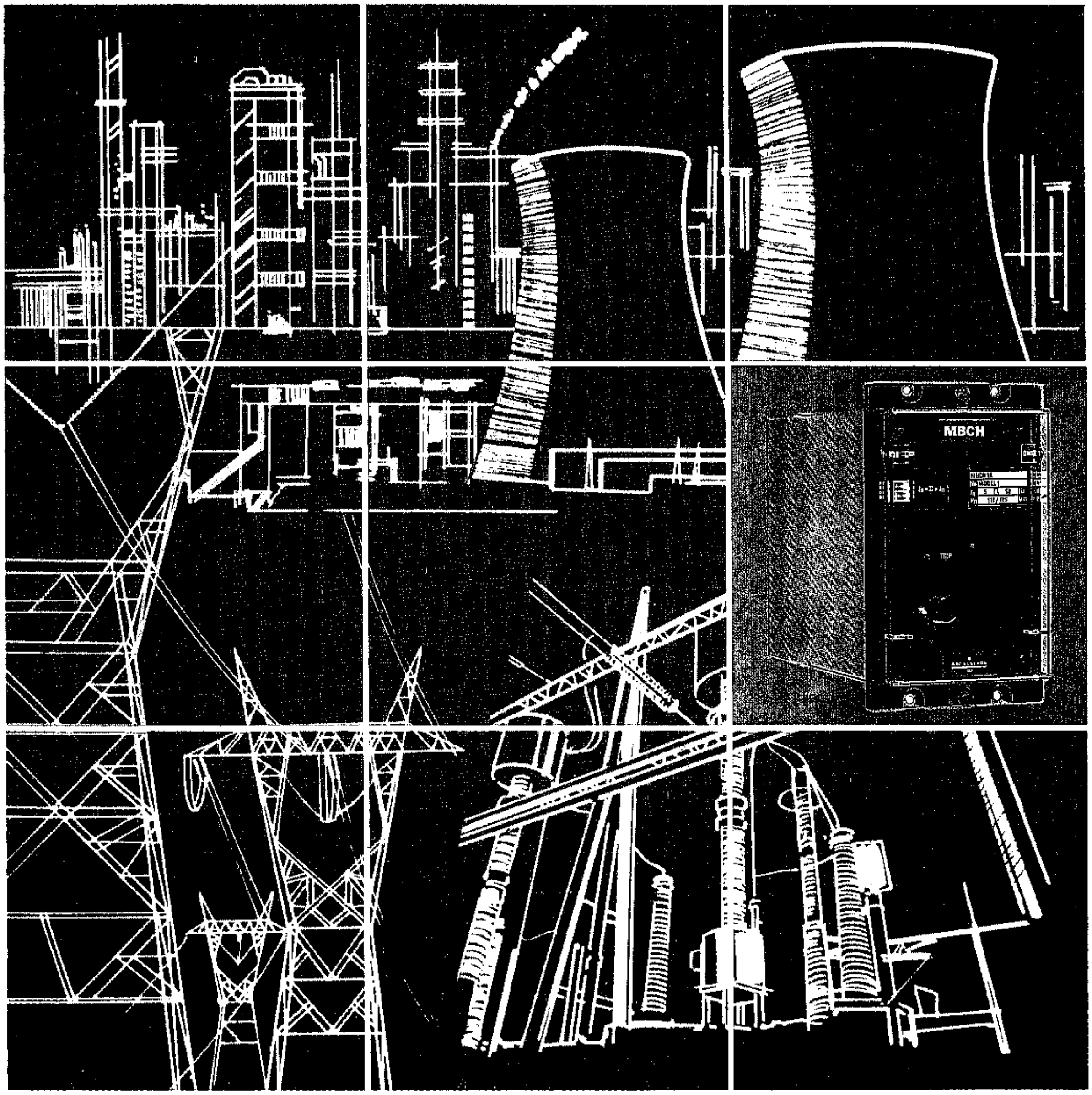
Type MBCH 12, 13, 16
Biased Differential Protection for Transformers, Generators and Generator Transformers



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Type MBCH 12, 13, 16 Biased Differential Protection for Transformers, Generators and Generator Transformers

Features

- Independent single phase relays suitable for single or three phase transformer protection schemes
- Fast operating times, typically 10 ms to 25 ms
- Dual slope percentage bias restraint characteristic with adjustable basic threshold setting of 10% to 50% I_n, selectable in 10% steps
- High stability during through faults even under conditions of CT saturation and with up to 20% ratio imbalance resulting from the effects of tap changing and CT errors
- Magnetising inrush restraint Over-excitation (over-fluxing) restraint
- Up to six biased inputs
- Transformer phase group and line CT ratio correction by means of separate tapped interposing transformers where required
- Two isolated change-over tripping contacts plus one isolated normally open latching alarm contact. The individual phase elements can be interconnected to provide six isolated change-over tripping contacts for three phase schemes
- Light emitting diode (led) fault indication.

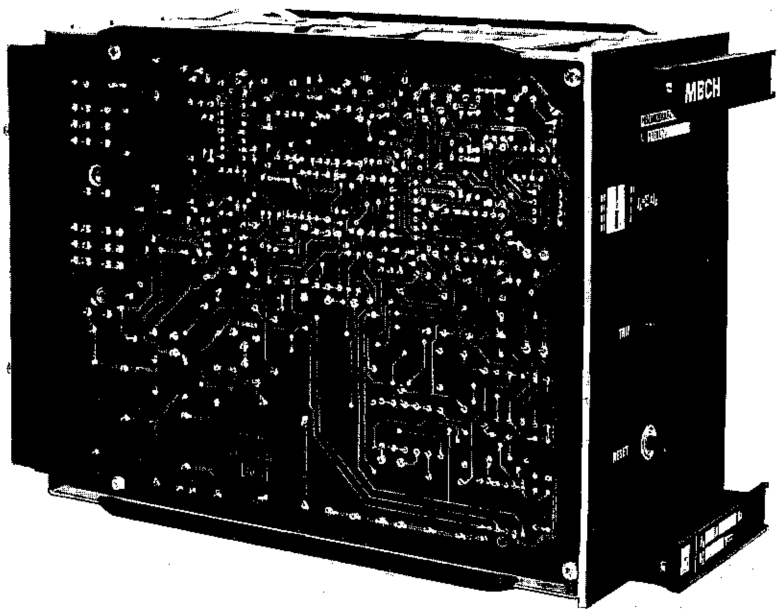

Figure 1: Relay type MBCH 12 withdrawn from case.

Application

The type MBCH 12, 13 and 16 are high-speed, single phase, biased differential relays suitable for the protection of two- or three-winding power transformers, auto-transformers, or generator-transformer units. Up to six biased current inputs can be provided to cater for power transformers with more than two windings and/or more than one circuit-breaker controlling each winding, as in 'mesh' or 'one and a half circuit-breaker' busbar arrangements. Typical applications are shown in Figures 2 to 8.

As a general low impedance biased differential relay, the MBCH may also be regarded as an alternative to the high impedance type relay for the protection of reactors, motors and generators.

Models Available

Type Designation	No. of Bias Circuits	Application
MBCH 12	2	Two-winding power transformer
MBCH 13	3	Generally 3 winding power transformer, where bias is required from each of the 3 groups of CT's
MBCH 16	6	For all applications requiring 4, 5 or 6 bias circuits

Description

The relay is extremely stable during through faults and provides high-speed operation on internal faults, even when energised via line current transformers of only moderate output. Immunity to false tripping due to large inrush currents on energisation of the power transformer, and also during overfluxing conditions, is provided by the use of a novel feature not involving harmonic filter circuits and their associated delay.

It can be beneficial to supplement the differential protection by a restricted earth fault relay, especially where the neutral point of the power transformer is earthed via a current limiting resistor. The restricted earth fault relay (type MCAG 14 or MFAC 14) may be connected into the differential circuitry, in association with a current transformer in the neutral connection of the power transformer, as indicated in Figures 3 and 6. Additional line current transformers are not required.

For optimum performance, the differential scheme should be arranged so that the relay will see rated current when full load current flows in the protected circuit. This may be achieved either by appropriate choice of main line current transformers, or the use of interposing current transformers.

When protecting a power transformer, the differential setting should not be less than 20% relay rated current, to give stability for moderate transient overfluxing. The maximum spill current with through load current should generally be kept below 20% of the relay rated current, allowing for CT mismatch and possible tap changer operation. Where higher levels of spill current exist, the relay setting may need to be increased.

A tapped interposing transformer is available for ratio matching of the main current transformers. The taps are spaced at intervals of 4% and better, allowing matching to well within 2% in most cases. The same interposing transformers may also be used where necessary for power transformer phase shift correction.

For some applications, no phase shift correction is necessary, but a zero sequence current trap is required to prevent zero sequence currents, due to external earth faults being seen by the differential relay. Two secondary windings are provided on the interposing transformer to allow the creation of an isolated delta connection for this purpose.

Each relay case incorporates a terminal block, for external connections, into which the module is plugged. Removal of the module from the case automatically causes the incoming line current transformer connections to be short-circuited, followed by the open circuiting of the relay tripping circuit.

Setting adjustment is by means of frontplate mounted switches. Indication of relay operation is provided by an led, also mounted on the relay frontplate, and which is resettable by a push button operable with the relay cover in position. The output elements consist of auxiliary attracted armature relays, the contacts of which are capable of circuit-breaker tripping. Three electrically independent contacts, comprising two self-resetting change-over contacts and one hand reset, normally open contact are provided per pole, for circuit breaker tripping and alarm purposes respectively. By interconnecting relays as shown in Figure 9, up to six self-resetting change-over contacts can be provided for the three-phase tripping of up to six circuit-breakers.

Functional Description

The differential transformer protection measuring circuit is based on the well known Merz-Price circulating current principle.

Figure 10 shows the relay functional block diagram. The outputs from each bias restraint transformer T3 to T5, proportional to the appropriate primary line currents, are rectified and summed to produce a bias restraint voltage. Any resulting difference current is circulated through transformers T1 and T2. The output from T1 is rectified and combined with the bias voltage to produce a signal which is applied to the amplitude comparator. The comparator output is in the form of pulses which vary in width depending on the amplitude of the combined bias and difference voltages. Where the measurement of the interval between these pulses indicates less than a preset time, an internal fault is indicated and a trip signal, initiated after a short delay ($\frac{1}{f}$ sec), level set by the bias. If, during the above mentioned delay, the instantaneous value of differential current falls below the threshold and remains below for longer than a further preset time, ($\frac{1}{4f}$ sec) as it would during transformer magnetising inrush conditions, the trip timer is reset and operation of the relay blocked.

An unrestrained high-set circuit, which monitors the differential current, will override the amplitude comparator circuit and operate the relay output element when the difference current is above the high-set setting.

Variable percentage bias restraint

Even under normal operating conditions, unbalanced currents (spilll current), may appear. The magnitude of the spill current depends largely on the effect of tap changing. During through faults the level of spill current will rise as a function of the fault current level. In order to avoid unwanted operation due to spill current and yet maintain high sensitivity for internal faults, when the difference current may be relatively small, the variable percentage bias restraint characteristic shown in Figure 11 is used. The setting I_s is defined as the minimum current, fed into one of the bias inputs and the differential circuit, to cause operation. This is adjustable between 10% and 50% of rated current.

The initial bias slope is 20% from zero to rated current. This ensures sensitivity to faults whilst allowing a 15% current transformer ratio mismatch when the power transformer is at the limit of its tap range, plus 5% for CT ratio error. Above rated current, extra errors may be gradually introduced as a result of CT saturation. The bias slope is therefore, increased to 80% to compensate for this.

At the inception of a through fault the bias is increased to more than 100%. It then falls exponentially to the steady state characteristic shown in Figure 11. This transient bias matches the transient differential currents that result from CT saturation during through faults, so ensuring stability.

However, during internal faults this transient bias is suppressed to ensure that no additional delay in operation is caused.

The transient bias circuits of the three phases are externally interconnected to ensure optimum stability of the protection during through faults.

Magnetising inrush restraint

Particularly high inrush currents may occur on transformer energisation depending on the point on wave of switching as well as on the magnetic state of the transformer core.

Since the inrush current flows only in the energised winding the protection relay sees this current as difference current. To avoid unwanted tripping of the power transformer it has been customary to incorporate second harmonic restraint to block the protection relay. Practice has shown that this technique may result in significantly slower operating times for internal faults when second harmonics are introduced into the current waveform by core saturation of line CT's.

In order to overcome the problems associated with second harmonic restraint a new technique has been developed to recognise magnetising inrush current and restrain the relay during such periods.

In practice the magnetising inrush current waveform is characterised by a period during each cycle when little or no current flows, as shown in Figure 12. By measuring this characteristic zero period, the relay is able to determine whether the difference current is due to magnetising inrush current or to genuine fault current and thereby inhibit operation only during the inrush condition. This new measurement technique ensures that operating times remain unaffected even during periods of significant line CT saturation.

Transformer over-excitation

When a large section of system load is suddenly disconnected from a power transformer the voltage at the input terminals of the transformer may rise by 10-20% of rated value giving rise to an appreciable increase in transformer steady state exciting current. The resulting exciting current may rise to a value high enough to operate the differential protection relay, since this current is seen by the input line current transformers only. Exciting currents of this order are due to the input voltage exceeding the knee point voltage of the power transformer resulting in a magnetising current wave shape as shown in Figure 13. By detecting the periods when the current remains close to or at zero, in a similar manner to that used to identify magnetising inrush current, the relay is able to detect and remain insensitive to substantial over-excitation current.

Where extremely large and potentially damaging over-exciting currents are possible it is recommended that an over-fluxing relay, responsive to V/Hz, should be used. Such relays are designed to operate after a time delay of several seconds.

High-set

An unrestrained instantaneous high-set feature is incorporated to provide extremely fast clearance of heavy internal faults. This instantaneous feature has an auto-ranging setting, normally low at normal load through-put, but automatically rising to a higher value under heavy through fault conditions. Furthermore, immunity to magnetising current inrush is guaranteed provided the first peak of the waveform is no greater than 12 times the rated rms current. The problem relating to choice of a high-set threshold which avoids tripping on magnetising current inrush does not, therefore, occur and no user adjustment is required.

Auxiliary interposing transformer

Auxiliary interposing transformers are available as single or triple unit assemblies as illustrated in Figure 15. A comprehensive tap adjustment range is available as indicated by the details of turns per tap shown in Table 2. All line CT connections should be made to the terminal strip marked 'S1 S2 S3 S4 P1 P2'.

Selection of appropriate primary taps is made using the flexible jumper leads connected to terminals P1 and P2. See Figure 16. The tertiary winding S3-S4 must be used in series with winding S1-S2 where a delta output winding is required to ensure correct operation of the differential scheme.

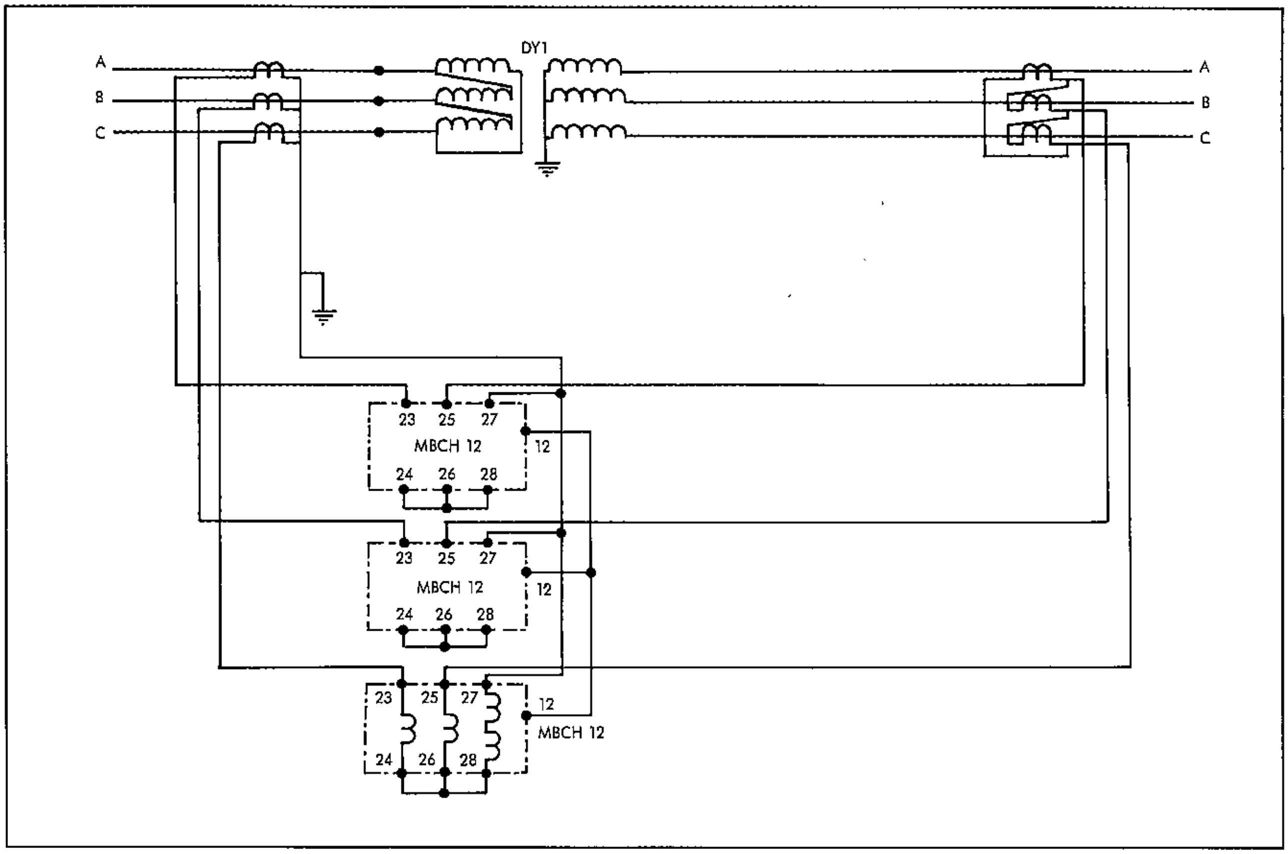

Figure 2: Application diagram: relay type MBCH 12 with two biased inputs.

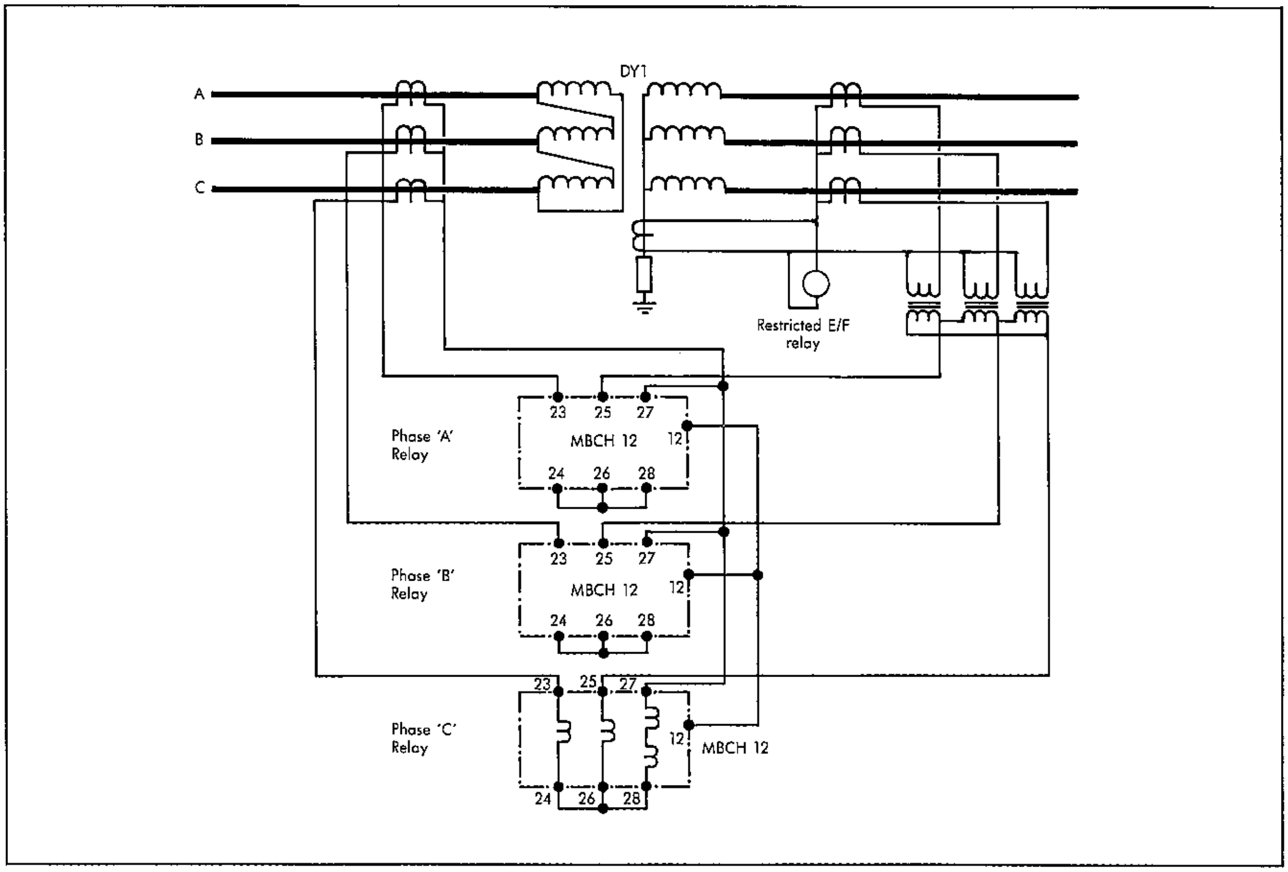

Figure 3: Typical connection diagram for MBCH 12 relays protecting a DY 1 transformer with integral restricted earth fault relay.

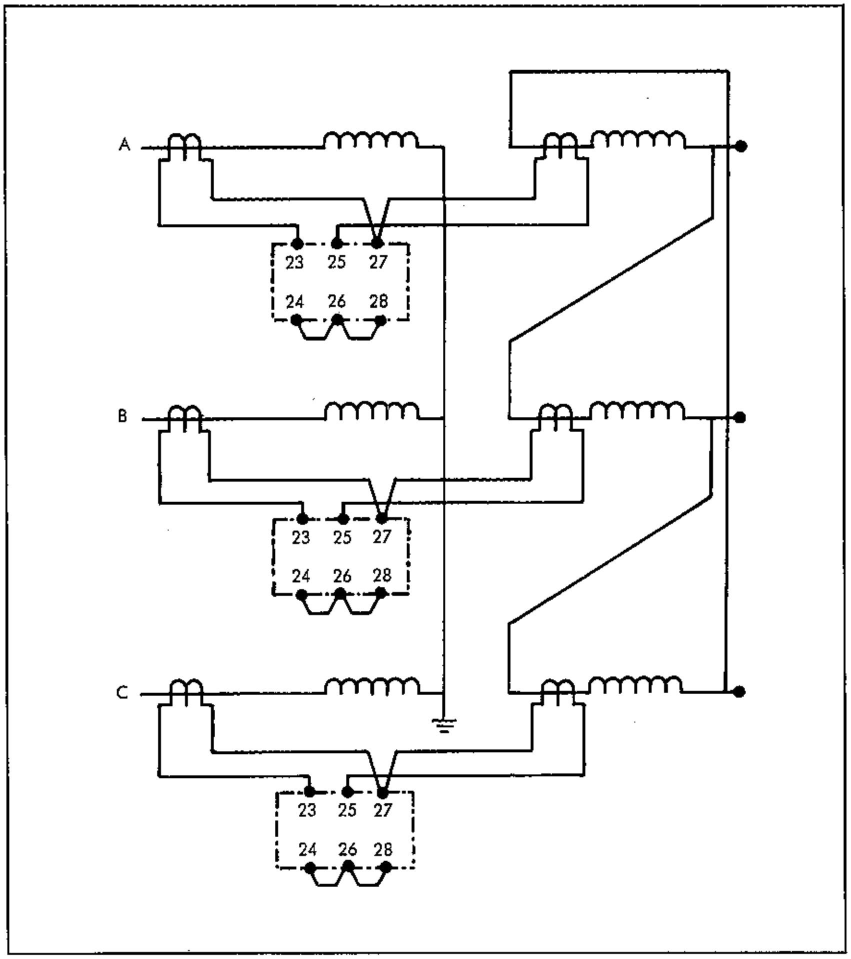

Figure 4: Typical connection diagram for MBCH relays protecting a YD 11 transformer on a phase by phase basis.

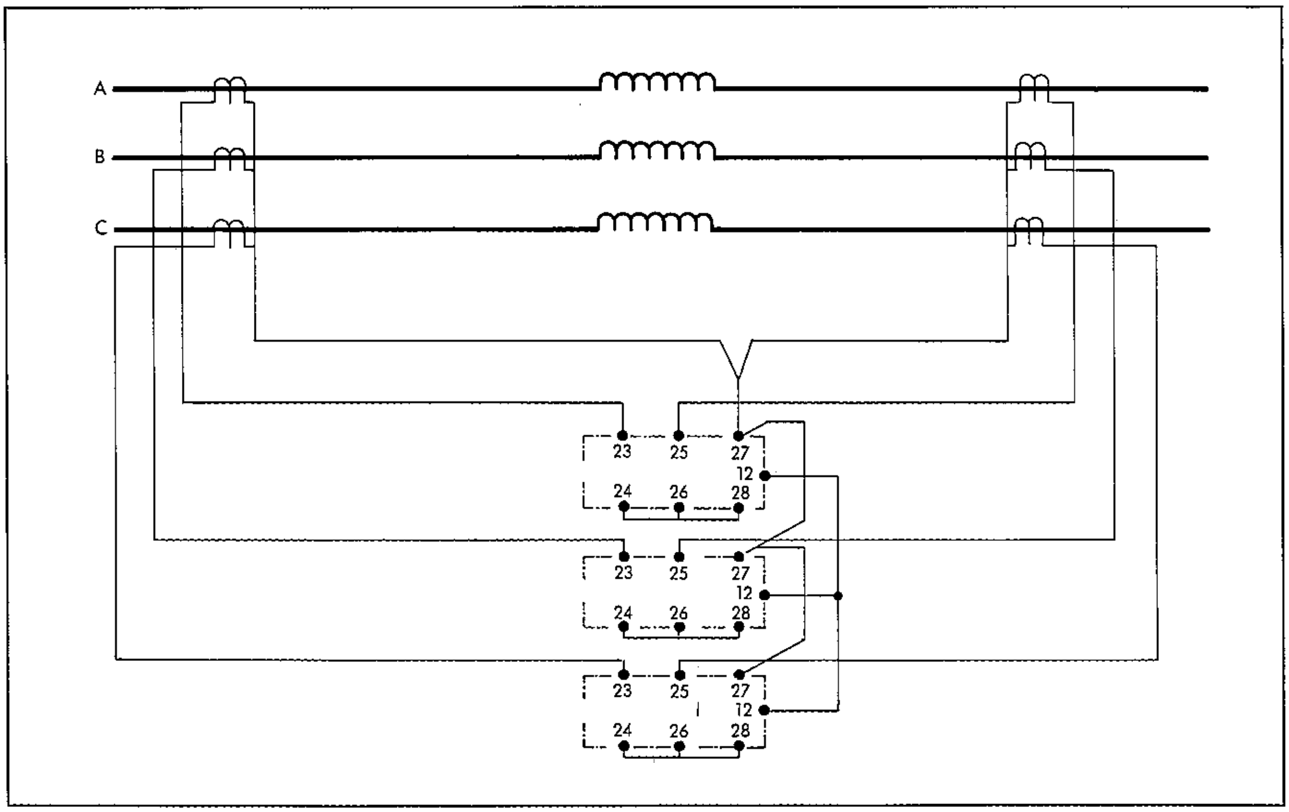

Figure 5: Typical connection diagram for MBCH 12 relays protecting a series reactor.

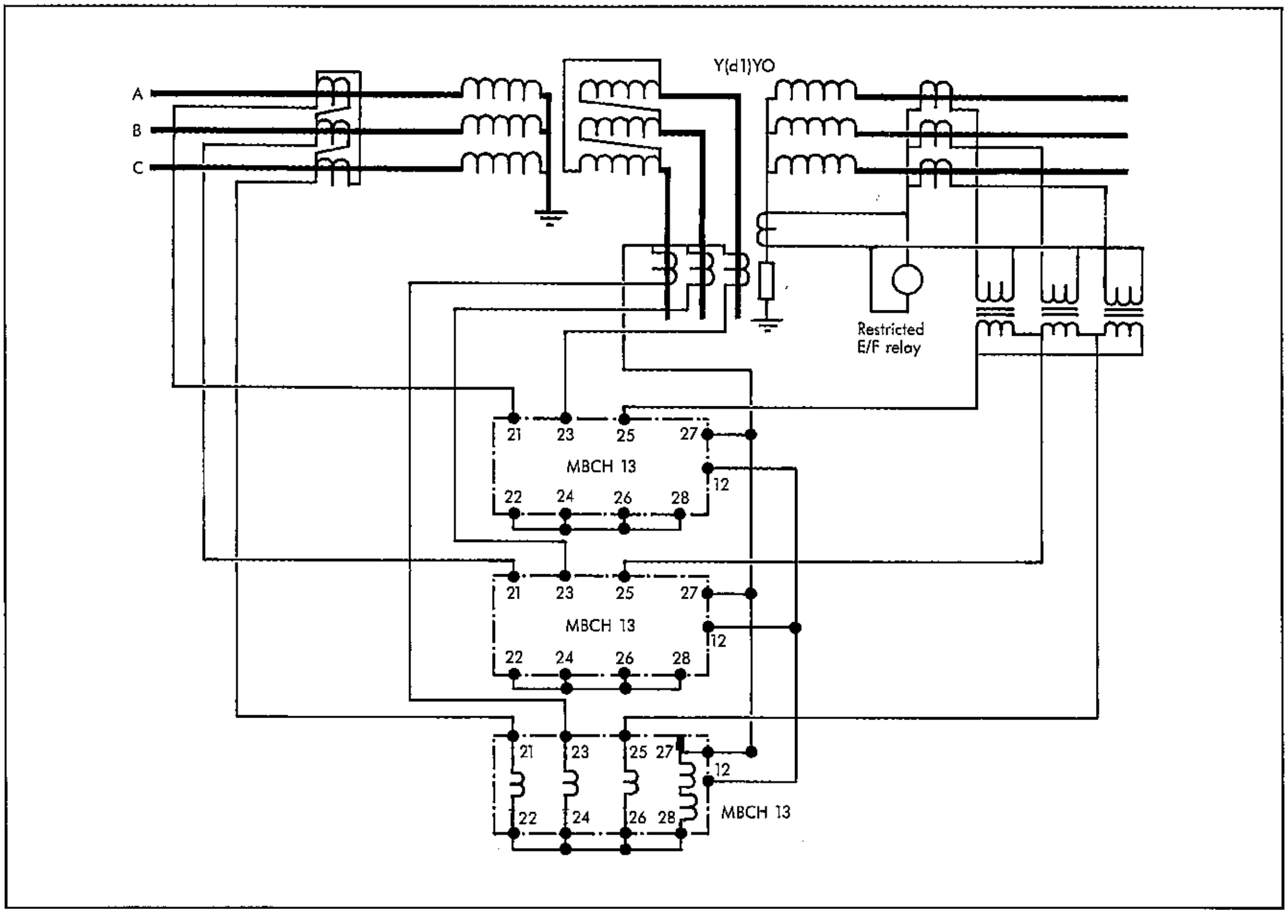

Figure 6: Typical connection diagram for MBCH 13 relays protecting a Y(d) YO transformer with integral restricted earth fault relay.

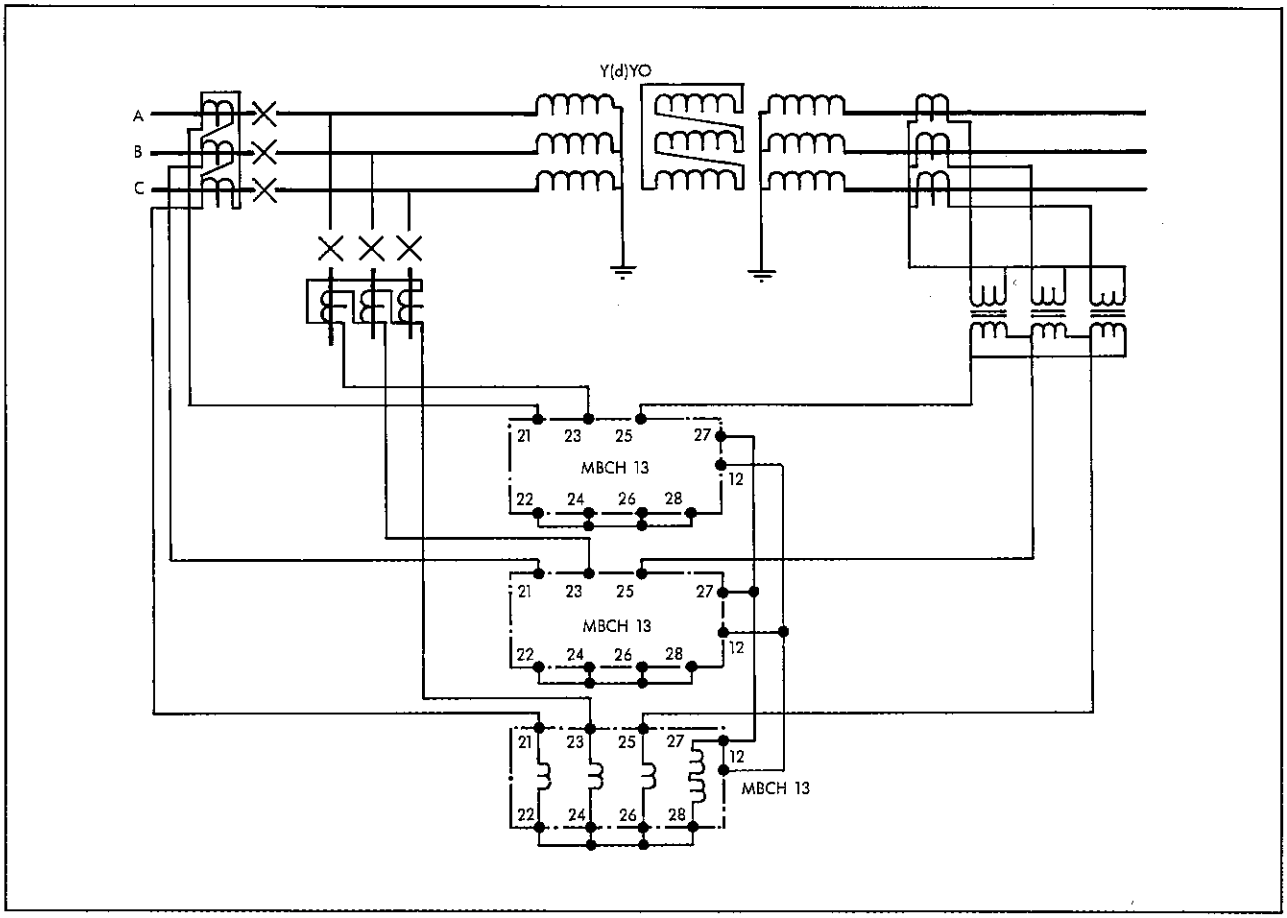

Figure 7: Typical connection diagram for MBCH 13 relays protecting a Y(d) YO transformer supplied from a 'mesh' busbar.

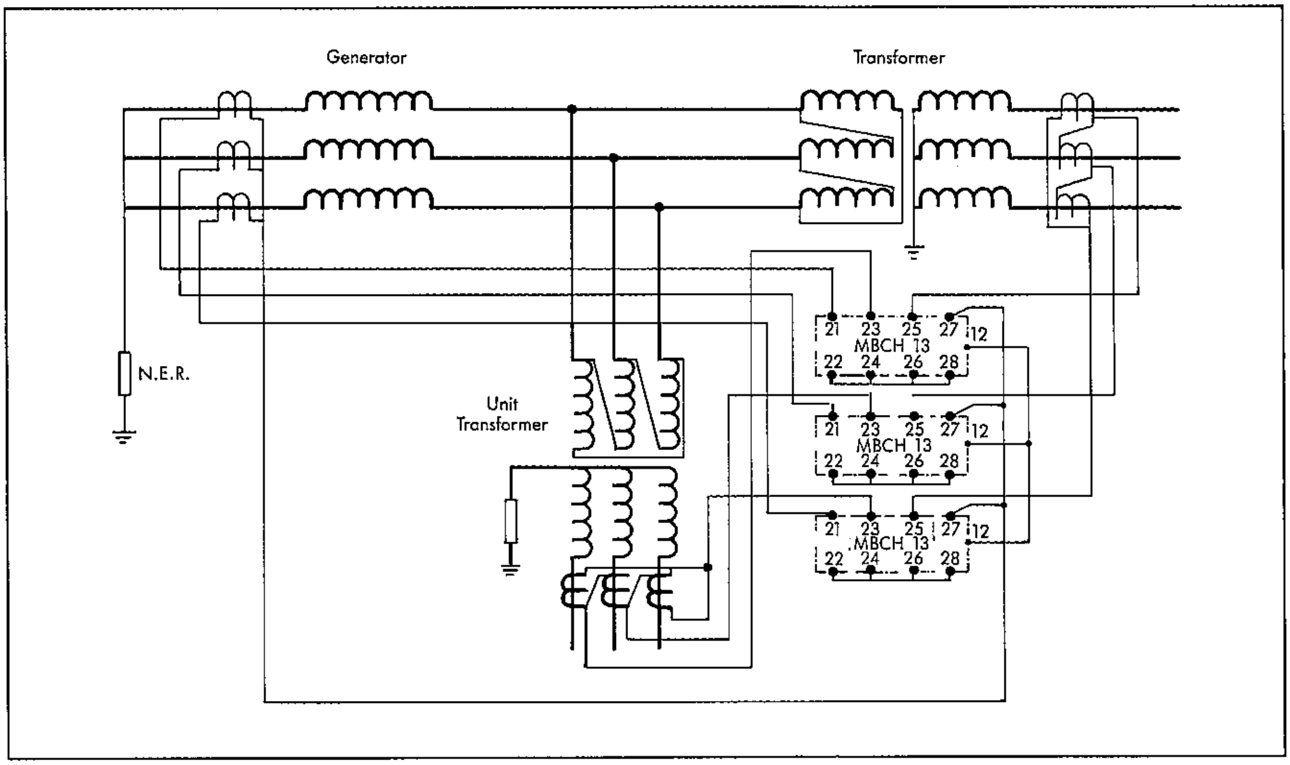

Figure 8: Typical connection diagram for MBCH 13 relays protecting a generator/transformer unit.

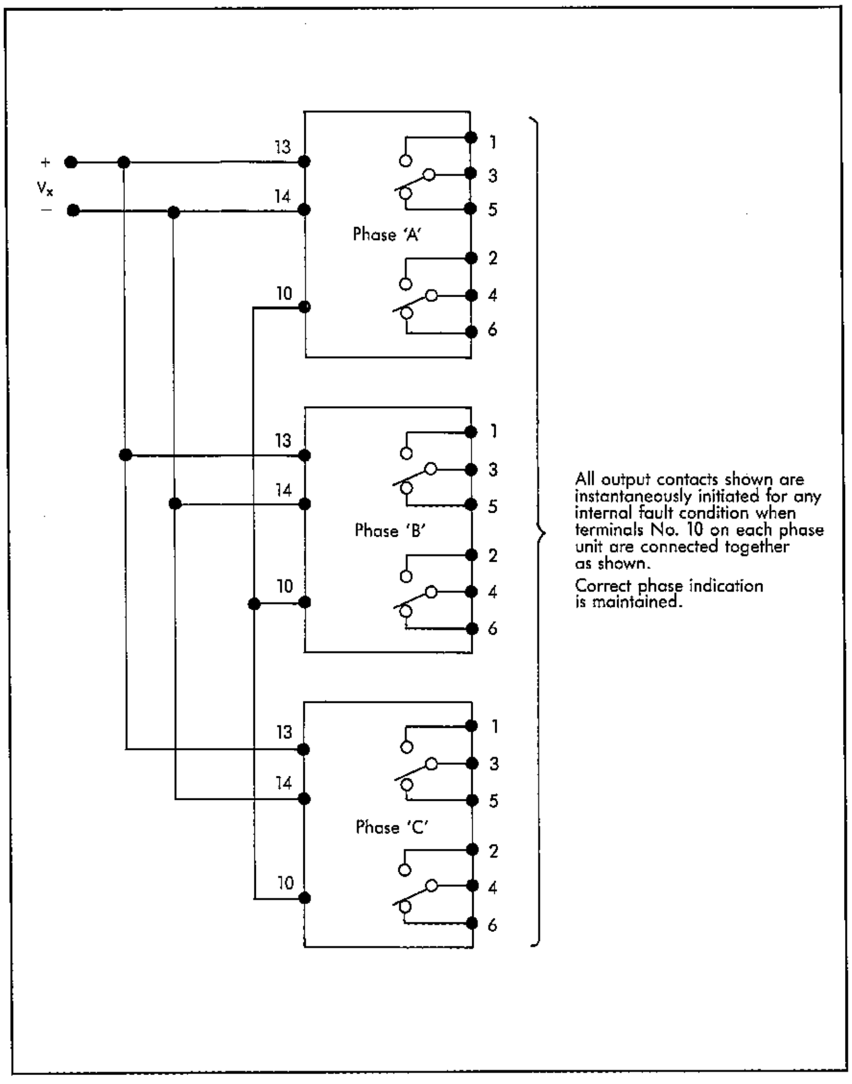

Figure 9: Connection for six change-over tripping contacts for three phase tripping of up to six circuit breakers.

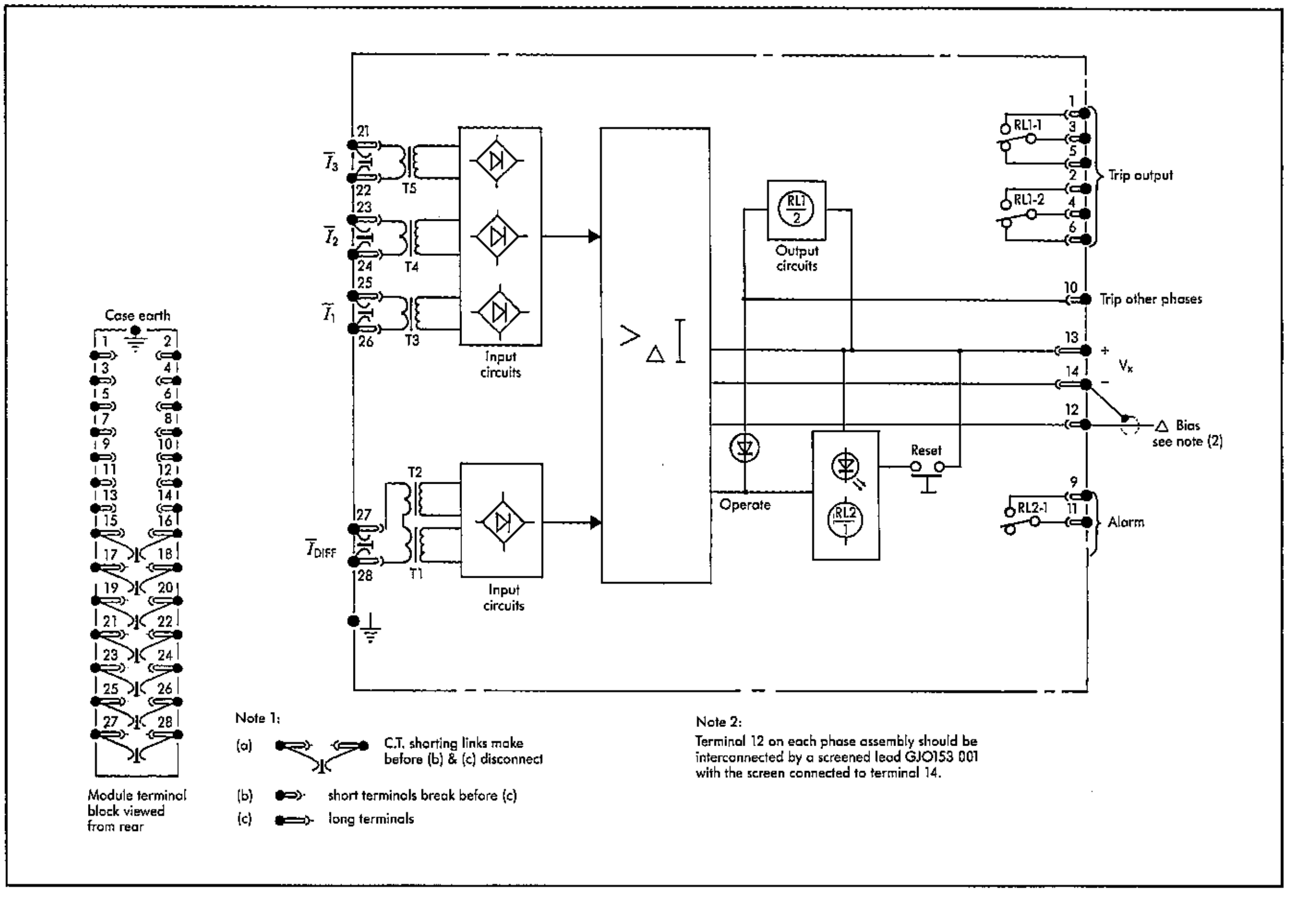

Figure 10: Block diagram: Biased differential protection relay type MBCH 13 with three biased inputs.

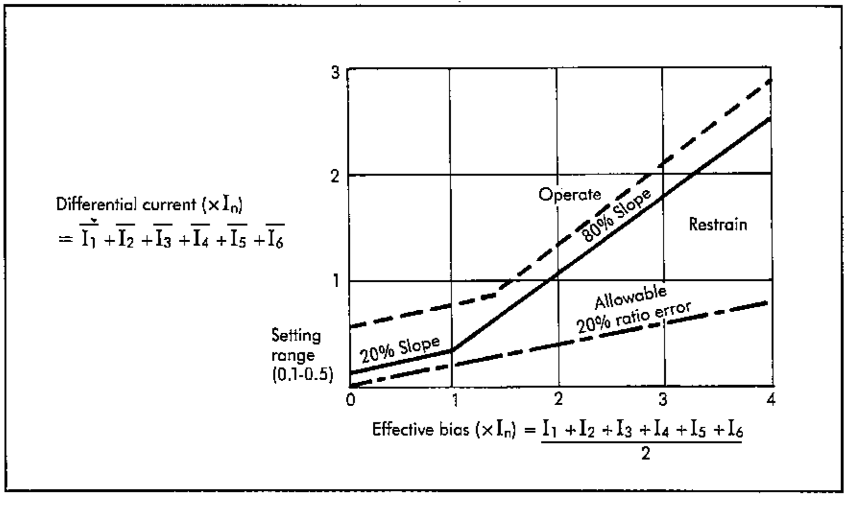

Figure 11: Typical percentage bias characteristic.

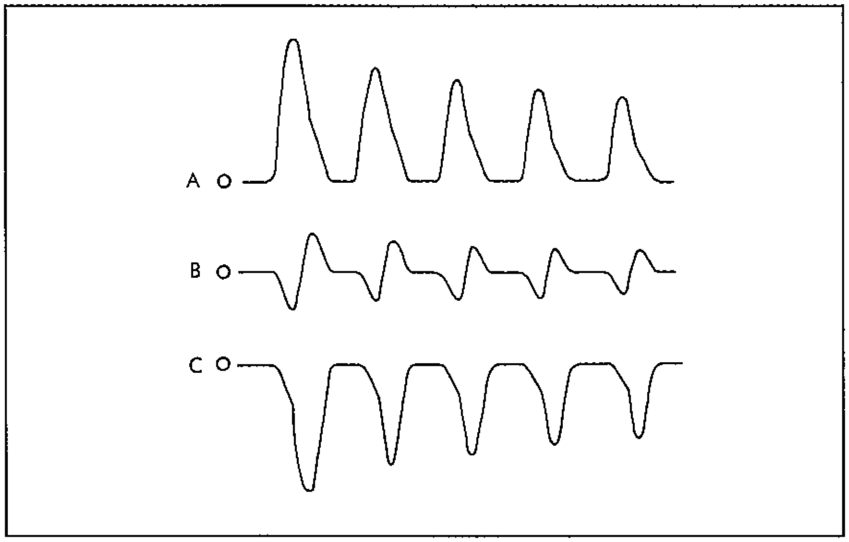

Figure 12: Typical magnetising inrush waveforms.

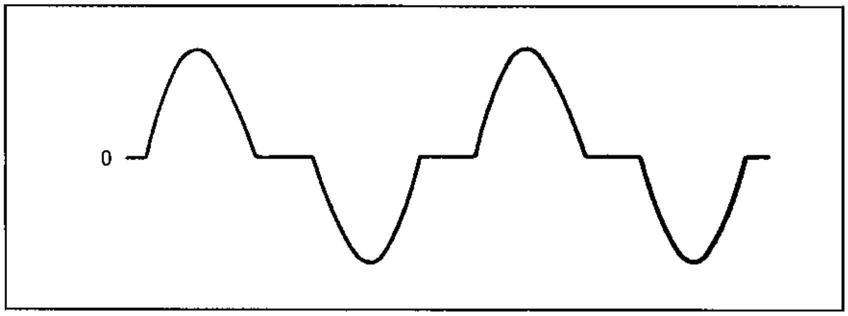

Figure 13: Magnetising current with transformer overfluxed.

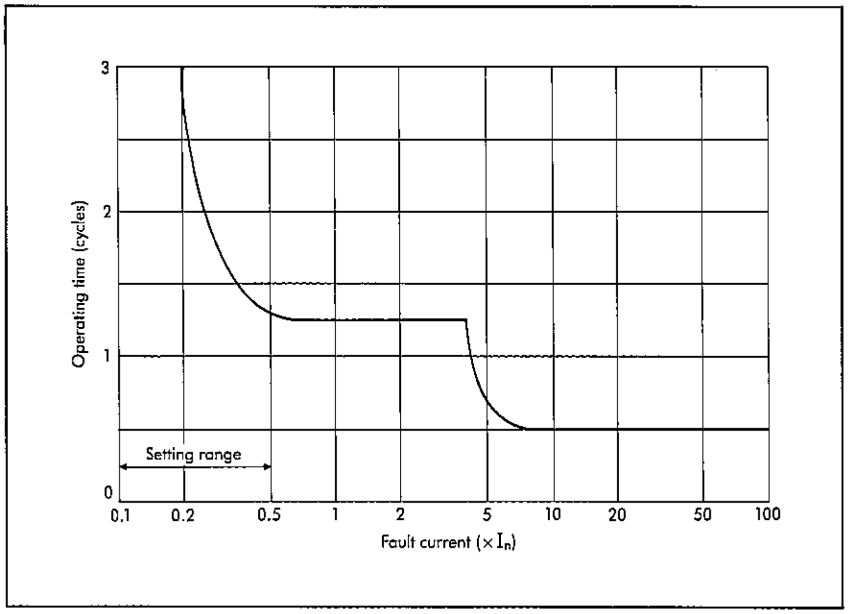

Figure 14: Typical operating time characteristic.

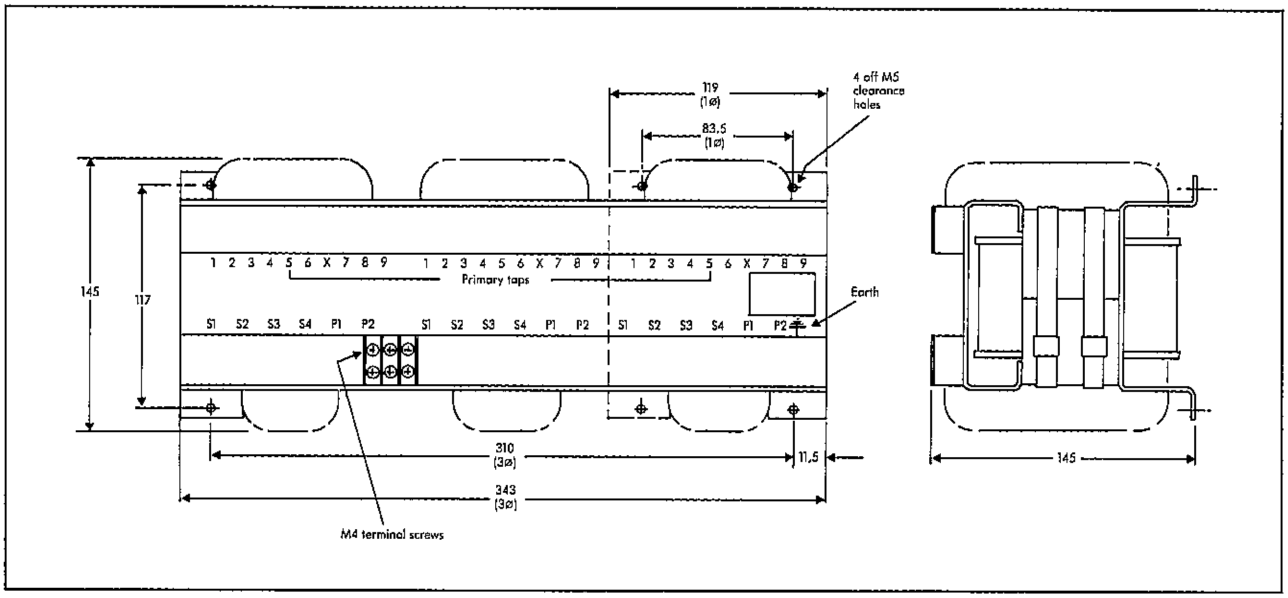

Figure 15: Outline details of single and triple unit auxiliary interposing transformer assembly.

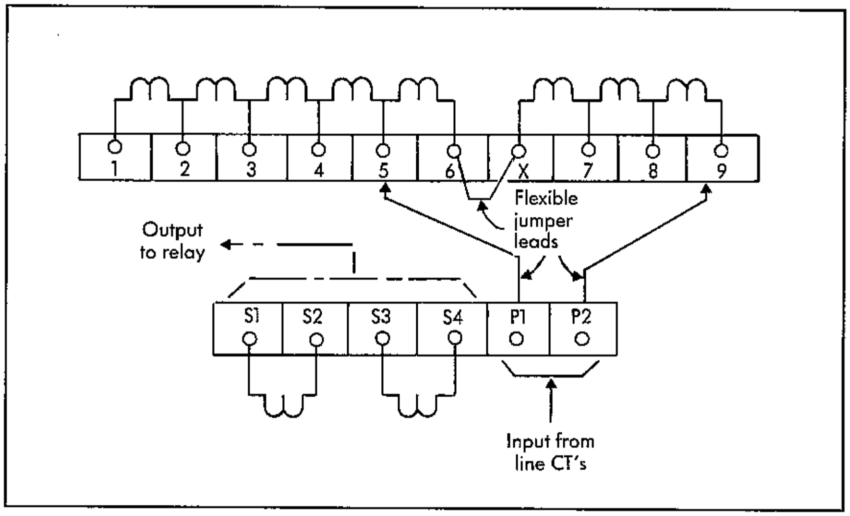

Figure 16: Winding arrangement of single pole of auxiliary interposing transformer.

Technical Data

Ratings

AC Current (I_n)	1A or 5A	
Frequency	50Hz or 60Hz	
Auxiliary dc supply (V_x)	Voltage Rating (Vdc)	Operating range (Vdc)
	30 - 34	24 - 41
	48 - 54	37.5 - 65
	110 - 125	87.5 - 150
	220 - 250	175 - 300

Minimum basic setting

Biased feature: 10%, 20%, 30%, 40%, 50% I_n

High-set feature: $4I_n$ up to through bias currents of $9I_n$, thereafter increasing gradually to $8I_n$ at through bias currents of $14I_n$.

High-set operation: Immunity to magnetising current inrush is guaranteed provided the first peak of the waveform is no greater than 12 times the rated rms current.

Accuracy: ±10%

Operating characteristic: Dual slope, 20% up to I_n, 80% above I_n.

Operating time: Typically 10 ms to 25 ms

Number of current inputs: MBCH 12 - 2 biased inputs
MBCH 13 - 3 biased inputs
MBCH 16 - 6 biased inputs

AC thermal rating

Continuous: MBCH 13,16: $4I_n$
MBCH 12: $2I_n$

Short time, all versions: $100I_n$ for 1s with a maximum of 400 A

DC burden

With output H/A not picked up

DC voltage rating (V)	Burden at upper voltage rating (W)
30 - 34	Approx 3
48 - 54	Approx 3
110 - 125	Approx 4
220 - 250	Approx 8

With output H/A picked up

DC voltage rating (V)	Burden at upper voltage rating (W)
30 - 34	Approx 4
48 - 54	Approx 4
110 - 125	Approx 7
220 - 250	Approx 12

AC burden

Through current only
(per bias circuit)
Ithro=$1 \times I_n$

Approx 0.15 VA (I_n=1A)
Approx 0.30 VA (I_n=5A)

Bias and differential circuit only
Idiff=$1 \times I_n$

Approx 2.80 VA (I_n=1A)
Approx 3.20 VA (I_n=5A)

Contact arrangement

Two change-over self-reset tripping contacts per relay. (For 3 phase schemes relays can be interconnected as shown in Figure 9 to provide instantaneous operation of all three sets of change-over tripping contacts.) One normally open latching contact per relay.

Contact rating

Make and carry: 7500 VA for 0.2s with maxima of 30A and 300V ac or dc.
Carry continuously: 5A ac or dc
Break: 1250 VA ac or 50W dc resistive, 25W, L/R = 0.04s.
Subject to maxima of 5A and 300V.

Operation indicator

Light emitting diode (red), hand reset

Line current transformer requirements

Application	Knee Point Voltage V_k **Note: Values to be as given below, with minima of $\frac{60}{I_n}$ for star-connected CTs and $\frac{100}{I_n}$ for delta connected CTs**	Through Fault Stability X/R	I_f
Transformers	$V_k \geqslant 24\ I_n\ [R_{ct}+2R_l+R_t]$	40	$15I_n$
Generators Generator transformers	$V_k \geqslant 24I_n\ [R_{ct}+2R_l+R_t]$	40	$15I_n$
Overall generator-transformer/units Motors Shunt reactors	$V_k \geqslant 48I_n\ [R_{ct}+2R_l+R_t]$	120	$15I_n$
Series Reactors also Transformers connected to a Mesh Corner having two sets of CT's each supplying separate relay inputs	$V_k \geqslant 24I_n\ [R_{ct}+2R_l+R_t]$	40	$15I_n$
Note: CT's should be of equal ratio and magnetisation characteristic	$V_k \geqslant 48I_n\ [R_{ct}+2R_l+R_t]$	40 120	$40I_n$ $15I_n$

Where:
I_n = Rated line CT secondary current (1A or 5A).
R_{ct} = Resistance of line CT secondary winding.
R_l = Resistance of a single lead from line CT to relay.
R_t = Effective resistance of interposing CT where used.
X/R = Maximum value of primary system reactance/resistance ratio.
I_f = Maximum value of through fault current.

Table 1: Current Transformer requirements.

Auxiliary interposing transformers

Nominal secondary current rating, I_n	1A or 5A
Nominal current ratios selectable in 4% I_n steps see Table 1	0.58 - 1.73/1 2.89 - 8.66/1 2.89 - 8.66/5 Note: Higher primary currents can be catered for. Refer to publication R-6077
Rated frequency	50/60Hz
Thermal withstand	$4 \times I_n$ continuous $30 \times I_n$ for 10s $100 \times I_n$ for 1s with 400A maximum
Effective resistance R_t	2.0Ω for 0.58 - 1.73/1 ratio 0.2Ω for 2.89 - 8.66/5 ratio 0.15Ω for 2.89 - 8.66/1 ratio
Insulation test voltage	2.5kV, 50Hz
Maximum terminal block wire size	84 strand, 0.3mm Ø
Dimensions	Outline drawings for single and triple group shown in Figure 15
Weight	4kg single unit 12kg triple unit

Number of turns

Primary top terminals	Transformer rating		
	1/1A	5/1A	5/5A
1 — 2	5	1	1
2 — 3	5	1	1
3 — 4	5	1	1
4 — 5	5	1	1
5 — 6	125	25	25
X — 7	25	5	5
7 — 8	25	5	5
8 — 9	25	5	5
S1 — S2	125	125	25
S3 — S4	90	90	18

Table 2: Interposing CT's: number of turns per tap.

Voltage withstand

Insulation IEC 255-5	2kV rms for 1 minute between all terminals connected together, and the case earth terminal.
High voltage withstand Insulation IEC 255-5 BS 142 Section 1.3	2kV rms for 1 minute between independent circuits including contact circuits. 1kV rms for 1 minute across normally open output contacts.
High voltage impulse	5kV peak, 1.2/50μs, 0.5J.
IEC 255-5	Between all case terminals of each independent circuit connected together and the case earth terminal. Between independent circuits including contact circuits. Between terminals of the same circuit except output contacts.

High frequency disturbance IEC 255-22-1 Class III	1 MHz bursts decaying to 50% of peak value after 3 to 6 cycles. Repetition rate 400 per second. 2.5kV between all case terminals of each independent circuit connected together and the case earth terminal. 2.5kV between independent circuits including contact circuits. 1kV between terminals of the same circuit except output contacts.
Environmental withstand	
Temperature IEC 68-2-1 IEC 68-2-2	 Storage and transit −25°C to +70°C Operating range −25°C to +55°C
Humidity IEC 68-2-3	 56 days (at 93% RH and +40°C).
Enclosure protection IEC 529	 IP50 (dust protected)
Vibration IEC 255-21-1	 0.5g between 10 Hz and 150 Hz.
Mechanical durability	
Loaded contact	10,000 operations minimum
Unloaded contact	100,000 operations minimum

Cases

Relays type MBCH are housed in size 4 cases as shown in Figure 17.

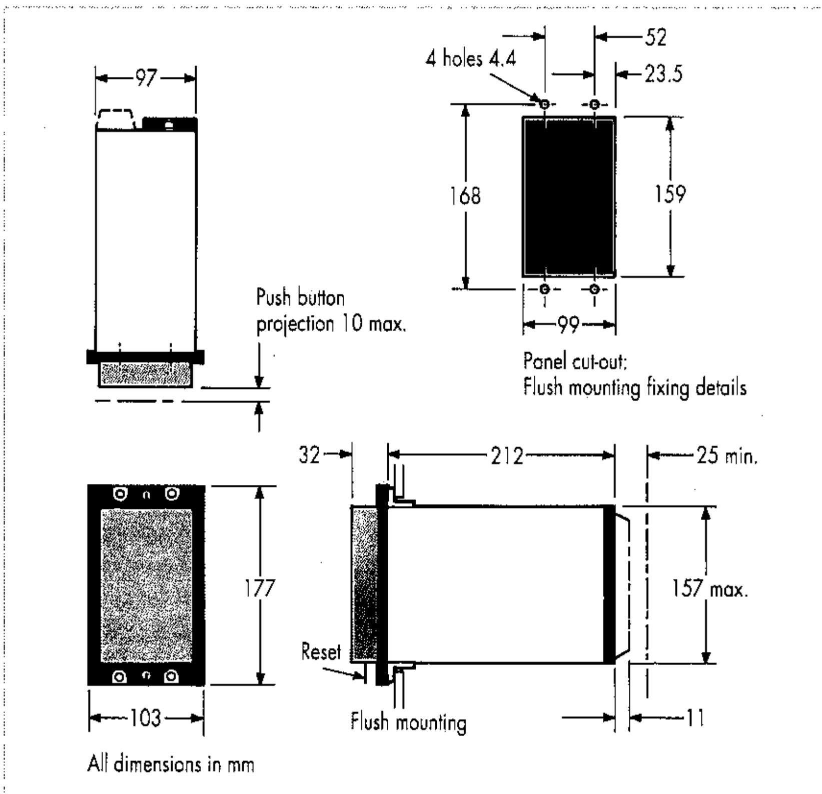

Figure 17: Case outline size 4.

Information required with order

Note: 3 single-phase MBCH relays are required for a 3-phase scheme. Please state total number of single-phase relays required.

Rated current I_n

Rated frequency

Auxiliary dc supply voltage V_x

Number of current bias inputs:
MBCH 12: 2 input
MBCH 13: 3 input
MBCH 16: 6 input

Auxiliary interposing transformer

Rated current I_n
Current ratio
Mounting: single or triple unit

Associated Publications

R-6077 Interposing matching CT's for use with MBCH relays.
R-6001 MIDOS system.
R-6004 MMLG/MMLB test block/test plug.

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