + 2R_L + B + Z]}$$

6.2 Operation for internal faults

The minimum operation time of the MBCZ protection remains fairly constant at 7ms including the trip relay. However, under the most onerous conditions, with maximum residual flux in the ct and the fault occurring at the most adverse point of wave, the maximum times that may result will vary with the degree of loading on the ct and the type of fault.

The K factor can be calculated for each circuit and the expected limits of operation time can be found from Figure 10. It is only necessary for the circuits feeding the busbar to have a K factor high enough to give high speed operation. These circuits will normally have the largest ct and give K factors of 40 or so. The load circuits will tend to have smaller ct and their minimum value will be that determined for through fault stability.

For solid earthed systems the total circuit burden should be that for earth faults. Resistance earthed systems have different requirements because the X/R ratio of the system is less than 1 for earth faults and since the operation time varies with X/R the phase burden only need be considered when calculating K.

Where the X/R ratio is not known the following may be taken as a general guide:

$$\frac{X}{R} = \frac{\text{System voltage kV}}{6}$$

For example X/R of 400kV system = 68

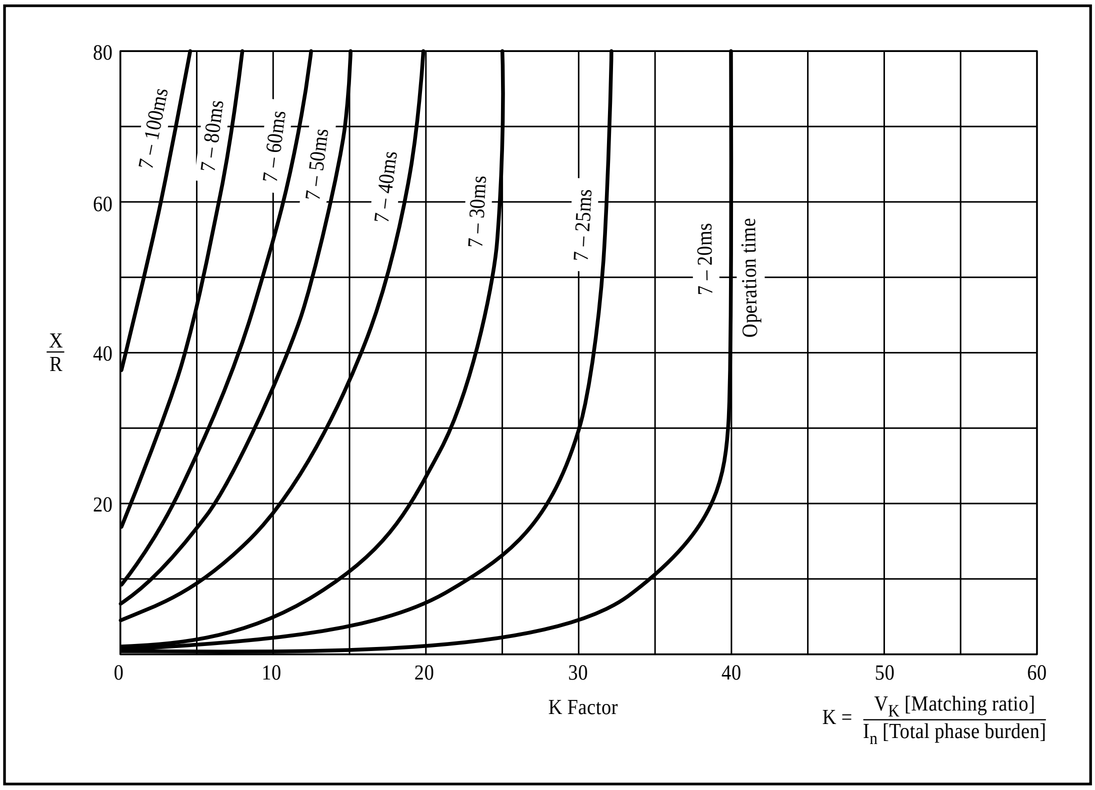


Figure 10 Operation for internal faults.

Section 7. INDICATIONS

Indication of settings is denoted by the position of the setting switches and these are visible through the front cover of the relay cases.

Trip and alarm indications are by means of light emitting diode (led) indicators and where necessary these are provided with a memory circuit to retain the information should the auxiliary dc supply be lost.

The indicators are colour coded to identify their function.

	Colour	Function
Switches	Blue	Settings
LED	Green	Healthy
	Amber	Alarm
	Red	Trip

7.1 Trip indications

7.1.1 Feeder breakers

Indication of trip on each module receiving both a “main” and “check” trip signal.

Indication of back trip when either breaker fail or bus zone trip is fitted. If the breaker fail function is initiated by a busbar fault, indication of trip will appear on the appropriate measuring units (main and check) as well as on the circuit breaker modules. Figure 11.

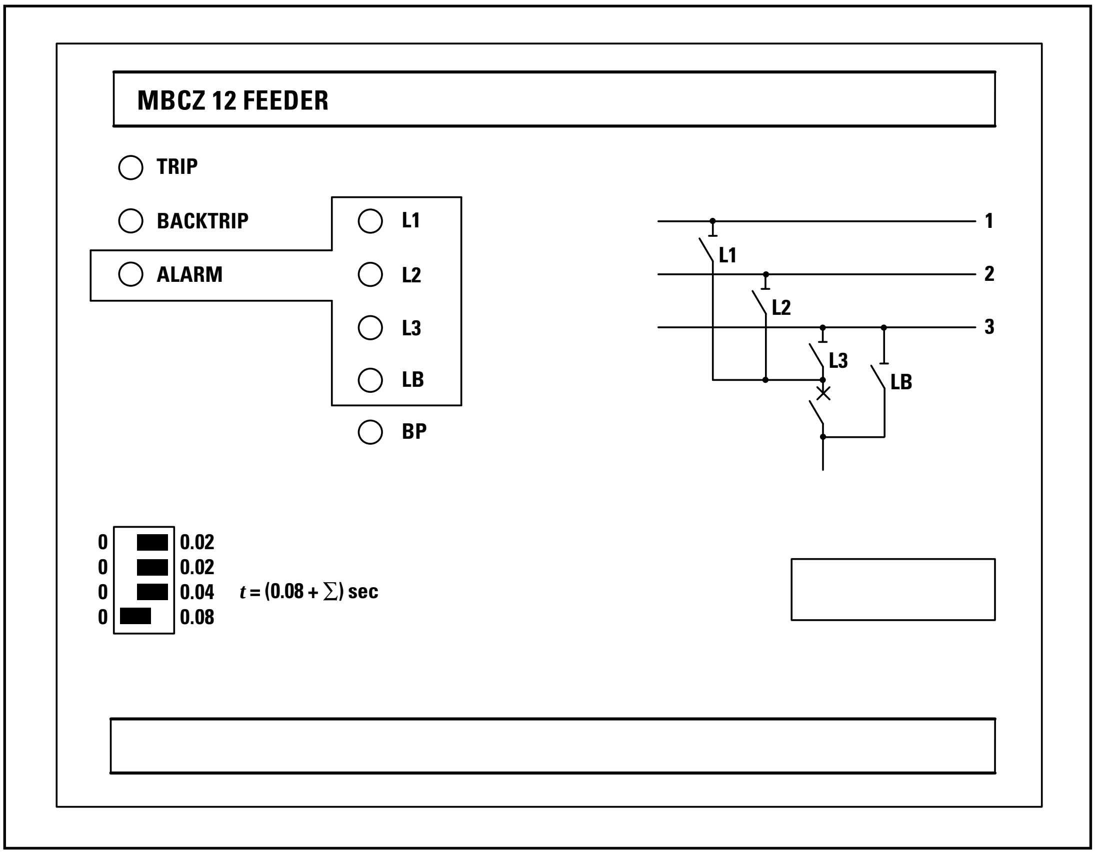
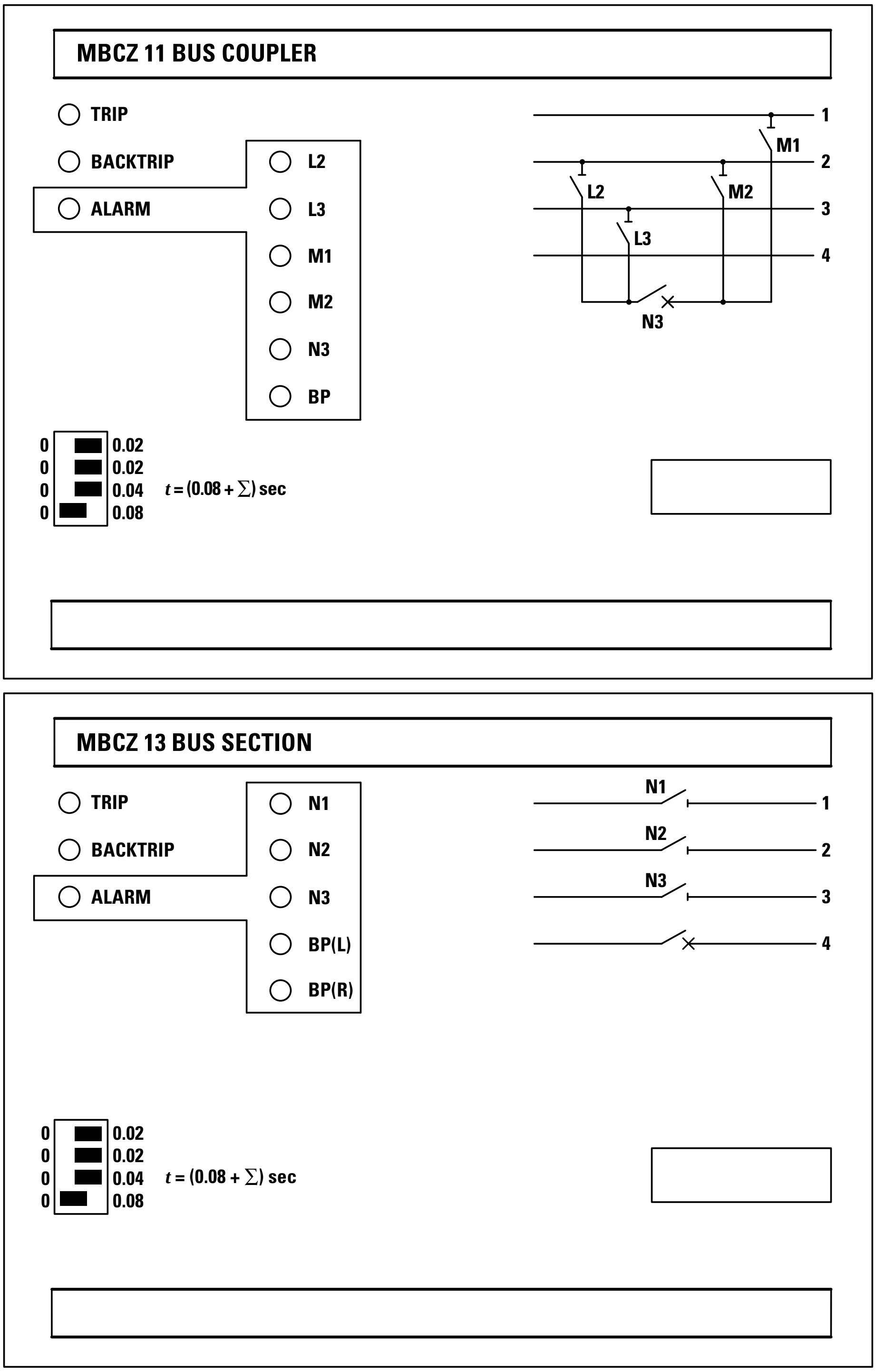


Figure 11 Feeder module

7.1.2 Bus couplers and bus section breakers

Indication of trip on each module receiving both a main and check signal.

Indication of back trip when breaker fail is fitted. If the breaker fail function is initiated by a busbar fault, indication of trip will appear on the appropriate measuring units (main and check) as well as on the current breaker modules. Figure 12.



Note: Pre-August 1989 modules have 3 pole switches.

Figure 12 Bus coupler and bus section modules

7.1.3 Measuring units

Indication of phases and zones tripped. Figure 13.

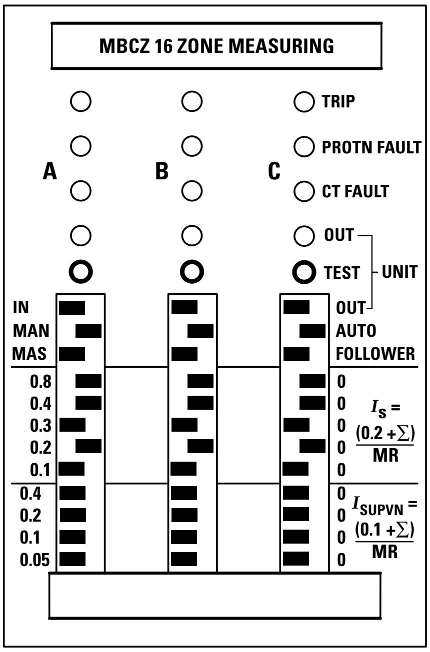


Figure 13 Zone measuring unit.

7.1.4 Alarm module

Protection trip for operation of both main and check zones. Circuit breakers should have been tripped. Figure 14.

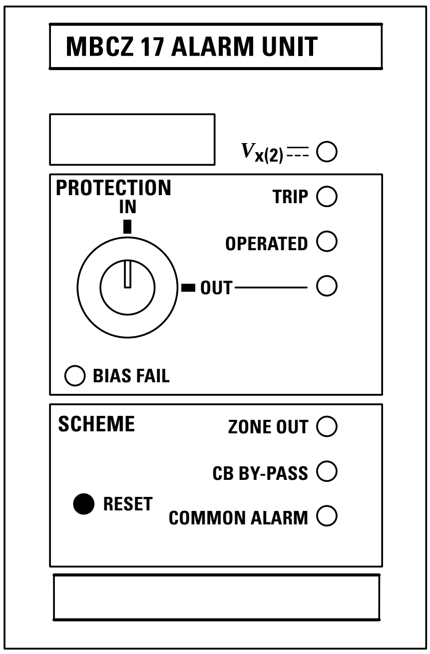


Figure 14 Alarm module.

7.2 Alarm indications

7.2.1 Feeder breaker

L1, L2, L3, LB - These indicate a discrepancy in the isolator repeat relay circuit. They are self resetting and may operate momentarily during an isolator switching operation.

BY PASS - Indicates that the associated feeder breaker is being by-passed via isolator LB.

This is not a fault condition and the alarm circuits are not activated, only the CB BY-PASS indication on the alarm module. (See Section 7.2.6.)

ALARM - Indicates that the supervision circuits within the module have detected a discrepancy of a permanent nature. The fault may be associated with :

- Trip relays
- Isolator repeat relays
- CT saturation detectors
- Overcurrent element
- Back trip timer

7.2.2 Bus couplers

L2, L3, M1, M2 - These indicate a discrepancy in the isolator repeat relay circuit. They are self resetting and may operate momentarily during an isolator switching operation.

BP - Indicates a discrepancy has been detected in the by-pass circuit within the bus coupler module. This indication is self resetting.

ALARM - Indicates that the supervision circuits within the module have detected a discrepancy of a permanent nature. The fault may be associated with :

- By-pass relays
- Trip relays
- Isolator repeat relays
- CT saturation detectors
- Overcurrent element
- Back trip timer

7.2.3 Bus section breakers

N1, N2, N3 - Indicate a discrepancy in the isolator repeat relay circuit. They are self resetting and may operate momentarily during an isolator switching operation.

BP - Indicates a discrepancy has been detected in the by-pass circuit within the bus section module. This indication is self resetting.

ALARM - Indicates that the supervision circuits within the module have detected a discrepancy of a permanent nature. The fault may be associated with :

- By-pass relays
- Trip relays
- Isolator repeat relays
- CT saturation detectors
- Overcurrent element
- Back trip timer

7.2.4 Bus section isolator/bus selector modules

M1, M2, M3/N1, N2, N3 - Indicate discrepancy in the isolator repeat relay circuit.

ALARM - Indicates that a discrepancy of a permanent nature has been detected in the isolator repeat relay circuit. See Figure 15.

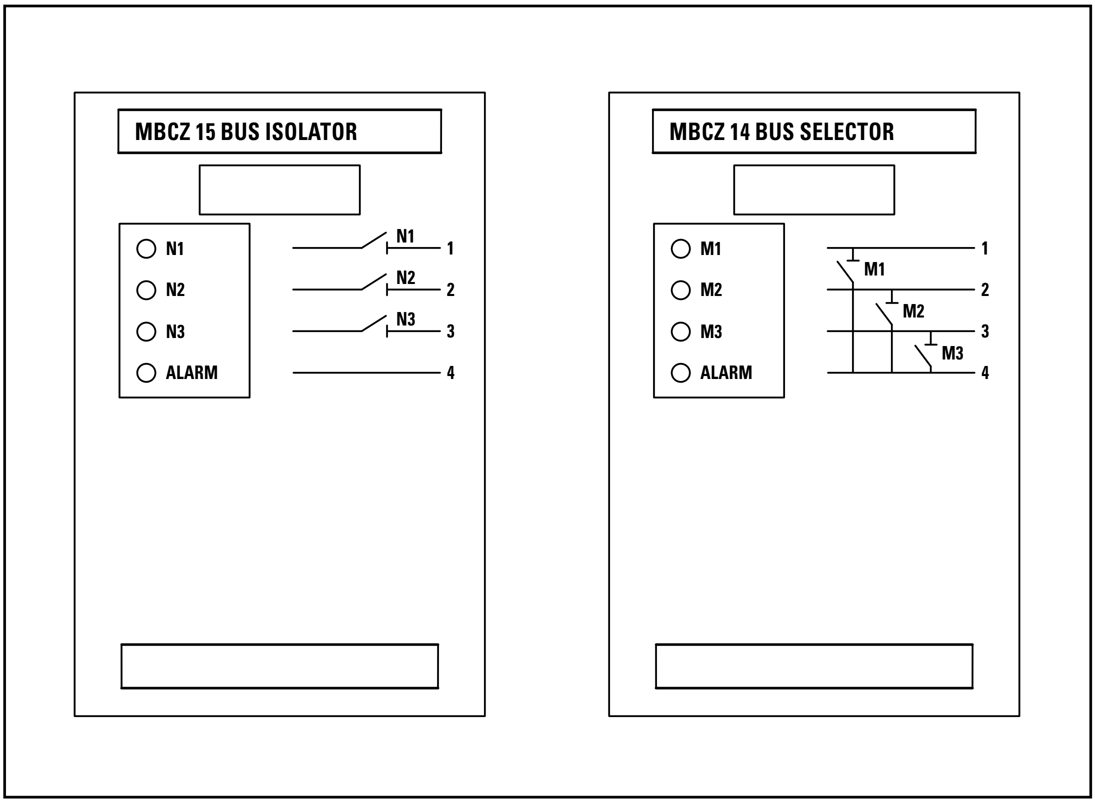


Figure 15 Bus isolator/bus selector modules.

7.2.5 Measuring units

CT FAULT - Indicates a persistent differential current above the supervision setting. This is indicative of a fault in the ct secondary circuits.

PROTN. FAULT - Operates for a fault that is detected in the biased differential protection element circuits. It does not operate for a persistent differential current.

UNIT OUT - Indicates that a measuring unit has been automatically or manually switched out of service. The alarm and supervision indications are cancelled if the unit is switched out manually.

Note : The indications in this module are provided separately for each phase.

7.2.6 Alarm module

PROTECTION OUT - Indicates the complete protection has been switched out of service by means of the key switch. The trip relay circuits are inhibited but all indications are functional for test purposes.

ZONE OUT - Indicates that a measuring unit has been either manually or automatically switched out of service. Hence that zone or part of that zone is out of service.

PROTECTION OPERATED - Indicates that a zone of protection has operated but a circuit breaker trip has been checked (not initiated).

CB BY-PASS - Circuit breaker by-pass is in operation.

COMMON ALARM - This is a common indication repeating all alarm functions after a delay.

BIAS FAIL - Indicates a detected failure in the bias circuit.

Vx - Green led, when lit, indicates that the power supply rails are healthy.

Section 8. SCHEME WIRING

8.1 Current transformers

It is recommended that separate current transformers are used for the main and check zones of protection, and also for the adjacent zones at the bus couplers and bus section circuit breakers. This will ensure the optimum protection of the busbar.

However, where only one set of current transformers is available, because of cost or space, the features will still ensure excellent performance and reliability.

When only one set of current transformers is available per circuit it is usual to adjust the fault setting to a value in excess of rated load current. The differential current that may flow as a result of an open circuited current transformer will then be insufficient to operate the protection. Suitable setting of the supervision differential current setting will then alarm for the condition and if required switch the protection out on the faulted circuit.

Other protection can be energised from the same current transformers used by the busbar protection but the total burden must not exceed the limit given in Section 6.2.

Note : This protection should not share its current transformers with a high impedance differential protection.

8.2 Trip contacts

Two trip relays are fitted to circuit breaker modules made before August 1989 and also all those without the breaker fail/back trip facility. The latched version is reset from the operated condition when the reset button on the alarm module is depressed, and it can also be reset externally by one of the auxiliary relays in the test module or in the buswire access module.

Each trip relay has two electrically separate “make” contacts, thus providing a total of four tripping contacts per circuit breaker module. The coils of the two relays are connected in parallel such that should one coil circuit fail, the other relay will still be able to function. For this reason it is recommended that a contact of each relay is used to energise the trip coil of the circuit breaker. Where two trip coils are available they should be energised separately via a contact of one trip relay or the other.

On modules with two trip relays the contacts are connected to the following terminals:

	Relay A	Relay B
Contact 1	5 – 7 [M]	9 – 11 [M or B]
Contact 2	6 – 8 [M]	10 – 12 [M]

Modules with the breaker fail/back trip facility made after July 1989 have the two trip contacts on Relay A only.

8.3 Back trip contacts

Circuit breaker modules with the breaker fail/back trip facility made after August 1989 have two contacts to indicate that the back trip function has been executed. These are connected to the following terminals:

	Relay B
Contact 1	9 – 11 [M]
Contact 2	10 – 12 [M]

Note: That make only contacts are available. There is the option of a latched on self-resetting relay but it must be the same choice as for the trip relay.

The back trip contacts may be used to inter trip the feeder remote end circuit breaker if feeder breaker fail occurs following a busbar fault.

8.4 Isolator repeat relays

The isolator repeat relays have two actuating coils; one to ‘set’ the relay and the other to ‘reset’ it. Diagrams always show relay contacts in the reset state, which for the isolator repeat relays corresponds to the isolator being in the open position.

The reset coil of the repeat relay must therefore be connected to an auxiliary contact on the isolator which is closed (made) when the isolator is open. The operate or set coil of the repeat relay is then connected to an auxiliary contact which has the same sense as the main contacts and is therefore closed (made) when the isolator is closed. (See Section 4).

Terminals 31 to 48 are used for repeat relay coils. The set coil of the isolator repeat relays are connected to the odd numbered terminal and the reset coil to the even numbered terminal. Terminal 29 is the common connection to all the coils and is connected to the negative terminal of the 30V dc power supply.

The terminal numbers quoted refer to terminals on the individual cases and cubicle terminals will have different numbers. Refer to the appropriate connection diagrams provided with the equipment for the cubicle terminal references.

8.5 Buswires

The modules are then interconnected via a multicore cable that plugs into the back of the modules. There are six main groups of buswires and these are normally to be used as follows:

1. Protection for main busbar.
2. Protection for reserve busbar but only when separate transfer bar is used.
3. Protection for the reserve/transfer busbar. This group is always used for transfer purposes.
4. Auxiliary connections used by the protection to combine modules for some of the more complex busbar configurations.
5. Protection for check zone.
6. Common bias, supply and alarm circuits.

Figure 16, shows the function of each buswire.

Note: Pin 5 is the trip relay positive rail supply. If this is inadvertently connected to another pin, with a ±15 volt supply on it, during testing the trip circuit will not be disenabled by the ‘out of service’ switch.

For added security the buswires in groups 5 and 6 may be connected in a ring. However, the wires in groups 1 to 4 inclusive should not be connected in a ring because it would cause a loss of zone discrimination as some zones would become connected in parallel. The special ring completion connector is marked with red bands at the ends.

Normally only one such connection may be fitted per scheme and it must be instaled in the position shown on the contact diagram. The exception is where feeder and half bus section modules MBCZ 12, 304 are used in a combined function scheme. Here a ring completion cable must be installed between each adjacent pair of 304's as will be shown on the contact diagram.

GROUP	FUNCTION		PIN NO.
1	Phase A	MAIN ZONE	30
	Phase B		12
	Phase C		31
	Trip		13
2	Phase A	RESERVE ZONE	32
	Phase B		14
	Phase C		33
	Trip		15
3	Phase A	TRANSFER ZONE	34
	Phase B		16
	Phase C		35
	Trip		17
	R Relay		6
4	Phase A	AUXILIARY ZONE	36
	Phase B		18
	Phase C		37
	Trip		19
5	Phase A	CHECK ZONE	7
	Phase B		26
	Phase C		8
	Trip		27
6	+	Phase A bias	20
	–		2
	+	Phase B bias	21
	–		3
	+	Phase C bias	22
	–		4
	Common MAIN trip alarm		23
	Trip relay supply		5
	Unit out of service		24
	By-pass in operation		25
	Reset flange		9
	Common alarm		28
	+15V	MAIN DC SUPPLY LINES	10
	0V		29
	–15V		11
	Screen		1

Figure 16 List of buswire functions.

8.6 Power supply and alarms

The alarm contacts in the alarm module are connected to the following terminals:

Protection out of service	Terminals 1 - 3
Common alarm	Terminals 2 - 4 - 9
Protection tripped	Terminals 11 - 13

8.6.1 Connections from power supply output terminals

If the busbar scheme consists of more than one cubicle then the connections should be made from the output terminals of the MSTZ 03/04 power supply which provides the +15V 0V –15V supply to the modules via the alarm module to terminals 57, 58 and 59 for the appropriately selected MBCZ 11 or MBCZ 12 modules as follows, using screened twisted cable (reference YW3158 001):

MBCZ 11/12 terminal	MSTZ 03/04
57	+15V
58	0V
59	–15V

One module per cubicle should be connected in this way and the modules chosen should be evenly distributed through the scheme.

8.7 Bus zone trip and breaker fail initiation

8.7.1 Feeder units

The feeder breaker units are provided with either a “Bus Zone Trip” relay, or a breaker fail circuit. The Bus Zone Trip can be activated by an external breaker fail scheme, by connecting the –30V power supply, used for isolator repeat functions, to terminals 29 (–ve) and 40 (+ve) via a contact on the breaker fail protection.
The breaker fail protection will then trip the Bus Zone that the feeder is connected to. When integral breaker fail protection is provided in the feeder unit it can be activated by connecting the 30V dc supply to terminals 29 (–ve) and 40 (+ve) via a feeder protection trip contact.

8.7.2 Bus coupler and bus section breaker units

When breaker fail protection is fitted to bus coupler or bus section breaker units, it can be activated externally by connecting the 30V dc (external) supply to terminals 29 (–ve) and 48 (+ve) via an external contact eg. on an overcurrent relay.

8.8 Alarm repeat relays

The test module contains three repeat relays with coils rated for 30V dc.
These relays are for use as contact multipliers for the alarm contacts.

One relay provides two ‘break’ contacts and this relay should be energised by the ‘make’ contact for the common alarm circuit. The other two relays can be used for the “Protection tripped” or “Protection Out of Service” alarms.

8.9 Buswire access units

Buswire access units are fitted where certain additional facilities are required as described in sections 8.9.1 to 8.9.5 following. There will usually be at least two units fitted, one on each side of the alarm module. The exception is the case where trip relay supply buswire switching (Section 8.9.1) is not required and there are no bus section breakers. Here only one buswire access unit is needed.

If the busbar is divided into two or more sections by bus section breakers, then one buswire access unit is required per section. Even if there are no bus section breakers, two units will be fitted if the switching facility of section 8.9.1 is required.

Before checking the buswire access units as described in sections 8.9.1 to 8.9.5, disconnect all trip contacts from the circuit breakers.

8.9.1 Trip relay supply buswire switching

This facility is optional. It gives an additional criterion for trip signals to be sent to the circuit breakers determined by an undervoltage relay. There will be an undervoltage relay for each zone of protection and if the contacts on any one of these are closed the trip relay buswire is energised for the whole scheme.

To test this facility first check that the shorting links are fitted in position 2—3 on plugs JM1 and JM2 on all units. Replace the units, switch on the power supplies and set the keyswitch on the alarm units to PROTECTION IN. Check that the TRIP INHIBIT indicator on each buswire access unit is illuminated.

Close or bridge the contacts of each undervoltage relay in turn and check that all the TRIP INHIBIT indicators are extinguished each time.

If the switching facility is not to be used fit the shorting links on all units to position 1—2 of JM1 and JM2. Check that the TRIP INHIBIT indicators are illuminated when the keyswitch on the alarm unit is set to PROTECTION OUT and are extinguished at PROTECTION IN.

8.9.2 Repeat contacts

The following pairs of contacts are closed in response to buswire energisation:

Buswire	Contacts SK1
T1	5-7
T2	5-9
T3	5-15
TC	5-6
	1-2
By-pass	5-17
Zone out	5-19

All these contact pairs except 1—2 are used for remote repeat or telecontrol. Pair 1 and 2 are used to initiate an external timer for transfer trip. (See Section 8.9.4).

Check the repeat contact closure either by observing the remote repeat or telecontrol or by using a continuity tester across the contact pairs. To energise the trip buswires connect the Test Unit output to the test socket of each measuring unit in turn. Set the Test Unit to INJECT and adjust the current to a value exceeding the setting.

The check zone measuring unit should close the contact pairs 5—6 and 1—2 on all the buswire access units. Pair 1—2 on each module can be checked individually but not pair 5—6 since they will be connected in parallel and it is only practicable to check the combination as open or closed.

The main zone measuring units should close the corresponding contact pairs on one buswire access unit only, that one in the corresponding bus section. (The exception will be the case where there is no bus section breaker and both buswire access units will respond. As in the case of the check zone trip contacts, corresponding contact terminals from the two units will probably be connected in parallel).

Check the by-pass repeat contacts by operating the by-pass relay in one of the feeder units. This can be done by temporarily reversing connections to terminals 37 and 38. The CB BY PASS indicator on the alarm unit should be illuminated and all buswire access units should respond. The corresponding contact terminals (5—17) on the buswire access units are probably connected in parallel.

Check the zone out repeat contacts by setting any one of the uppermost switches on a main zone measuring unit to OUT. This should cause the ZONE OUT indicator on the alarm unit to be illuminated and all buswire access units should respond. Again, the corresponding contact terminals (5—19) on the buswire access units are probably connected in parallel.

8.9.3 Remote reset

To check the remote reset function it is first necessary to produce a suitable indication on the scheme. Connect the test unit to the test socket on any measuring unit. Set the test unit to INJECT and adjust the current to a value higher than the setting. Hold the INJECT button until indicators are illuminated, eg. CT FAULT, ALARM, PROTECTION OPERATED, COMMON ALARM. Any of these will serve the purpose. Release the INJECT button and either press the remote reset button or connect terminal 27 on one of the buswire access units to the positive terminal of the external power supply (terminal 3, 5, 7, 9, 11 or 13). Terminals 27 on the buswire access units will probably be connected in parallel.

8.9.4 Transfer trip

Check that in each bus section at least one feeder unit is connected to the main busbar and one to the reserve/transfer busbar. If this is not the case, temporarily change over isolator repeat relay connections to simulate this situation, but ensure that there is no direct connection through isolators between the busbars. Also ensure that if there is a bus section breaker with isolators connecting the main busbars, that these isolators are either open or open connections are simulated by reversing the isolator repeat relay connections.

The intention of the above checks is to ensure that all the main zone and reserve/ transfer zones of protection are effectively separated from each other in the scheme and that there is at least one feeder unit connected to each zone.

Connect the test unit to one of the test sockets on the check zone measuring unit. Set the test unit to INJECT and adjust to a value higher than the measuring unit setting. Hold the INJECT button and check that, after a delay, all the feeder units connected to the main and reserve/transfer zones give a trip indication.

8.9.5 Earth fault inhibit

This facility is fitted only to schemes with two phase and neutral connection, phase B of the scheme being used for the neutral connection.

Set PROTECTION OUT on the alarm unit. Connect the test unit to the test socket on phase B of the check zone measuring unit. Set the test unit to INJECT and adjust the current to a value exceeding setting. Press the INJECT button and check that there is no trip indication on the measuring unit. Bridge the earth fault inhibit contacts on each buswire access unit in turn and check that when the INJECT button is pressed the measuring unit indicates TRIP.

Ensure that all main zone buswires are isolated from each other in the scheme. If any buswires are connected together by isolators which are closed, reverse the the isolator repeat connections to separate the buswires.

Proceed for each main zone measuring unit as follows. Connect the test unit to the phase B test socket. Set the test unit to INJECT and adjust the current to a value exceeding setting.

Press the INJECT button and check that there is no indication on the measuring unit. Identify the buswire access unit corresponding to the main zone under test and bridge the earth fault inhibit contacts. Press the INJECT button and check that the measuring unit indicates TRIP.

Section 9. TRIP INDICATION ANALYSIS

The following sequence is recommended for analysing the trip indications. See also Figure 17 Trip indication charts.

9.1 Alarm module

TRIP indication should register whenever a circuit breaker is tripped via the busbar protection trip relays.

9.2 Measuring units

A TRIP indication on the check zone measuring unit and at least one main zone measuring unit indicates a busbar fault. However the main zone unit that has tripped does not necessarily identify the faulty zone. If two zones are parallelled by isolators and one of the main zone units is set to MASTER and the other to FOLLOWER, on a low level fault only the MASTER unit will trip. The fault could be in either zone and even if both units had tripped it would be impossible to tell which had the fault. It is therefore necessary to check which circuit breaker modules are giving a TRIP indication.

9.3 Circuit breaker units

A circuit breaker unit gives a TRIP indication on receiving a trip command on main and check zone buswires irrespective of whether this is due to a busbar fault, breaker fail or back trip.

A busbar fault is indicated by a TRIP signal on main and check zone measuring units as explained in the last section. A breaker fail or back trip operation is shown by a BACKTRIP indication on one of the circuit breaker units.

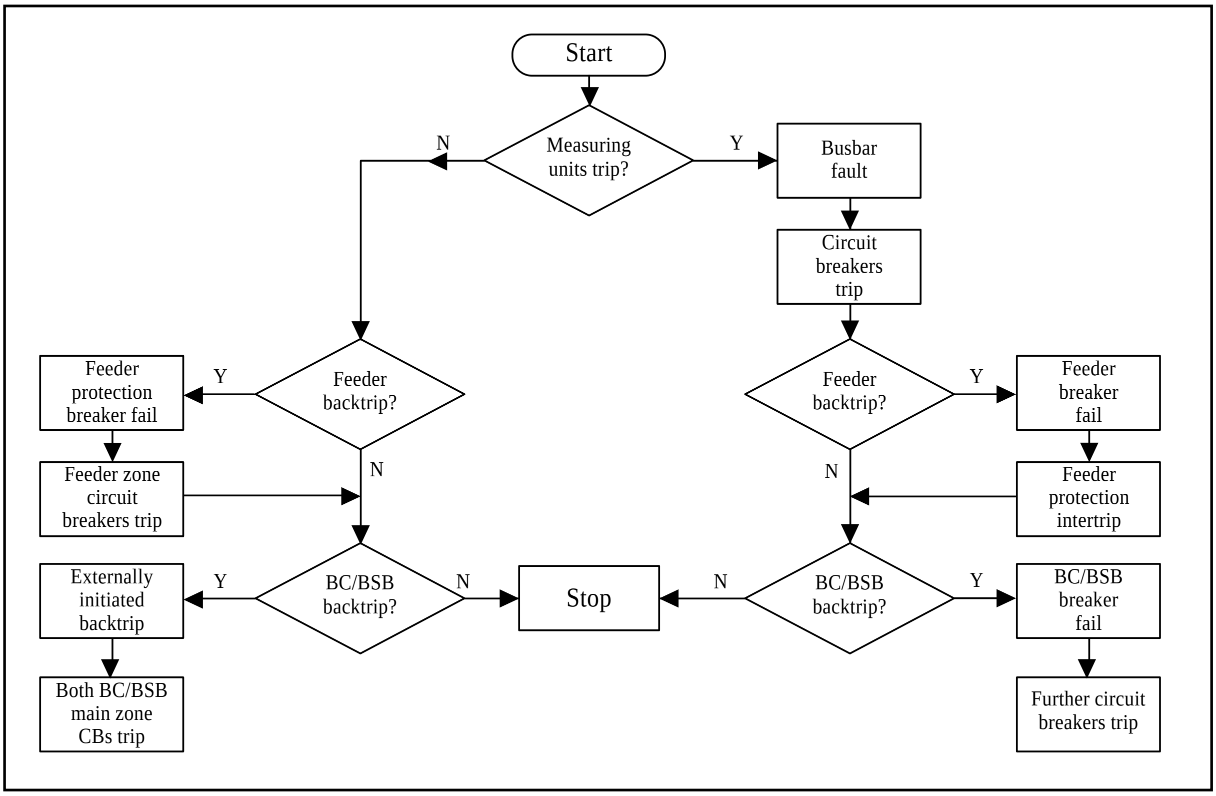


Figure 17 Trip indication analysis chart

If a busbar fault is closely followed by a BACKTRIP indication on one of the feeder units in the faulty zone, this shows that the feeder breaker has failed (or the fault was in the dead zone between breaker and current transformer) and the back trip has operated.

If a TRIP indication appears on main zone circuit breaker units together with a BACKTRIP on one of the feeder units but without measuring unit trip, this shows that back trip has been initiated by feeder protection breaker fail.

If a busbar fault is closely followed by a BACKTRIP indication on one of the bus coupler or bus section breakers in the faulted zone, and TRIP indications appear on circuit breaker units on the healthy side of the bus coupler or bus section breaker, breaker fail has occurred on the bus coupler or bus section switch and the back trip has operated. (Alternatively there is a fault on the dead zone between breaker and current transformer). There will now be TRIP indications on circuit breaker units on both main zones associated with the faulty breaker, but only on the main zone measuring unit where the original fault occurred.

If a BACKTRIP indication appears on a bus coupler or bus section breaker unit together with a TRIP indication on circuit breaker units on both main zones associated with that unit, but without measuring unit trip, this shows externally initiated back trip on the bus coupler or bus section breaker.

Section 10. FAULT FINDING

The various alarm indications can be analysed in order to determine where an equipment fault may lie. However, it may be necessary to perform one or two additional tests to establish the cause of the problem and isolate the fault.

During parts of the fault finding procedure it will be necessary to remove modules from their cases and make disconnections of the buswires. It is essential to switch off the power supplies before making or breaking any connections.

10.1 Alarm indication analysis

First record all indications on the table in Figure 18, and then follow the fault diagnosis chart shown in Figure 19.

10.1.1 Alarm module

COMMON ALARM indicates that a persistent fault has been detected by the monitoring circuits and that the alarm relay has been instructed to announce the fault. This indication will usually be supported by other alarms which give additional information.

* Indicates that a given alarm actuates this common alarm.

PROTECTION OPERATED* registers that one of the measuring units has operated or has operated but tripping of a circuit breaker has been blocked.

PROTECTION OUT indicates that the protection trip relays have been inhibited by the key switch on the alarm module. The indicator is driven directly from the trip relay supply line and will not go out unless the trip supply line is energised or the auxiliary power switched off completely.

BIAS FAIL* operates when the bias circuit supervision detects a persistent imbalance in the vector sum of the three phases of bias voltage. The measuring

ALARM	Vx(2) HEALTHY	
	BIAS FAIL	
	PROTECTION OPERATED	
	PROTECTION TRIP	
	COMMON ALARM	
	ZONE OUT	
	BY PASS	

MEASURING	ZONE	CHECK			1			2			3			4		
	PHASE	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
	TRIP															
	PROTECTION FAULT															
	CT FAULT															
	UNIT OUT															
	AUTO SELECTED															
	MASTER SELECTED															

FEEDER	NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	TRIP																				
	BACKTRIP																				
	ALARM																				
	L1																				
	L2																				
	L3																				
	LB																				
	BY-PASS																				

BUS COUPLER	NUMBER	1	2
	TRIP		
	BACK TRIP		
	ALARM		
	L2		
	L3		
	M1		
	M2		
	N2		
	N3		
	BP		

BUS SECTION	NUMBER	1	2	3	4
	TRIP				
	BACK TRIP				
	ALARM				
	N1				
	N2				
	N3				
	BP(L)				
	BP(R)				

BUS SELECTOR	NUMBER	1	2	3	4
	ALARM				
	L1				
	L1				
	L3				

BUS SECTION ISOLATOR	NUMBER	1	2	3	4
	ALARM				
	N1				
	N2				
	N3				

Figure 18 Record of indications.

circuits take some bias from the phase with the highest bias current. This improves the discrimination of the protection to the different types of primary system faults and renders the likelihood of a false operation due to a bias circuit fault improbable.

ZONE OUT registers that at least one phase of measurement in a zone has been switched out of service either automatically by the supervision or manually. Other alarm signals from that phase of measurement are suppressed.

BY-PASS repeats the fact that a feeder breaker is being by-passed. No action need be taken.

Vx(2) ===* This denotes the power supply lines for the protection are healthy when it is lit. The common alarm contact closes for power supply failure.

10.1.2 Measuring units

CT FAULT* indicates that the differential current has exceeded the set supervision level for a time in excess of the supervision time delay. This can result from a fault in the secondary circuit of the current transformers. The fault may be external to the relay or internal.

External - check current from each group of ct feeding into the zone which gave the alarm.

Internal - the fault may be in the buswires or the isolator repeat relays.

PROT. FAULT* This indicates a discrepancy between the dual measuring circuits of the protection.

UNIT OUT If this indicator is lit the alarm and trip signals and indications from that particular phase and zone have been inhibited either automatically by the supervision or manually.

10.1.3 Feeder breaker

ALARM* This indicator will be lit for any fault detected in the module. The fault may be in the ct saturation detector circuit, the trip or back trip relay coils, the back trip timer, or the isolator repeat relays. For the latter it should be accompanied by another indication L1, L2, L3 or LB to indicate the isolator circuit at fault.

Note: If all isolators on one feeder are indicated as faulty then suspect the common supply leads but if all circuit breaker modules indicate a fault then suspect the power supply.

BY-PASS indicates the circuit breaker is being by-passed on that feeder and no action need be taken.

10.1.4 Bus section and bus coupler breaker

ALARM* This indicator will be lit for any fault detected within the module. The fault may be in the ct saturation detector circuit, the trip, back trip or by-pass relay coils, the back trip timer or the isolator repeat relays. For the latter it should be accompanied by another indication to indicate the isolator circuit at fault.

B.P. indicates a fault on the by-pass relay within the module eg. open circuit coil.

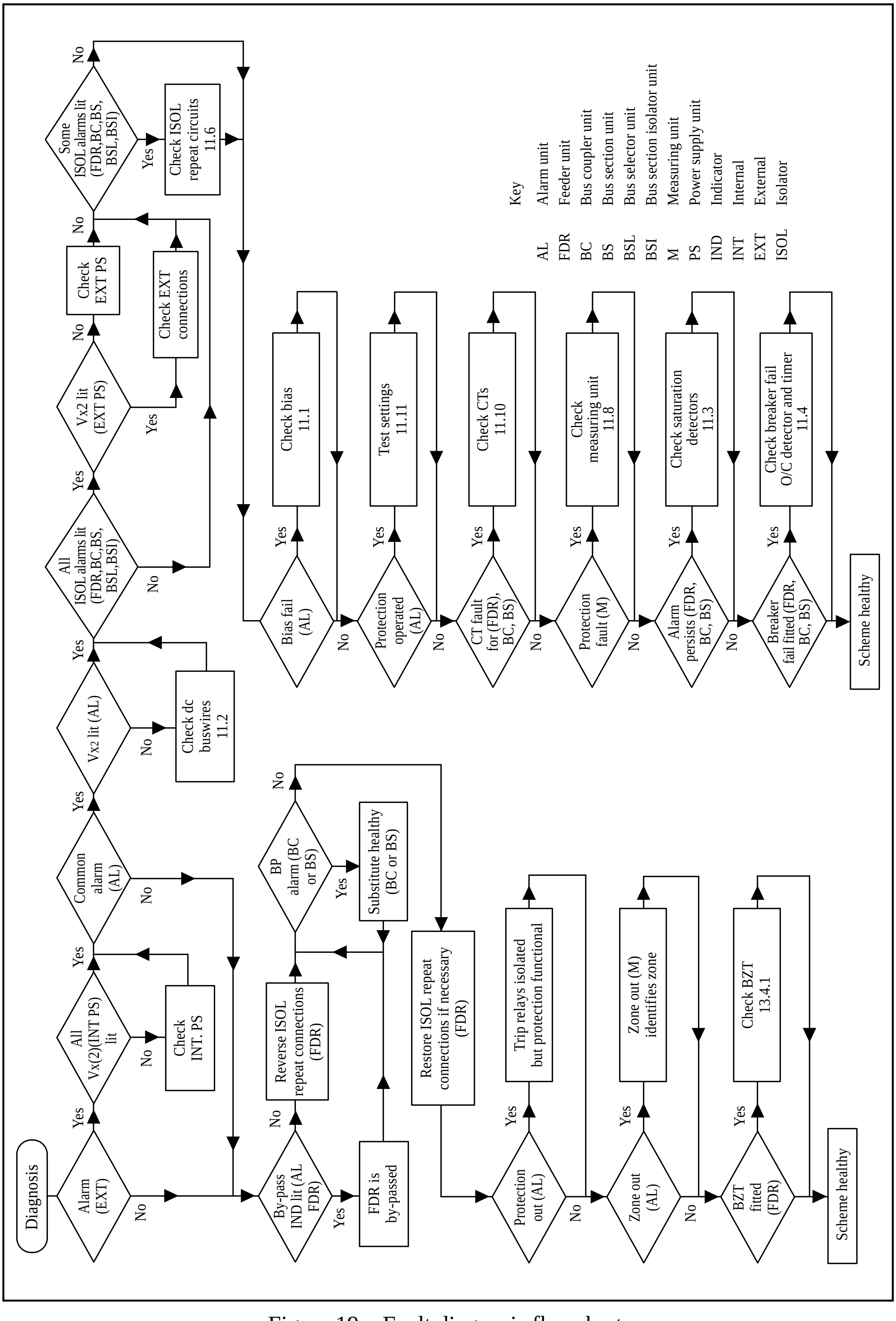


Figure 19 Fault diagnosis flowchart.

10.1.5 Bus section isolator and bus selection isolator

ALARM* This indicator will be lit when there is a fault in the isolator repeat relay circuit (see Bus Section Breaker). This indication should be accompanied by an isolator indication.

Note: if all isolators are indicated as faulty then the dc power supply for the repeat relays should be suspected.

The following tests will enable more detail of the problem to be be obtained. They are called up in the fault diagnosis chart, Figure 19, as required.

It is advisable to switch the protection out of service before any of the following tests are carried out. This will ensure that the busbar is not inadvertently tripped.

10.2 Fault finding tests

10.2.1 Bias circuit

It will be necessary to have load current flowing in the check zone for this test. If the current is too low for satisfactory measurements to be made additional current may be injected via one of the ct inputs to the check zone on a feeder. Where there is no check zone the bias is derived from the main zone.

The bias circuit will then produce a voltage across the relevant buswires. There are two buswires per phase for the bias voltage, one for the positive half cycle and one for the negative half cycle as shown in Figure 20. The voltage between each of these wires and the common line should be equal in magnitude if the circuit is healthy.

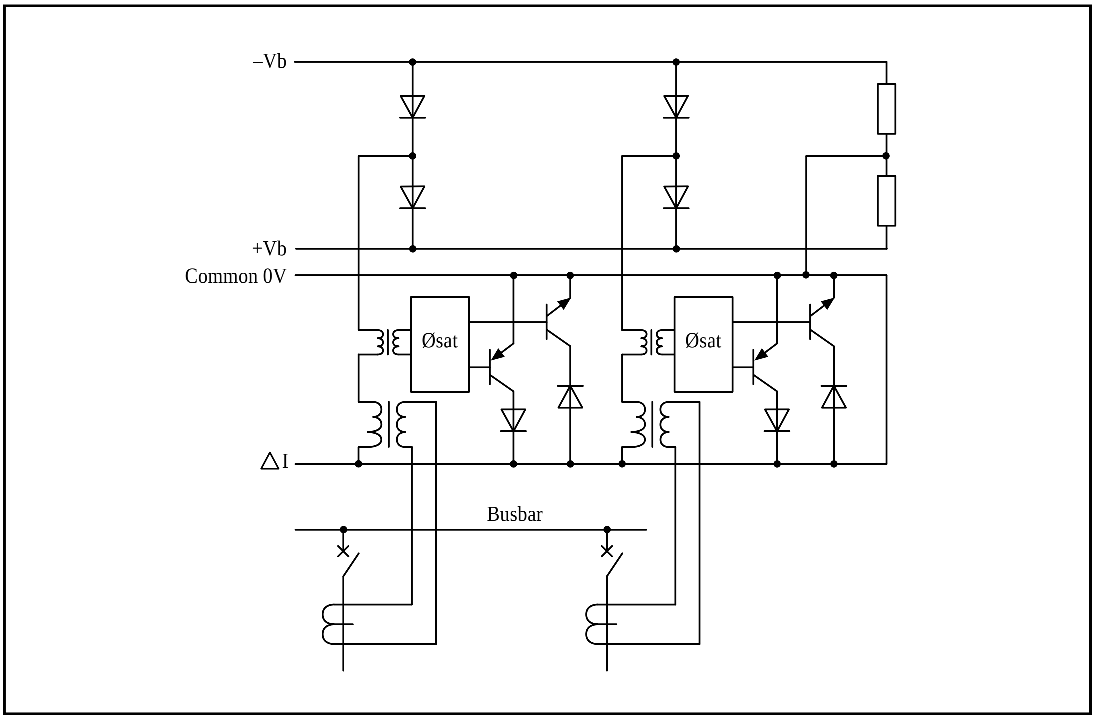


Figure 20 Bias circuit

The buswires can be accessed from the multiway ‘D’ connector on the back of one of the circuit breaker units at the end of the buswire. If the buswires are connected in a ring, as described in Section 8.4, it will be necessary to disconnect one end of the special interconnecting link to break the ring. No other connectors in the buswiring should be disturbed.

A digital multimeter with a high input impedance is recommended for this test. Connect one lead of the meter to pin 29 (common 0V line) on the ‘D’ connector (see Figure 21). The other lead is then connected in turn to pins 2, 3, 4, 20, 21 and 22; the corresponding voltages should be:

Phase A V2 = –V20
Phase B V3 = –V21
Phase C V4 = –V22

with the meter on the 20 volt dc range the allowable difference is ± 20%.

If the voltages are equal then the fault may be in the bias supervision circuit. This resides in the alarm unit and is most easily tested by substitution. If the BIAS FAIL indication cannot be reset with the present alarm module and can be reset with the substitute alarm module, then the fault is in the alarm module. If the voltages were unbalanced in the previous test and are now balanced, then the fault is likely to be in the bias resistors. However, if the voltages were balanced then the bias supervision circuit is likely to be at fault.

Should the fault indication occur with the substitute alarm unit then the fault is most likely to be detectable as a short circuit on the buswires. This may be in a module, detectable by partially withdrawing modules in turn. (Switch off the power supplies MSTZ03/04 when withdrawing or replacing a module). If this does not clear the fault then the multicore interconnectors should be checked.

Note 1: Avoid contact with components or tracks on printed circuit boards when substitutingmodules. Remake any connections, that were broken for test purposes, before putting equipment back into service.

Note 2: Bias is produced by the sum of all the currents flowing to and from the busbar system and is not derived separately for each zone. The measuring units are restrained by the highest bias voltage from the three phases and the bias reference resistors comprise several resistors in parallel. It is therefore unlikely that the protection will be unstable as a result of a fault in this part of the circuit.

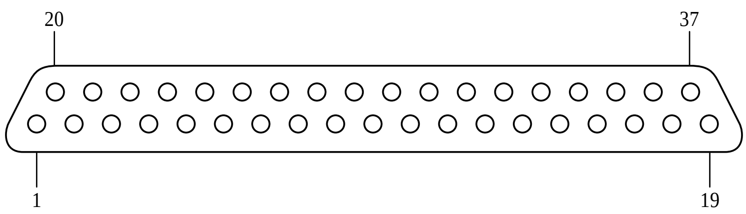


Figure 21 Pin number for buswire socket

10.2.2 DC buswires

The auxiliary ±15 volt supply to the busbar protection is fed into the buswires via the alarm module. If the Vx(2) supply healthy indicator is not lit there is a failure of this auxiliary supply.

First check that the switches on the front of the MSTZ03/04 power supply units are in the ‘up’ position ; they may have been tripped out by an overload. Try resetting if necessary with the switch on the front of the power supply (turn OFF then ON).

Next check the voltages on the rear terminals of the alarm module MBCZ17. They should be +15 volts on terminal 27 with respect to terminal 22 and –15 volts on terminal 28 with respect to terminal 22. If these voltages are grossly unbalanced then disconnect the wires from terminals 22, 27 and 28 and check the voltages across the corresponding pairs of free wires taking care to keep them apart. If the voltages are still unbalanced the power supplies are at fault but if they are now balanced there is a fault in one of the modules or the buswires. The fault can be traced by sectioning the buswiring but the protection must be in the OUT OF SERVICE position.

Note: Repair as necessary and replace all connections before returning to service.

10.2.3 Saturation detectors

There are separate saturation detectors for the positive and negative half cycles of current. The switching action of the two buswire shorting transistors driven by the two saturation detectors are compared. If a fault is detected by the supervision circuit an alarm is given. Typical faults may result in one of the buswire shorting transistors not switching or alternatively being continuously turned on.

The protection is capable of operating in less than one half cycle and should therefore still be capable of tripping for an internal fault, even if a saturation detector is faulty. Through fault stability will be maintained by the main and check zone feature as they have separate saturation detectors. Even so remedial action should be taken as soon as possible.

Fit a replacement circuit breaker module or new saturation detector printed circuit boards to effect a repair, but first ensure that there is not a fault with the trip relay coil circuit test 10.2.5 or the isolator repeat circuit test 10.2.6. When fitting a replacement module ensure that the ct matching ratio is correctly set.

10.2.4 Breaker fail overcurrent and timer

This section applies to feeder, bus coupler and bus section units fitted with the breaker fail facility. Maintain protection OUT throughout the following tests.

Set the time switch to 0.36 seconds and inject a current of 0.41 (Matching Ratio) into terminals 17 and 18. Connect terminal 56 on the terminal block to either terminal 40 for a feeder unit or 48 for a bus coupler or bus section breaker and check that after a fraction of a second the BACKTRIP and TRIP indicators light on the unit under test together with the TRIP indicators on the main zones. (There are two main zones for a bus coupler or bus section unit and one for a feeder). The ALARM indicator should not light.

Repeat the test on the other two phases by injecting into terminals 19 and 20; then 21 and 22. If the alarm lamp comes up for a test on one phase only then there is a fault in the overcurrent circuit of that phase. However, if the alarm comes up for all three phases then the fault will be with the time delay circuit. There is also the possibility of there being a fault with the trip circuit test 10.2.5.

10.2.5 Trip relay coils

The coils of the trip relays are monitored when the protection is IN SERVICE, but not when the key switch is in the OUT OF SERVICE position. If the alarm on any circuit breaker module can be reset and will stay reset in the OUT OF SERVICE position but continually reoperates in the IN SERVICE position then the fault is with the trip circuit of that module.

If the buswire access unit is fitted, the trip relays are not monitored unless either the trip enable input is energized or the buswire switching facility is not used leaving the trip enable buswire always energized with PROTECTION IN. See Section 8.9.1.

10.2.6 Isolator repeat relay circuit

When one of these circuits fails there will be an alarm given and this will be accompanied by lights indicating the faulty isolator circuit. If all isolators are indicated faulty the power supply to the repeat relays is likely to have failed. Try to reset it and check the output is 30 volts dc.

If the indication is limited to a group of relays then the common supply lines to that group of relays should be checked. If only one failure is indicated check that either the ‘set’ or ‘reset’ terminals on the case have a 30 volt dc potential. If the voltage on both these terminals is zero then the fault lies with the auxiliary contacts or external wiring. Should one of the terminals be energised then the opto coupler in the coil circuit may have failed or the coil may be open circuit.

The isolator led will be lit if both the ‘make’ and ‘break’ auxiliary contacts on the isolator are both closed together or open together during the switching sequence. This feature can be used to check for correct operation of the isolator repeat relays during an isolator switching sequence.
If the contact overlap period exceeds fifteen seconds a latched alarm will be given.

10.2.7 Isolator repeat relay power supply

The power supply units type MSTZ03/04 are fitted with overcurrent protection on the input and overvoltage and undervoltage protection on input and output. With the exception of the input undervoltage protection, when the protection operates the front panel circuit breaker will trip and the green led indicator will go out.
The circuit breaker must be reset to restore the unit to operation, but see the warning in the next paragraph. When the undervoltage protection operates the green led will go out but the circuit breaker will not trip. Operation will be restored as soon as the correct input voltage is applied.

First check the incoming dc supply has not failed. If this is within the voltage range of the power supply do not attempt to reset the circuit breaker (if this has tripped out) since an attempt to start the power supply on to a short circuit will damage the unit. Ensure that the circuit breaker is off then check the load resistance. It should be at least 15 ohms, and will probably be higher depending on the number of isolators and by pass circuits in the scheme. If it is less than 15 ohms check the wiring for short circuits.

Next check the fuse FS1. If this has blown it may indicate a fault within the power supply. However it is worth replacing it since the power supply is unlikely to suffer further damage from an attempt to restart it.

If the input voltage, the load circuit and the fuse are now in satisfactory condition, the circuit breaker may be closed. If the power supply still fails to operate it must be withdrawn for repair.

Note: The positive terminal of this supply is usually connected to earth. Faults on the external wiring will therefore cause the isolator repeat relays to receive false signals and these will be alarmed.

10.2.8 Measuring circuits discrepancy

This test is necessary when a protection fault alarm is given by a measuring unit. After removing the cover from the front of both the test unit and the faulty measuring unit, the test lead should be used to interconnect the faulty phase of the measuring unit to the test module. Figure 22.

The differential current should then be measured by setting the selector switch on the test unit to DIF X1. The standing differential current will be less than 10% of rated load for normal conditions when the busbar is energised. If it is higher there may be a wiring fault in the current transformer circuit and there should be an indication CT FAULT.

Note: 100% In on meter is equivalent to rated current injected T1 - T9 on matching ratio ct.

Set the test selector switch to INJECT and press the reset button on the alarm unit and the indications should reset and stay reset. If the PROTN FAULT alarm recurs after 3 seconds then there may be a fault in one of the dual measuring circuits.

Should the alarm stay reset then a current above the relay setting should be injected. To do this the current selector switch on the test unit should be set to 99 and the injection button depressed and held for five seconds. If the PROTN. FAULT alarm occurs then one of the dual measuring elements is not operating. If no alarm is given it is possible that there was a fault close to the relay setting that caused the original alarm.

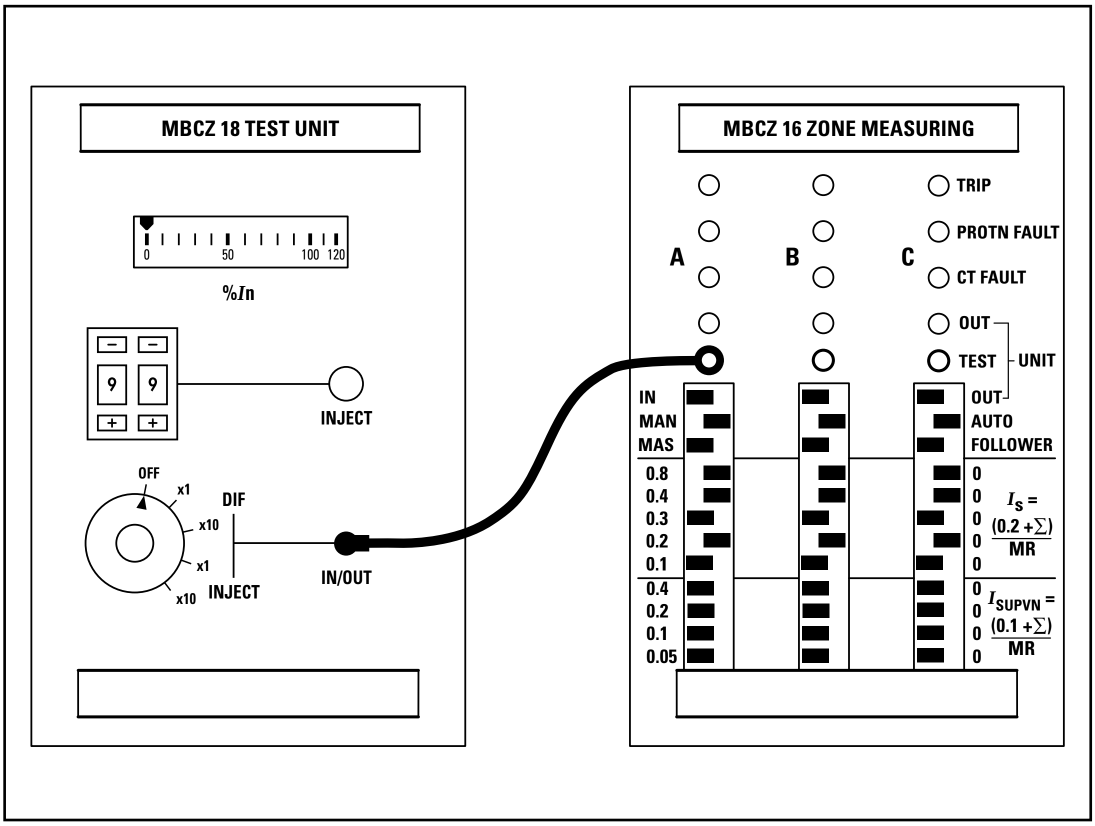


Figure 22 Connection of test unit to measuring unit.

10.2.9 Differential supervision

Set the selector switch on the test unit to INJECT and the current selector switches to give a current above the supervision setting but less than the protection fault setting. Reset the indications and then depress the injection button to inject the current, a CT FAULT alarm should be given after 3 seconds.

10.2.10 CT circuit open or short circuit

If a CT FAULT is not given on all three phases of the faulted zone it should be possible to determine the faulted circuit by measuring the current in each phase of each circuit feeding the faulted zone. An unbalance between the phase quantities should indicate the faulted circuit.

Where a type MMLG Midos test block is fitted the current can be measured by means of an ammeter connected to a type MMLB02 single finger test plug. This is plugged into each phase in turn and the current measured.

When a CT FAULT is indicated on all three phases of a zone the fault should be detectable by the absence of current in all three phases of a circuit. It is possible that the fault may lie within the equipment but if it does there will usually be some other alarm such as an isolator repeat relay failure.

10.2.11 Differences in zone settings

When the protection operated alarm is raised it is most likely to be due to a setting difference between the main and check zones. This may result from a difference in settings due to relay tolerances, wrongly adjusted setting controls, or even because the zones are set to MASTER and FOLLOWER. These will result in alarms for marginal faults.

If only a main zone has operated then the problem may be a faulty isolator repeat relay, which could result in a current input being directed to the wrong zone.

10.2.12 Protection of power supply failure

Two or three power supplies are usually connected in parallel to provide security of supply. If some of these power supplies fail leaving at least one working normally the external alarm will be given and the green healthy light will be extinguished on the failed units. However the green light will remain illuminated on the healthy power supplies and on the alarm unit.

Under these circumstances it is permissible to attempt to re-start the failed units since there cannot be a short circuit on the load. First check that the incoming dc is within the limits of the poower supply, then see that the circuit breaker is off and check whether fuse FS1 has blown. If it has, replace it. Then attempt to re-start the power supply by closing the circuit breaker. If the power supply fails to re-start, it must be removed for repair.

If all the power supplies fail it indicates either an overvoltage on the incoming dc or an overload on the output. First check that the incoming dc is within the limits of the power supply. Then see that the circuit breakers are off and check the fuses, replacing any that are blown. With the circuit breakers still off check the load resistances between the positive output and 0V and the negative output and 0V. It should be greater than 4.0 ohms for two power supplies or 2.8 ohms for three. If the resistances are less than these limits, check the system for short circuits.

The best way to re-start the power supplies, particularly when there are three, is simultaneously. Switch off the incoming dc, reset the circuit breakers and switch on the dc again. If one or more power supplies trip out, investigate each one individually as previously indicated but with the load disconnected.

Section 11. METHOD OF REPAIR

In the first instance the fault finding procedure will lead to the identification of a faulty circuit or module. To enable faults to be rectified quickly it is advisable to have spares as listed at the end of this section. Faulty units should be replaced or fitted with new printed circuit boards as necessary.

Assembled modules are generally safe to handle but the spare printed circuit boards should only be removed from a module or their conductive plastic bags in the special handling area.

11.1 Replacing modules

First switch power supply units off

To remove a module from its case it is first necessary to remove the cover from the case. There are four retaining screws, two at the top and two at the bottom of the cover. The large modules are heavy because of the transformers they contain. These modules should be partially withdrawn by pulling forward with the top and bottom handles. They should then be supported with one hand from underneath before they are completely withdrawn.

Modules, cases and covers as supplied are identified by matching serial numbers. When another module is substituted in the original case the serial numbers will no longer agree. Before sliding a replacement circuit breaker module into an existing case the matching ratio taps should be correctly set to agree with those on the module being replaced.

Note: When refitting the module into its case it should be gently slid in until some resistance is felt. It should then be given a firm push on the bottom and top handles so that it goes completely home. When correctly inserted the front plate will be recessed approximately 1mm below the edge of the metal case.

If there is difficulty inserting the module do not attempt to insert it by sliding it in rapidly as this may damage the rear connectors. Instead try pushing on the lower handle only with two thumbs.

Refit cover and secure with the four fixing screws.

11.2 Replacing printed circuit boards

The main printed circuit boards within each module are arranged to plug into a printed circuit backplane. This backplane interconnects the main boards with the case terminations, and is mounted in the back of the case. The larger size 8 cases have a secondary backplane in the module to interconnect the printed circuit boards. The two backplanes then plug together when the module is inserted into its case.

The buswiring is continuous through the backplane in the cases for all type MBCZ units except for the MBCZ13 and MBCZ15. Being bus section units, these must sectionalise the buswires to match the busbar arrangement.

11.2.1 Replacing pcb in size 8 circuit breaker module

Peel the labelling strip from the top and bottom handles by starting at one end and pulling forward with a slight twisting movement. Remove the handle fixing screws that are now exposed together with the handles. The front plate will then only be retained by an earthing screw. When this is removed the frontplate can be slid gently forward to expose the front edge of the printed circuit boards.

Note: On some modules two of the handle fixing screws will be found to be shorter than the other four. These short screws should be replaced on the right hand side to avoid shorting the input transformer terminals.

From this point until the frontplate is replaced the module should not be picked up otherwise the top or bottom plates may become distorted by the weight of the transformers.

The printed circuit boards are located by notches in the top and bottom plates of the module which form guides, see Figure 23. Grasp the front edge, of the board to be changed, between the thumb and forefinger. Then pull forward to withdraw it from the module.

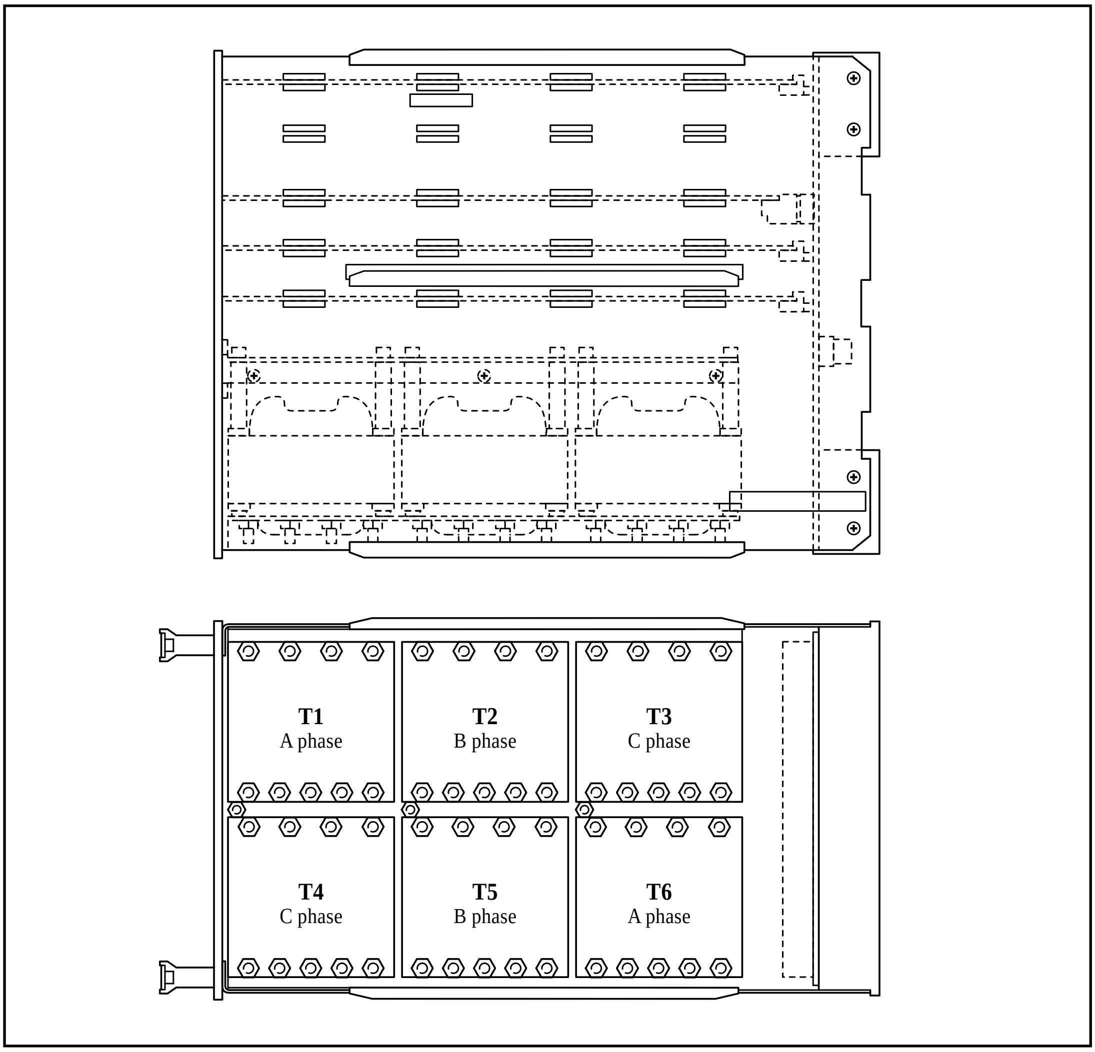


Figure 23 Assembly of size 8 modules.

Note: Components on the extreme left hand board may foul the mounting brackets on the front edge of the top and bottom plates of the module. Do not force the board past these obstructions, but gently lift the corner of the top plate near the board so that the guide notches are free of the top edge of the board. The printed circuit board can then be removed by tilting the board to the left and removing it from the side of the module.

The left hand board is fitted with an insulating cover plate to prevent contact with the printed circuit boards when removing the module to adjust the ct matching ratio. This insulating cover plate must always be replaced if it has been removed during a service.

A new printed circuit board can be refitted in the reverse of the above sequence and the module reassembled. The interconnecting pins on the backplane of the module are not designed for frequent use but more as an assembly aid. Care must be taken when inserting a printed circuit board to ensure that the pins on the connectors line up with the socket as they are being inserted and do not become misaligned.

The trip and back trip relays are mounted on the backplane of the module. It is possible to replace these but the printed circuit board has through hole plated connections and these are likely to be damaged when desoldering. The preferred method of repair is to replace the complete backplane.

The backplane can be removed by removing the screws securing the Midos terminal block to the top and bottom plates of the module. There are eight screws in all. The current connections can then be removed in turn and plugged on to the new terminal block. Ensure that the wires are terminated correctly to the same terminal positions. Any change of polarity or phases is likely to lead to an unbalance in the differential circuit. Refit terminal blocks to the module and secure them with the retaining screws.

11.2.2 Replacing pcb in size 4 module

The printed circuit boards are removed by unscrewing the four fixing screws at the corners of the boards. It will be necessary to remove the left hand board first followed by the centre one. See Figure 24.

The new boards should be fitted in the reverse of the above sequence. The trimpots on the boards should not be adjusted as they are factory set during the test sequence.

New printed circuit boards should be kept in their protective conductive bags until required and only removed in the safe working area described. Faulty boards should be placed in a protective bag to prevent further damage if they are to be repaired or further tested to determine the mode of failure.

Recommission the protection using the appropriate tests from Section 12.

11.2.3 Recommended spares

1 – case of ancillary equipment (usually supplied with cubicles) containing the following items :

- 2 Multifinger test plugs MMLG01
- 2 Single finger test plugs MMLG02
- 16 Test leads with 4 mm plugs
- 12 4mm plugs
- 1 Measuring unit to test module lead

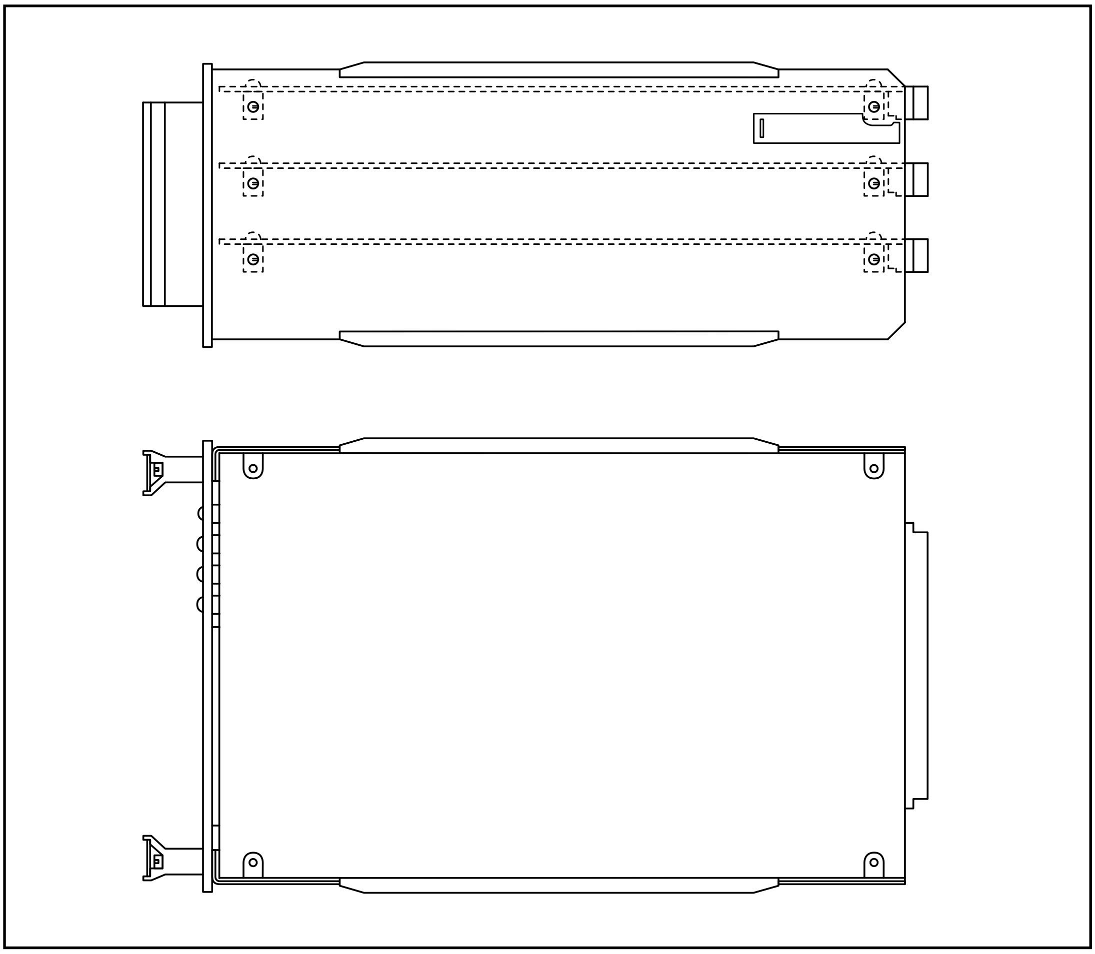


Figure 24 Assembly of size 4 modules.

3 Leads with buswire connection pins
8 Fuses for power supplies and cubicle
2 Spare lamps for cubicle
1 Wrist strap and lead for prevention of electrostatic damage

1 – MBCZ17 alarm module

1 – MBCZ12 feeder module of the type used in the scheme

1 – Set of pcb for bus couplers and bus section modules where they are not common to those in the feeder breaker modules.

1 – MSTZ03/04 power supply.

Whilst these spares are not essential, outage time will be reduced if they are available.

11.3 Return of module to factory

Should the need arise for the equipment to be returned to GEC ALSTHOM T&D PROTECTION & CONTROL LIMITED for repair, then the form at the back of this manual should be completed and sent with the equipment together with a copy of any commissioning test results.

Section 12. COMMISSIONING

Modules will have been tested and calibrated individually, including checks for polarity and correct functional operation When assembled into a cubicle, are interconnected by means of pretested multicore cables fitted with multipin connectors.

There are no items of equipment to be mounted at the back of the cubicle except for injection test facilities and terminal blocks. All required auxiliary current transformers and relays are contained within the Midos modular cases.

When supplied in a cubicle the standard terminations will be the Midos terminal block and the Midos test facility type MMLB. This is covered in more detail in publication R6004. The equipment will have been tested from the cubicle terminals. A large portion of the usual commissioning work will therefore have been covered during the works tests. The majority of the remaining work will involve checking the plant connections and checking the protection with the applied settings. Section 3 of this document deals with the choice of settings and how to adjust them. This work should be done now.

During commissioning it is important to take account of the effect of withdrawing units from their cases. For instance, if a bus section breaker or bus section isolator unit is withdrawn, buswires in groups 1 to 4 (Table 1) will be severed.

12.1 Insulation tests

All deliberate earth connections on the wiring to be tested should be temporarily removed, ie. earth links on current transformers and supply lines. There will be an earth connection on the power supply for the isolator repeat relays. This will have to be disconnected from one of the positive terminals of the MSTZ03/04 power supply.

Note: This power supply unit may not be fitted to some schemes.

The two MSTZ03/04 power supplies that are used to supply the protection with ±15 volts are earthed in the alarm module by an internal connection to 0 volts. There is no need to break this connection, in fact it will be extremely difficult to do so without damaging the equipment.

All insulation testing should therefore be restricted to the cubicle terminals and not directly to the relay terminal blocks. All cubicle terminals can be tested to earth, with an electronic brushless insulation tester at voltages up to 1000V dc when the above mentioned earths are disconnected.

It is difficult to predict the insulation resistance to be expected, as this varies widely depending on the amount of wiring involved, its grade, and the site humidity. Readings between a few megohms down to 0.1 megohms are generally obtained.

The insulation resistance should be measured to earth and between circuits. Readings should be recorded and compared with subsequent routine tests to check for any deterioration of the insulation.

Separate circuits will be:

a) CT groups

b) Alarm circuits

c) Trip circuits

d) Coils of isolator repeat relays

e) Coils of breaker fail initiation, bus zone trip and buswire switching relays

f) Auxiliary dc and ac supplies

RECONNECT ANY EARTHS THAT WERE TEMPORARILY REMOVED.

12.2 Power up

If there is only one cubicle and therefore three MSTZ03/04 power supply units, one on the extreme left for the isolator repeat relays and the other two for the protection circuits, proceed as follows.

Turn the key switch on the alarm unit to the PROTECTION OUT position. Then start up the power supply unit that feeds the protection circuit via the alarm unit. Some alarm lamps will be lit as a result of previous tests that have latched an indication. Reset these alarms by momentarily depressing the RESET button on the alarm unit. Only green indications, indicating healthy conditions should remain.

However, if the protection contains isolator repeat relays, then amber fault alarms will be given for each of these. This results from the supervision circuit detecting an absence of current in the coils of these relays.

Now switch on the other power supply which feeds the coil circuits of the isolator repeat relays. All the isolator alarms should self reset and latched alarms can be reset by means of the reset button on the alarm unit.

If an isolator alarm is still showing it is most likely due to a fault in the external wiring or a defective auxiliary contact on the isolator. The possibility of the fault being within the protection can be eliminated if there is a potential difference between the cubicle terminals for the operate and reset circuit of the relay indicated faulty. The voltage should be measured with a high impedance voltmeter. Reset alarms by means of reset button.

If a module is fitted with more isolator repeat relays than required it will be necessary to energise either the operate or reset coil via a link on the terminal block. This will remove the alarm signal and latch the relay in the required closed or open state.

If a ZONE OUT or UNIT OUT OF SERVICE indication shows, it can be reset by switching the appropriate measuring unit back into service. The only amber indication remaining should indicate PROTECTION OUT OF SERVICE.

A back-up power supply can now be switched on.

Note: If more than one cubicle is to be powered up at a time ie. there are three or more power supply units for the protection circuits, then these units must be switched on before dc supply is switched on since one power supply can feed a maximum of one cubicle.

12.3 Injection tests via the test unit

Turn the keyswitch on the alarm unit to the PROTECTION OUT position. The test unit can be used to check the zone measuring units. To do this the covers must be removed from the test unit and the zone unit to be checked. The screened test lead should be plugged into the test unit using the end of the lead with the 3.5mm jack plug. The 2mm plug on the other end of the test lead is then plugged into the test input on the phase of the zone to be tested. It is assumed for these tests that the busbar is dead.

Note: Assume a matching ratio of 1.0 when testing units by this method.

12.3.1 Test ct supervision

Set the selector switch on the front of the test unit to INJECT X1. Set the digital current switch to 00. Press the button marked INJECT and whilst holding it down increase the current until the meter reads a current just below the setting of the supervision relay. Then increase slowly until the supervision operates to indicate a ct fault. There is a fixed fifteen second delay built into this circuit. The minimum operating current can then be read from the meter as a direct percentage of rated current.

12.3.2 Test differential measurement

For this test no bias will be produced and hence the setting will be somewhat less than the marked value. The effective setting will be in the order of 90% of the marked values.

Set the MAN/AUTO switch to MAN.

Set the current to 80% of the marked value of the selected setting and the relay should not indicate a trip. Increase the current to the marked setting value and the protection should operate. There should be a TRIP indication on the element being tested and a PROTN OPERATED indication on the alarm unit. The latter has a 15 second delay.

Release the injection button and reset the indications. Check that when the inject button is now depressed the trip is instantaneous and that when the current is injected for five seconds no PROTN FAIL indication comes up.

Repeat 12.3.1 and 12.3.2 on the other two phases and then on each other zone in turn.

12.4 Breaker fail check

12.4.1 Feeder units for external breaker fail

These feeder units are fitted with a bus zone trip relay (BZT). To test this relay first ensure that the keyswitch is at PROTECTION OUT, then bridge the BZT contacts. Check that the feeder under test and all the other circuit breaker modules connected to the same main zone and the alarm unit show a TRIP indication.

If the feeder is not connected to a main zone (because all its isolators are open), check that PROTECTION OPERATED appears on the alarm unit followed by COMMON ALARM.

12.4.2 Feeder units for internal breaker fail

For this test it is necessary for the feeder to be connected to the busbar or appear to the scheme to be so connected. Where there are no isolators the feeder is always connected to the busbar. The problem arises where there are isolators but none of them is closed. In that case reverse the connections to the operate and reset coils of one of the isolator repeat relays to make the feeder appear to be connected to a busbar. Note to which zone the connection or simulated connection is made, and set Is on phase C of the appropriate zone measuring unit to 0.5.

Inject a current equal to 0.2 x rated current/matching ratio into terminals 21 and 22 of the feeder unit. This should not cause any TRIP or PROTECTION OPERATED indicators to light. Now close or bridge the breaker fail contact on the feeder protection. Check that all the circuit breaker units on the relevant zone give a TRIP indication and the feeder unit under test shows BACKTRIP as well.

This concludes the test for feeder units manufactured before August 1989. These units do not contain a back trip indicator relay reference 95 nor diode D66, but have two trip relays reference 94 in parallel instead of one. See figure 26. Restore the isolator repeat relay connections to normal, if necessary, if the test is concluded.

Proceed as follows for units manufactured after August 1989. Leave the breaker fail contact open and reconnect the current injection to terminals 21 and 27 and link 22 and 28. Set the check zone measuring unit phase C Is to 0.5, ie. the same as the main zone. Inject a current of 0.7 x rated current/ratio and check that a TRIP indication appears on the main and the circuit breaker units in the main zone, followed by a BACKTRIP on the feeder unit under test.

Restore the isolator repeat relay connections to normal, if necessary.

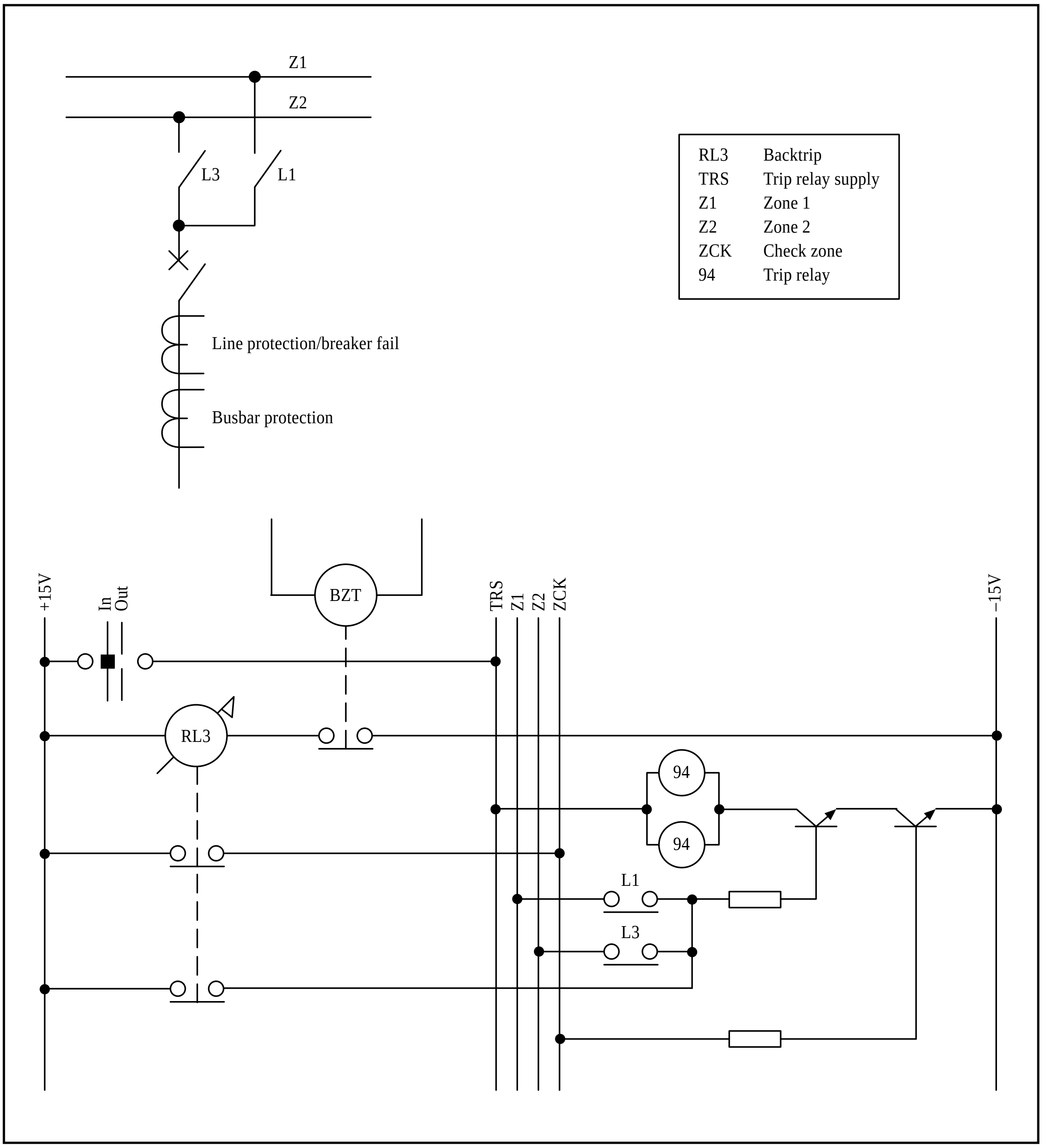


Figure 25 Feeder breaker with external breaker fail.

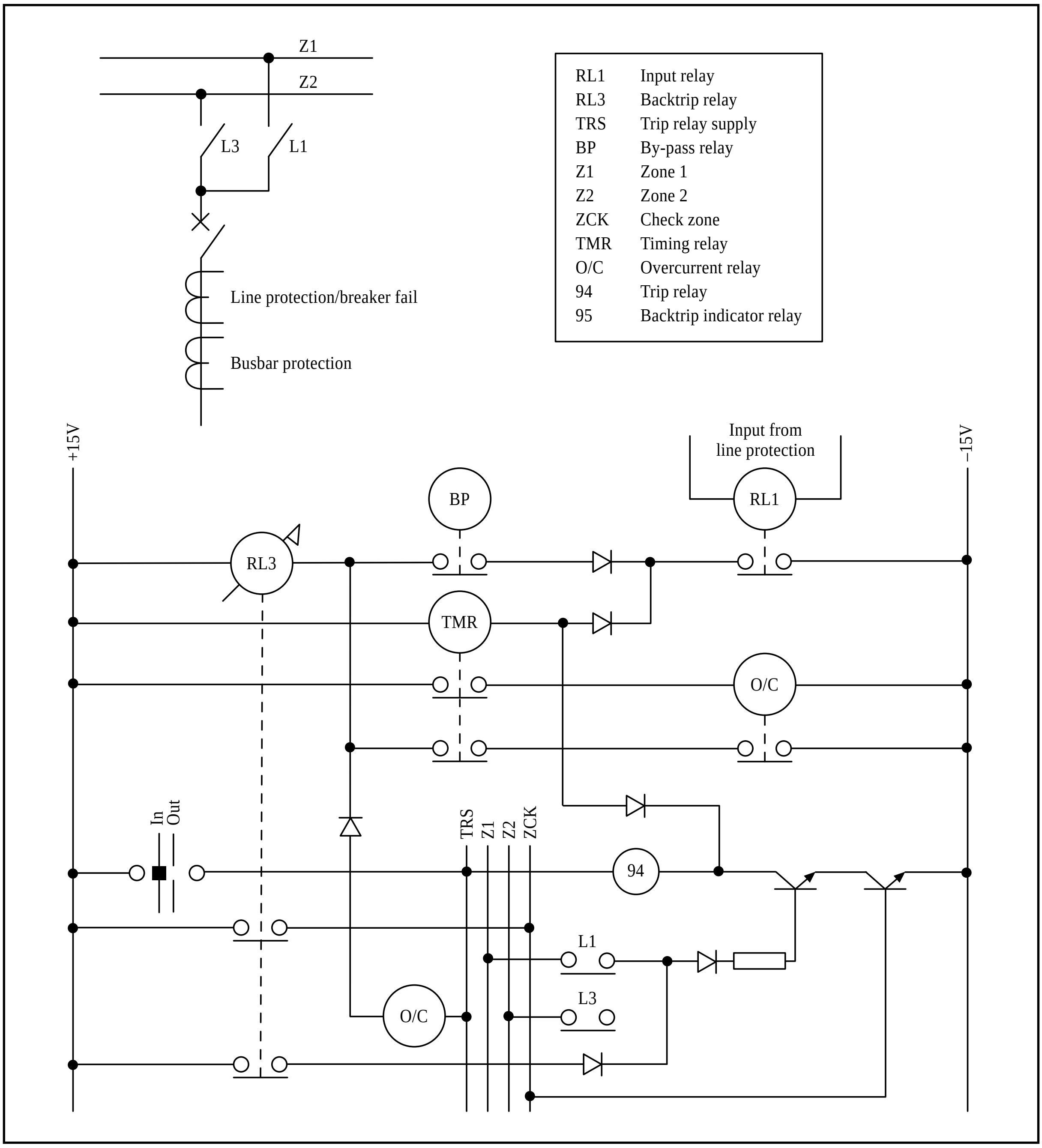


Figure 26 Feeder breaker with internal breaker fail.

12.4.3 Bus coupler and bus section units with breaker fail facility

All bus coupler and bus section units have breaker fail facility except those designed for use with a circuit breaker without current transformers.

For this test it is necessary for the circuit breaker to be connected to the busbar on both sides, or appear to the scheme to be so connected. Where there is no isolator the circuit breaker is always connected to the busbar. The problem arises where there are isolators but none of them is closed. If this is the case on either side of the circuit breaker reverse the connections to the operate and reset coils of one of the isolator repeat relays to make the circuit breaker appear to be connected to the busbar.

Note to which zones the circuit breaker is connected (or to which a connection has been simulated) on the left and right. For the bus coupler breaker these connections must be to different busbars. For a bus section breaker the same busbar may be used but it is necessary to ensure that the left and right sections of the busbar are not connected by an isolator. If they are so connected reverse the connections to the operate and reset coils of the isolator repeat relay, to make the busbar isolator appear open to the scheme.

Connect a current injection generator as follows. Select a feeder unit on the same matching ratio as the unit under test and connect one end of the generator to terminal 21 of the unit under test and the other to terminal 27 of the feeder. Connect terminal 22 of the unit under test to 28 of the feeder. Set Is on phase C of the check zone and both main zone measuring units to 0.3.

Inject a current of 0.4 x rated current/matching ratio into the circuit and check that a TRIP indication appears on the check zone and right hand main zone measuring circuits and all the circuit breaker modules in the right hand zone including the unit under test. This should be followed almost immediately by a TRIP on all the circuit breaker modules in the left hand zone and a BACKTRIP on the unit under test.

This concludes the test for bus coupler and bus section units manufactured before August 1989. These units do not have an initiation input nor a back trip indicator relay reference 95, but they have two trip relays reference 94 in parallel instead of 1. See Figure 27. If the test is concluded restore the isolator repeat relay connections to normal as necessary.

For units manufactured after August 1989 proceed as follows. Reconnect the current generator to terminals 21 and 22 and inject a current of 0.2 x rated current/matching ratio. This should not cause any TRIP or OPERATED indicator to light. Now close or bridge the initiation input contact and check that a TRIP indication appears on all the circuit breaker modules in both main zones including the unit under test and also BACKTRIP on the unit under test.

Restore the isolator repeat relay connections to normal as necessary.

12.5 Isolator repeat functional test

For this test it will be necessary to operate the associated isolators.
It may be necessary to perform this test as part of the primary injection tests.
(See Section 12.6).

When an isolator operates there will be a momentary overlap when both the MAKE and the BREAK contacts are either both closed together or both open together.
The indicator for the supervision of the associated isolator repeat relay should therefore light up for a short time during the switching sequence. This will indicate that the correct relay is operating for that isolator.

No alarm lamp should latch unless the time of the contact overlap exceeds the supervision delay.

12.6 Primary injection tests

The relay settings should have already been applied and the current transformer matching ratios adjusted to suit the primary current transformer ratings. If this has not been done check the ratio of the ct on each item of primary plant that feeds the busbar protection. Then refer to Section 3.1 for the required matching ratios and adjust the ratio in each circuit breaker module as required.

With the correct matching ratio the fault setting, in terms of primary current, will be the same for each circuit. Also a balance will be obtained for through faults if the polarity of the current transformer connections is correct.

The most convenient way to check ratio and polarity in a large switchgear installation is to choose a circuit with the highest current transformer ratio as a reference. Then after testing its current transformers use it to check the remaining circuits.

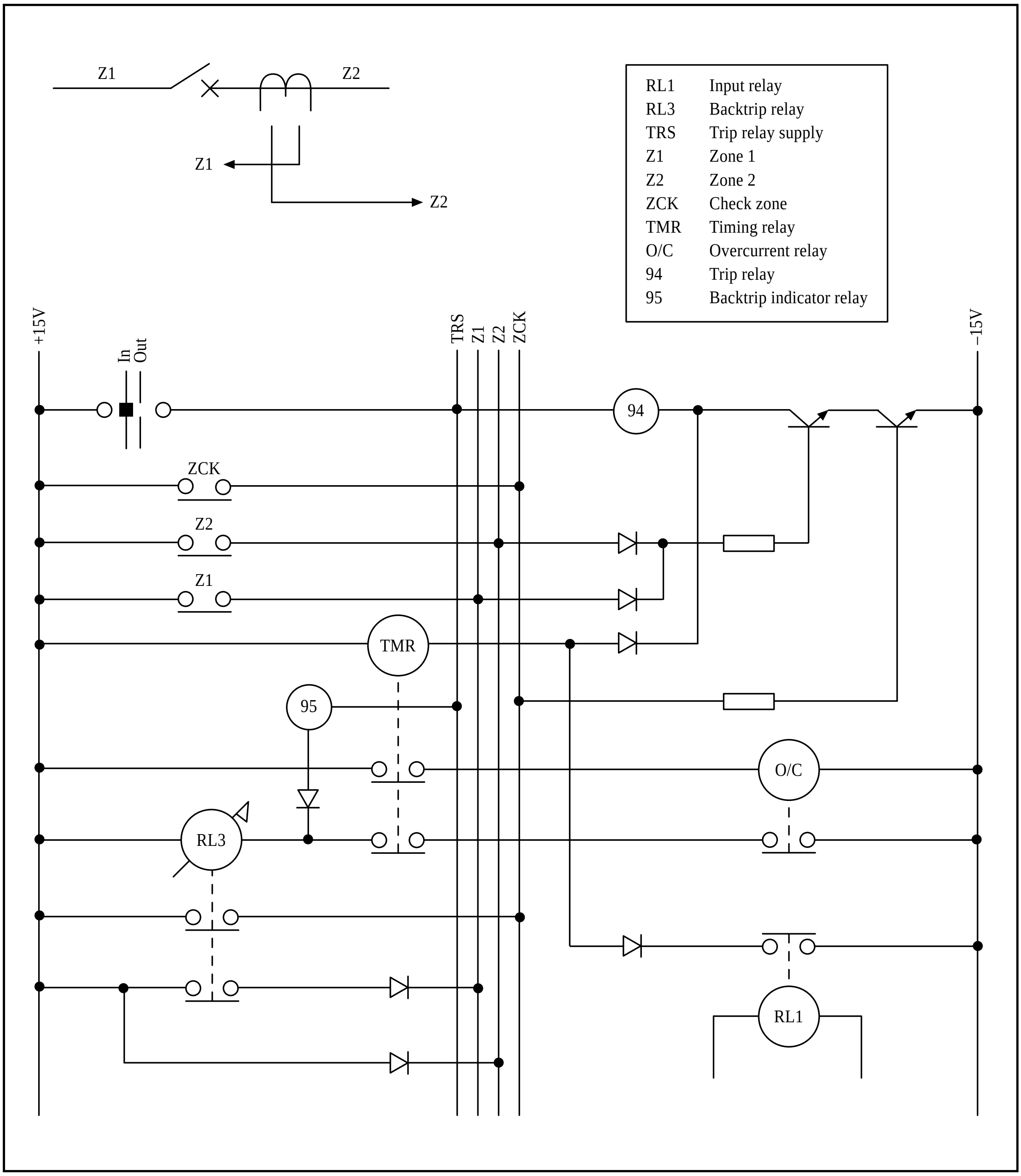


Figure 27   Bus section/bus coupler back trip.

12.6.1 Ratio of reference current transformers and sensitivity check

To check the ratio of the reference circuit current transformers, current should be injected through the primary of each current transformer in turn, as shown in Figure 28, and the ratio of the two ammeter readings A1 (primary current) and A2 (secondary current) compared with the actual ratio which should be close to the nominal ratio. The value of primary current to be injected should be 50 to 100% of the full load rating of the circuit.

The primary fault setting for the protection will be as described in Section 3.2.2. A current should be injected through the primary winding of each phase of current transformers on the reference circuit that feed the busbar protection. The value of current to operate the protection should be within +25% and -10% of the calculated setting. Note the readings for comparison with other circuits.

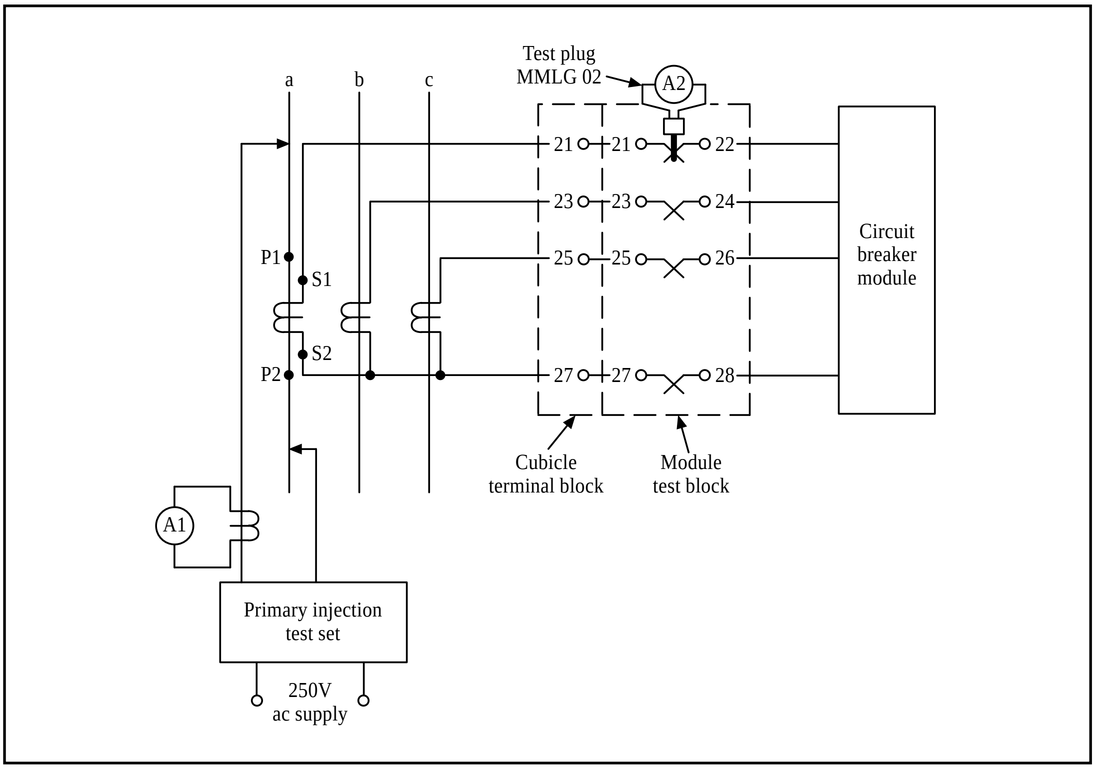


Figure 28 Ratio check of reference current transformers

12.6.2 Phasing the reference current transformers

To check the polarity of the reference current transformers, current injection should be carried out through the primaries of the current transformers on two phases together as shown in Figure 29, Appendix A. Correct polarity is indicated if the readings on an ammeter in the neutral of the current transformer secondary circuit is only a few milliamperes. This test should be carried out using first phases A-B and then B-C.

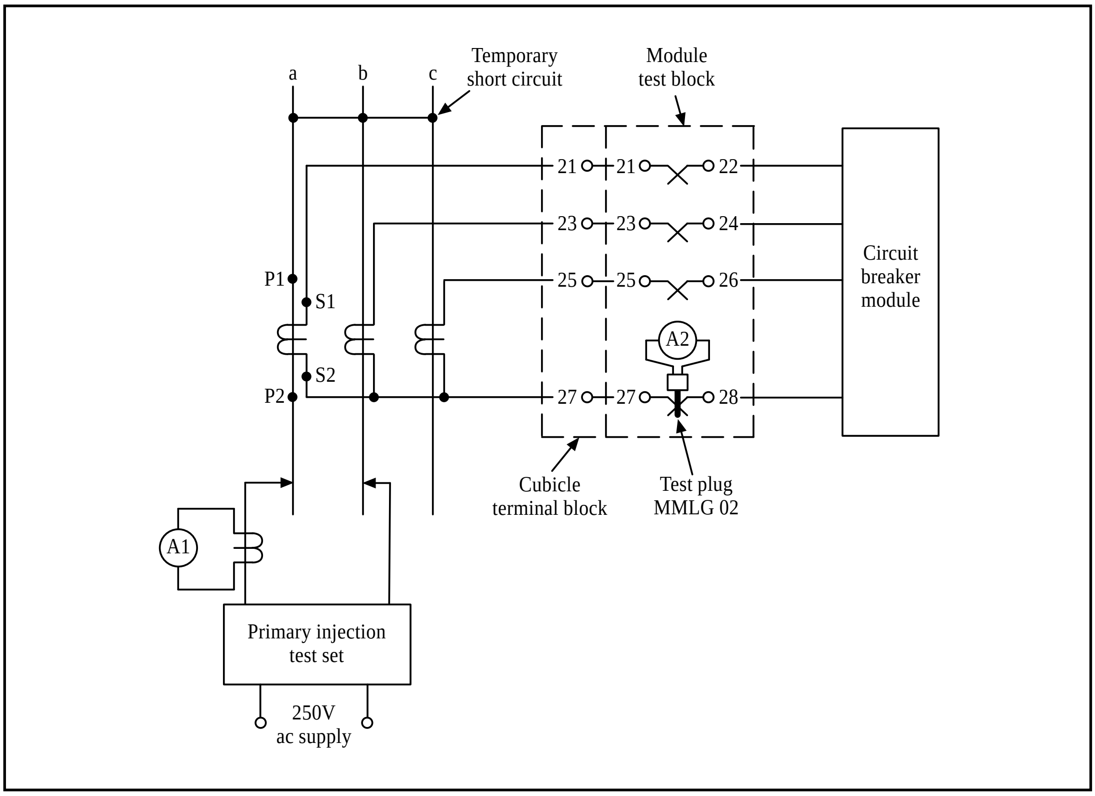


Figure 29 Phasing the reference current transformers

12.6.3 Ratio and phasing of other circuits

Having checked the reference circuit current transformers for ratio and polarity it now remains to check the current transformers on each of the other circuits against the reference group. This is carried out by injecting primary current through the reference circuit transformers and the current transformers of each of the remaining circuits in turn as shown in Figure 30. The primary current is injected into one pair of phases of the reference circuit, with a three phase temporary short circuit applied on the test circuit.

For correct ratio and polarity there should be no current in the neutral of the test current transformers and the protection should not operate. If required the current in the differential circuit for each phase of the check zone and the appropriate main zone of the protection may be measured in turn. The test module provides the facility for measuring the differential current.

Set the selector switch to DIF X1 on the front of the test unit. Connect the test lead between the test unit and the test point on the measuring element of the zone where the differential current is to be measured.

$$\frac{\text{Meter reading x ct ratio}}{\text{Matching ratio}} = \text{\% Primary Rating}$$

The test meter can be plugged into each phase in turn, but note that the measuring circuit will be inhibited on the phase where the measurement is being made.

The primary injection should then be changed so that all phases will have been tested. If the scheme is of the duplicate busbar type, where the current references are switched within the protection to alternative zones by isolator repeat relays, it is recommended that the tests are carried out with the busbar isolators in both positions in order to check all wiring circuits. When switching the isolators check the operation of the isolator repeat alarm indications as described under 12.5.

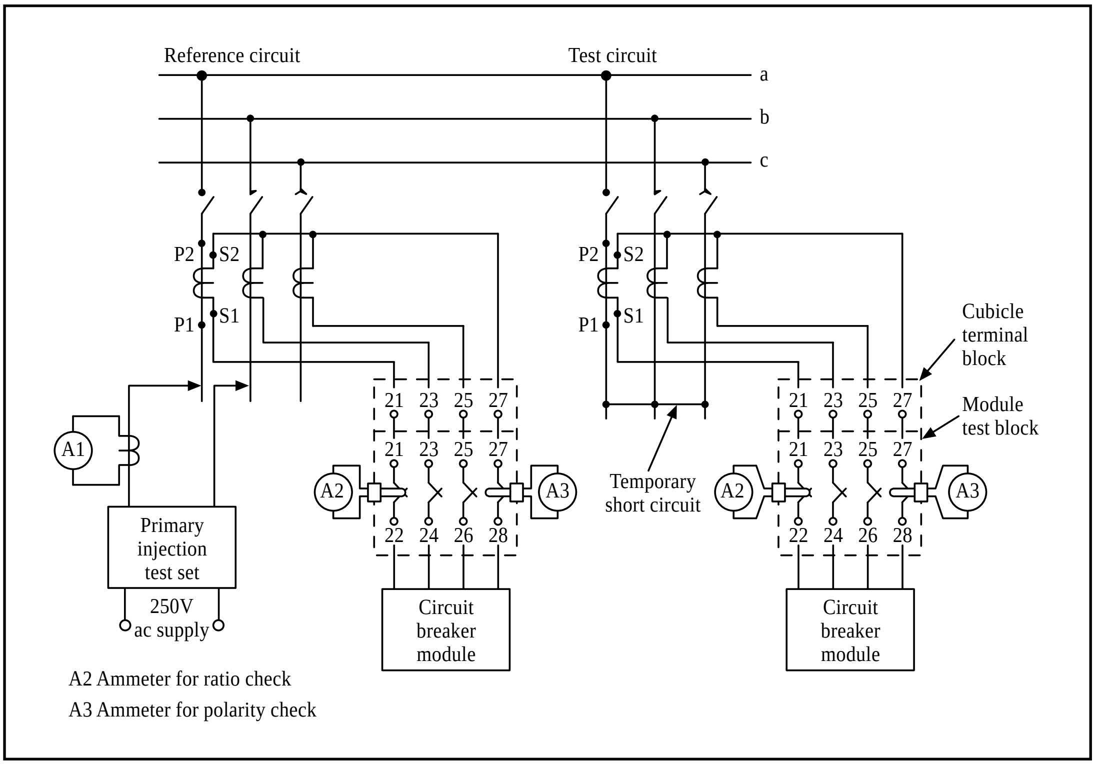


Figure 30   Inter-group ratio and polarity check of current transformers

12.6.4   Current transformers on bus couplers and bus section

These can be tested as described in the last section. However, the current transformers feed into two adjacent zones of protection and only the zone to which the reference feeder is also connected will be stable. It is therefore preferable to inject via a feeder, with the three phase test short on another feeder, so that both zones balance correctly (see Figure 31).

12.6.5   Sensitivity test

The sensitivity test has already been described in Section 12.6.1 for the reference circuit. This can be repeated for injection into different feeders to check the sensitivity of the other zones. On multiple busbar installations it will be necessary to operate isolators in order to select the zone being tested.

Note: Bias is derived from the current flowing to and from the busbars via the feeders, and is not produced by current flowing through bus couplers or bus section circuits. The fault settings will therefore be reduced by approximately 10% if the injection is through the current transformers on these items of primary plant, as a result of the reduced bias. This is purely a test condition since current flowing to a fault on the busbar would have to flow in via a feeder and bias would therefore be produced.

It should also be noted that if the current is held on for longer than the BACK TRIP time delay on the bus coupler or bus section module the trip will be transferred to the next zone. However, although a trip will be indicated on the circuit breaker modules in the next zone the measuring circuits for that zone operate when injection is via a feeder.

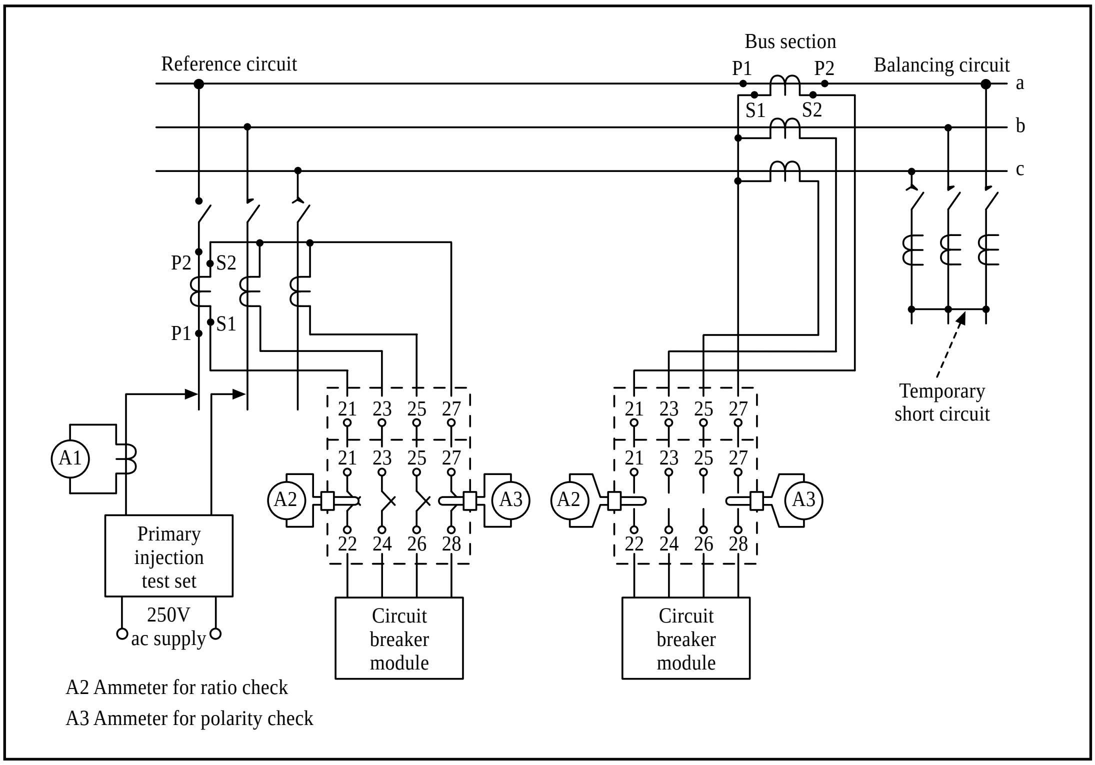


Figure 31 Bus section current transformers ratio and polarity check.

12.6.6 Sensitivity with zones paralleled

Where zones can be connected in parallel via isolators the adjacent zones will be set to MASTER and FOLLOWER respectively. With the isolators closed to parallel two zones the fault setting of the MASTER measuring circuit will remain unchanged and the FOLLOWER measuring circuit setting will increase. This can be tested during the primary injection sensitivity tests if required.

12.7 Trip test

The circuit breakers can be tripped via the trip relays of the busbar protection if the keyswitch on the alarm unit is in the IN SERVICE position. To trip the circuit breakers of a zone it is only necessary to activate the bus zone trip (BZT) relay on a feeder connected to the same zone. Alternatively a current may be injected into the current circuit of a feeder connected to the zone.

It should be remembered that where two sets of current transformers are provided, for main and check zones, both inputs must be energized.

12.8 Schemes with no ct in bus section and/or bus coupler

When full discrimination is required between the various sections of the busbars and no current transformers are provided in the bus section and/or bus coupler, it is necessary to trip instantaneously the bus section and/or bus coupler circuit breakers via the check trip buswire and to time delay the energisation of the discriminating trip buswire. This is achieved by means of a printed circuit board timer which is accessible from the top of the measuring module and has a switched delay of 40 to 180ms in steps of 20ms.

To common the buswires when the bus section and/or bus coupler circuit breakers are closed, it is necessary to replicate the bus section and/or bus coupler by means of a repeat switching relay inside the modules. For this purpose, two auxiliary contacts per circuit breaker, one n/o and one n/c are required, which must be set as for the busbar selector switches described in Section 4.

During commissioning it will be necessary to check the timer setting against the opening time of the bus section and/or bus coupler circuit breaker, by having them closed and injecting current into a feeder module via the appropriate test block. When the current setting of the master measuring module is exceeded the bus section and/or bus coupler circuit breaker will open and allow the time delayed biased circuits to discriminate. If the time delay is correctly set, only the feeder modules associated with the injected zone should operate.

12.9 Combined functions schemes

These schemes which may be applied to single bus, 11/2 circuit breaker and mesh substations, are designed without the overall check measuring module and are arranged with one of the duplicated biased circuits to energise the discrimination trip buswire and the other, the check trip buswire. In this way, the scheme still retains the 2 out of 2 tripping logic and during testing and commissioning follows the same procedure as for the standard schemes.

Section 13. PERIODIC MAINTENANCE TESTS

The majority of the electronic circuits that perform the protective functions are duplicated and continuously monitored. The faults that may develop in the equipment will result in an alarm being given so that remedial action can be taken. Because of the circuit duplication a protection fault is extremely unlikely to prevent a fault on the busbar being detected and cleared. Also the use of main and check zones ensure that a protection fault, that would otherwise result in a false trip, is blocked.

A summary of the circuits that are monitored is given below:

1) CT saturation detectors
2) CT secondary circuit
3) Measuring circuits
4) Trip relay coils
5) Isolator repeat relays - including relay coil, opto couplers, wiring to isolator auxiliary contacts, the isolator auxiliary contacts and the power supply.
6) All power supplies
7) The by-pass relay coils
8) The bias circuit
9) Breaker fail/back trip timers and overcurrent circuits

The need for routine maintenance tests is therefore reduced to the remedial actions required in the case of an alarm. The use of constant monitoring of vital functions is generally considered more reliable than automatic self testing equipment. With the latter it is usual to block the trip output relays for a short period during the test and there is always the risk of the protection being left out of service by a fault in the test equipment.

However, should the user wish to perform some routine tests in order to improve confidence that all is working correctly the following tests are suggested.

13.1 Test supervision for isolator repeat relays

Switch off the power supply to the isolator repeat relay circuit. The indicators for the isolator repeat relay supervision should light up; this will be followed after a delay by an alarm indication on the modules containing the repeat relays. Then after a further delay the alarm indication should be given by the alarm unit. The power fail alarm should also be initiated by the action of switching off the power supply.

13.2 Test ct supervision circuit

See test 12.3.1. The only difference will be that there may be a standing differential current due to the through load on the busbar and this will add to the injected current. When the supervision operates the total differential current (standing + injected) can be measured by turning the switch on the test unit to DIF X1.

13.3 Test biased differential measuring unit

As test 12.3.2 but taking into account the standing differential current as described in 13.2 and also making allowance for the setting being increased by the bias signal derived from the transfer current.

13.4 BZT and breaker fail circuits

These may be tested periodically to ensure they are fully operational. Repeat tests 12.4.1 to 12.4.3 as necessary.

13.5 Alarm circuit check

Switch off each of the protection power supplies in turn and check that the alarm is given each time. Also the protection should continue to function on the supply from the remaining power supply units.

When the power supply for the isolator repeat relays is turned off check that all isolator supervision alarms operate.

Section 14. COMMISSIONING TEST RECORD

Date ______________

Site ________________________________

		Model No.	Serial No.
Relay Details			
	MSTZ	________________	________________
		________________	________________
		________________	________________
		________________	________________
		________________	________________
Test Module	MBCZ 18	________________	________________
Alarm Module	MBCZ 17	________________	________________
Measuring Modules	(Z1)MBCZ 16	________________	________________
	(Z2)MBCZ 16	________________	________________
	(Z3)MBCZ 16	________________	________________
	(Z4)MBCZ 16	________________	________________
	(CH)MSTZ 16	________________	________________

Measuring Module Settings

Supervision ______________________________

Differential ______________________________

Zones set to Master ________________________

Zones set to Follower ______________________

Auto/Non Auto ____________________________

Other Modules (Feeders, Bus Sections, Bus Couplers etc.)

Model Number	Serial Number	Matching Ratio	Selected Taps

MSTZ Power Supply Modules Aux Supply Voltage ____________Vdc

MSTZ03 Power Supply Ref	Input Voltage Terminals 27 +ve 28 –ve	Output Voltage +15Vdc Terminals 3, 5, 7 9, 11, 13 w.r.t –15Vdc terminals 21, 22	Output Voltage –15Vdc Terminals 21–22 +ve w.r.t –15Vdc terminals 4, 6, 8, 10, 12,	Check Vx Fail Terms 1 – 2
Isolator Supply				
Scheme Supply 1				
Scheme Supply 2				
Scheme Supply 3				
Scheme Supply 4				

MSTZ04 Power Supply Ref	Input Voltage Terminals 5/7 +ve 1/3 –ve	Output Voltage +15Ddc Terminals 17/19 w.r.t 0V terminals 21/23/25/27	Output Voltage –15Vdc Terminals 13/15 w.r.t 0V terminals 21/23/25/27	Check Vx Fail Terms 9/11
Isolator Supply				
Scheme Supply 1				
Scheme Supply 2				
Scheme Supply 3				
Scheme Supply 4				

MBCZ17 Alarm Module

Check Indications

Vx(2) ☐ Zone Out ☐

Trip ☐ By-Pass ☐

Operated ☐ Comm. Al. ☐

Prot. Out ☐

Check Output Contacts

Protection out (Terminals 1– 3) ☐

Inverse Comm. Al./Vx Fail (Terminals 2 – 4) ☐

(Terminals 4 – 9) ☐

Protection Trip (Terminals 11 – 13) ☐

MBCZ18 Test Module

Check Current Monitoring Feature ☐

Check Current Injection Feature ☐

Check Outputs

Inverse Comm. Al./Vx(2) Fail (Terminals 1 – 3) ☐

(Terminals 2 – 4) ☐

Protection or Remote Reset (Terminals 7 – 9) ☐

(Terminals 8 – 10) ☐

Protection Trip (Terminals (13 – 15) ☐

(Terminals (14 – 16) ☐

Circuit ________________ CT Ratio ____________ Mat. Ratio ___________

Operating Current Amp. (State primary or secondary injection) _______________________

Phase	Discriminating Zone						Check Zone	
	Supervision			Differential			Supvn.	Diff.
	L1	L2	L3	L1	L2	L3	- - - -	- - - -
A								
B								
C								

Contact output terminals
5 – 7 ________
6 – 8 ________
9 – 11 ________
10 – 12 ________

Breaker Fail Phase A ________
Phase B ________
Phase C ________

Breaker Fail Time Setting __________

Timing Test to one
pair of contacts ___________________

Breaker Fail Op. Time __________

Circuit ________________ CT Ratio ____________ Mat. Ratio ___________

Operating Current Amp. (State primary or secondary injection) _______________________

Phase	Discriminating Zone						Check Zone	
	Supervision			Differential			Supvn.	Diff.
	L1	L2	L3	L1	L2	L3	- - - -	- - - -
A								
B								
C								

Contact output terminals
5 – 7 ________
6 – 8 ________
9 – 11 ________
10 – 12 ________

Breaker Fail Phase A ________
Phase B ________
Phase C ________

Breaker Fail Time Setting __________

Timing Test to one
pair of contacts ___________________

Breaker Fail Op. Time __________

Primary Injection

Inter Group Polarity Test

Reference Circuit ______________	Correct (Zero Spill)	Reversed (Spill)
	Phase A _______________	____________________
Matched Circuit _______________	Phase B _______________	____________________
	Phase C _______________	____________________

Inter Group Polarity Test

Reference Circuit ______________	Correct (Zero Spill)	Reversed (Spill)
	Phase A _______________	____________________
Matched Circuit _______________	Phase B _______________	____________________
	Phase C _______________	____________________

Inter Group Polarity Test

Reference Circuit ______________	Correct (Zero Spill)	Reversed (Spill)
	Phase A _______________	____________________
Matched Circuit _______________	Phase B _______________	____________________
	Phase C _______________	____________________

Inter Group Polarity Test

Reference Circuit ______________	Correct (Zero Spill)	Reversed (Spill)
	Phase A _______________	____________________
Matched Circuit _______________	Phase B _______________	____________________
	Phase C _______________	____________________

Inter Group Polarity Test

Reference Circuit ______________	Correct (Zero Spill)	Reversed (Spill)
	Phase A _______________	____________________
Matched Circuit _______________	Phase B _______________	____________________
	Phase C _______________	____________________

Inter Group Polarity Test

Reference Circuit ______________	Correct (Zero Spill)	Reversed (Spill)
	Phase A _______________	____________________
Matched Circuit _______________	Phase B _______________	____________________
	Phase C _______________	____________________

______________________________	______________________________
Commissioning Engineer	Customer Witness
______________________________	______________________________
Date	Date

REPAIR FORM

Please complete this form and return it to AREVA T&D with the equipment to be repaired. This form may also be used in the case of application queries.

AREVA T&D
St. Leonards Works
Stafford
ST17 4LX
England

For : After Sales Service Department

Customer Ref: ____________________ Model No: ____________________

AREVA Contract Ref: ____________________ Serial No: ____________________

Date: ____________________

1. What parameters were in use at the time the fault occurred?

   AC Volts ____________________ Main VT/Test set

   DC Volts ____________________ Battery/Power supply

   AC current ____________________ Main CT/Test set

   Frequency ____________________

2. Which type of test was being used? ____

3. Were all the external components fitted where required? Yes / No
   (Delete as appropriate)

4. List the relay settings being used

   ____

   ____

   ____

5. What did you expect to happen?

   ____

   ____

   ____

   ____

continued overleaf

6. What did happen?

7. When did the fault occur?

Instant	Yes / No	Intermittent	Yes / No
Time delayed	Yes / No	(Delete as appropriate)	
By how long?	______		

8. What indications if any did the relay show?

9. Was there any visual damage?

10. Any other remarks which may be useful:

Signature

Title

Name (in capitals)

Company name

Publication: R8059H