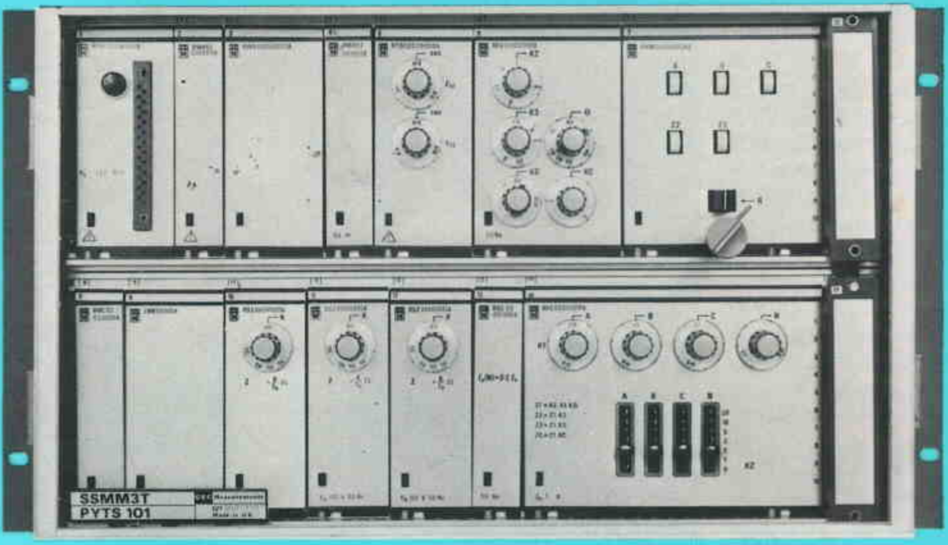
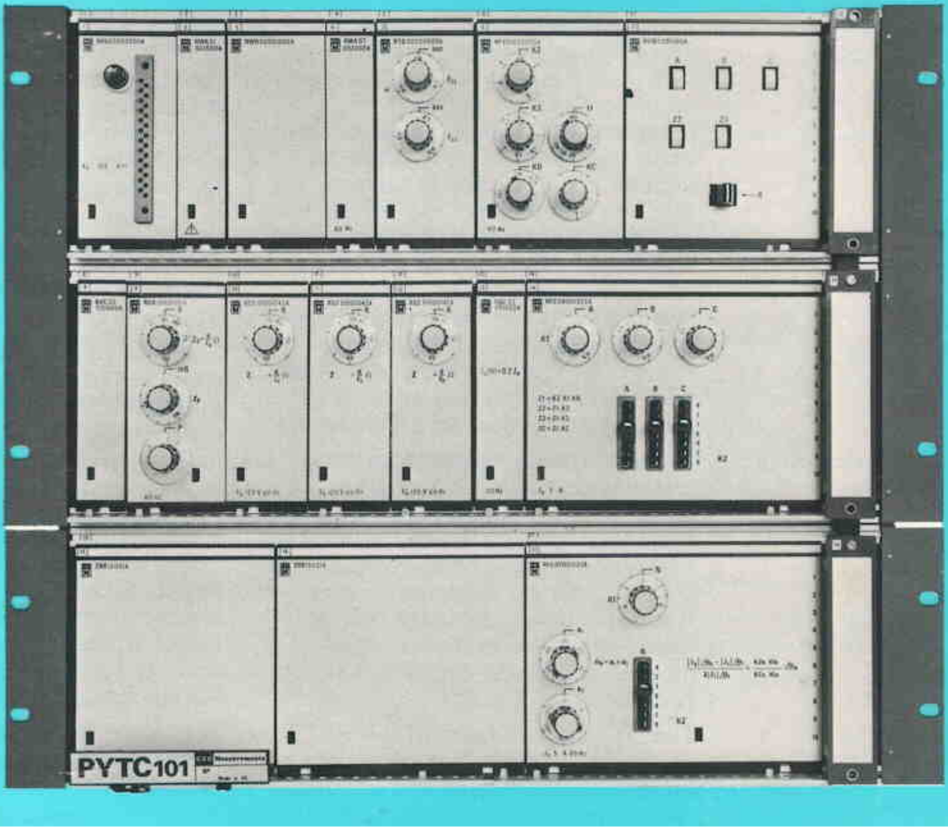
GEC Measurements

Types PYTS & PYTC Switched Distance Relays

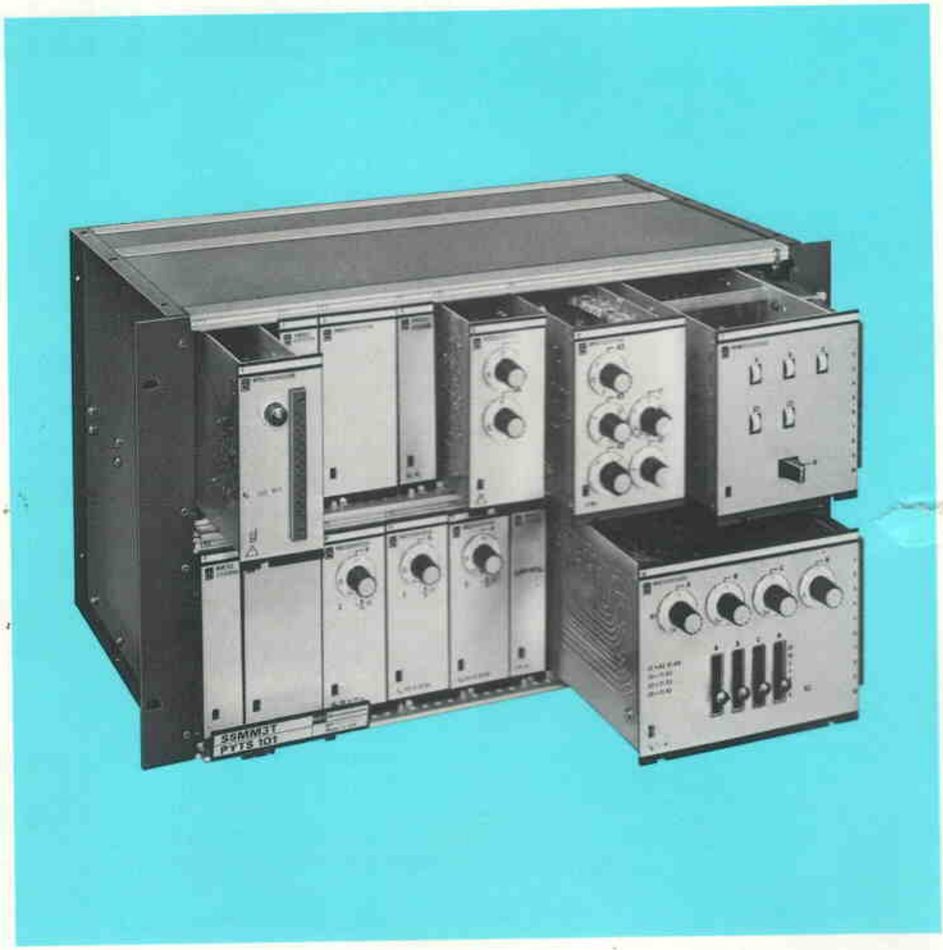




Types PYTS & PYTC

FEATURES

* Minimum operating time 20 milliseconds for Zone 1 faults.
* Mho characteristic with full cross polarisation ensures maximum tolerance of arc resistance on the type PYTS.
* Accurate measurement for source/line impedance ratios up to 100/1 (phase faults) and 60/1 (earth faults).
* Static circuitry throughout imposes low VA burden on current transformers and voltage transformers.
* Mho characteristic with self polarisation and optional cross polarisation on the type PYTC to cover a mixture of overhead and cable systems.
* Angular residual compensation is available on the PYTC for accurate earth fault measurement.
* Versions available to suit systems earthed solidly, by resistance or Petersen coil and to suit insulated systems.
* A relay characteristic angle setting of 30° to 85°.
* Modular plug-in construction, with built-in test points, permits easy maintenance.
* Compact construction saves panel space.
* Trip circuit supervision, high speed trip relays and auxiliary relays for use with protection signalling, available in additional integral sub-rack.



APPLICATION

The PYTS is a fast and accurate switched distance relay scheme which employs the mho principle of measurement. It provides phase and earth fault protection and can be applied economically to short or medium length overhead transmission and distribution lines. The scheme is a practical alternative to directional overcurrent protection in power systems with a multiplicity of infeeds which make grading difficult, a realistic choice for protection where pilot wires cannot be used and as back-up protection on EHV systems.

Complete three phase, three zone distance protection is provided, using a mho characteristic for power systems which are solidly earthed or resistance earthed or are earthed by means of an arc suppression coil. Residual current compensation is included to ensure that the relay measures correctly under earth fault conditions.

The PYTC is a version of the PYTS designed for protection of underground cable systems and combined cable and overhead line applications addition of a neutral compensation module providing phase angle adjustment as well as amplitude adjustment of the residual compensation factor. This 6" module is located separately in a third sub-rack.

Two types of starting elements are available for phase selection.

Instantaneous overcurrent starting elements

These can be applied only where the minimum fault current is greater than the maximum load current and where the increase in healthy phase currents for an earth fault is less than the setting of the overcurrent starting elements.

Impedance starting elements

These are recommended for applications where the fault current under minimum plant conditions is less than the maximum load current and are available for solidly or resistance earthed systems only.

A residual overcurrent starting element is a standard feature of the protection.

Features

Standard features among the many facilities available include:

* Provision for single or three phase auto-reclose selection.
* A 'switch-on-to-fault' facility which provides an instantaneous trip if the line is energized on to a three phase fault.
* The protection is suitable for use on systems using either line or busbar voltage transformers and time delay link adjustments are fitted to cater for electromagnetic or capacitor type voltage transformers.

Optional facilities include:

* Instantaneous zone extension. This allows instantaneous tripping for the complete line when used with auto-reclose facilities without the need for a signalling channel. It can also be used in other specialized modes such as in carrier acceleration schemes.
* A directional/non-directional fourth zone which permits time delayed tripping from starting elements.
* Power swing blocking (PSB) used with impedance type starting elements. This module detects power swings on the system and blocks operation of the distance protection. It has the advantage that it can be added when required.
* Override facilities are provided with the PSB element, enabling the distance protection to override it in various zones.
* The relays can be fitted with remote flag control, a feature used in blocking or permissive overreaching schemes.
* Fuse failure detection can be incorporated in the distance protection as an additional module housed in a third sub-rack or provided as a separate relay type PVFS.

Figure 14 shows a diagram of the modular construction together with a key describing the functions of the various modules.

OPERATION

The relays use block-average comparators to produce the well established and proven mho measuring characteristic.
The PYTS relay utilises a fully cross-polarised directional mho measuring element which is switched to the correct phase by starting elements.

The PYTC relay uses self-polarisation with a small amount of cross-polarisation for plain cable feeders. For hybrid combinations of underground cable and overhead line, where high values of arc resistance may be encountered, the relay is provided with 100% cross-polarisation to enable the mho characteristic to expand in the presence of unbalanced faults.

Phase selection is performed by static phase starter elements S1, S2 and S3. Figure 2 shows the block diagram of the complete relay with overcurrent elements; Figure 3 shows the alternative input arrangements for impedance starters.

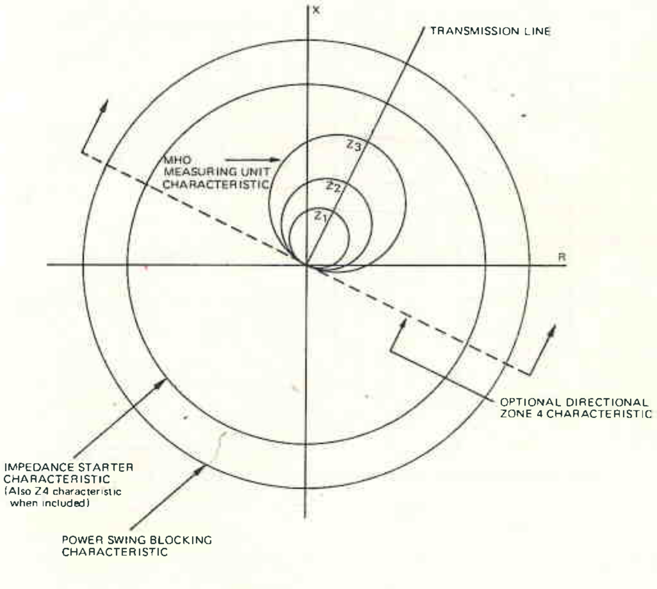
The neutral overcurrent starter element S4 is fitted to provide remote indication of earth faults and to control the zone extension facility for earth faults only when required. It is also used to override the power swing blocking unit under earth fault conditions when used in conjunction with impedance starter elements.

A voltage V is derived from the faulted phase or phases and a voltage V POL is taken from a combination of faulted and healthy phases depending on the polarising characteristic chosen. A signal (IZ) proportional to the fault current is provided by transactors T5, T6, T7 and T8 which eliminate the effects of d.c. offsets. Transactor T8 provides zero sequence current compensation.

The measuring unit characteristic is produced by a phase comparator circuit which receives the signals V-IZ and V POL. These inputs are selected by a switching network according to the fault detected by the appropriate starting element(s). An output from the phase comparator is fed into an integrator and then to a level detector to initiate a trip circuit.

A 'switch-on-to-fault' circuit controlled by the voltage supplied by interposing voltage transformer (T10) produces an operation signal for the trip circuit if the circuit breaker is closed on to a three phase faulted line.

The d.c. supply for the scheme is taken from the station battery and is regulated and stabilized by a series regulator. An a.c. assisting circuit, fed from an interposing voltage transformer T9, is used to supplement the d.c. regulator, ensuring negligible battery drain under quiescent conditions.



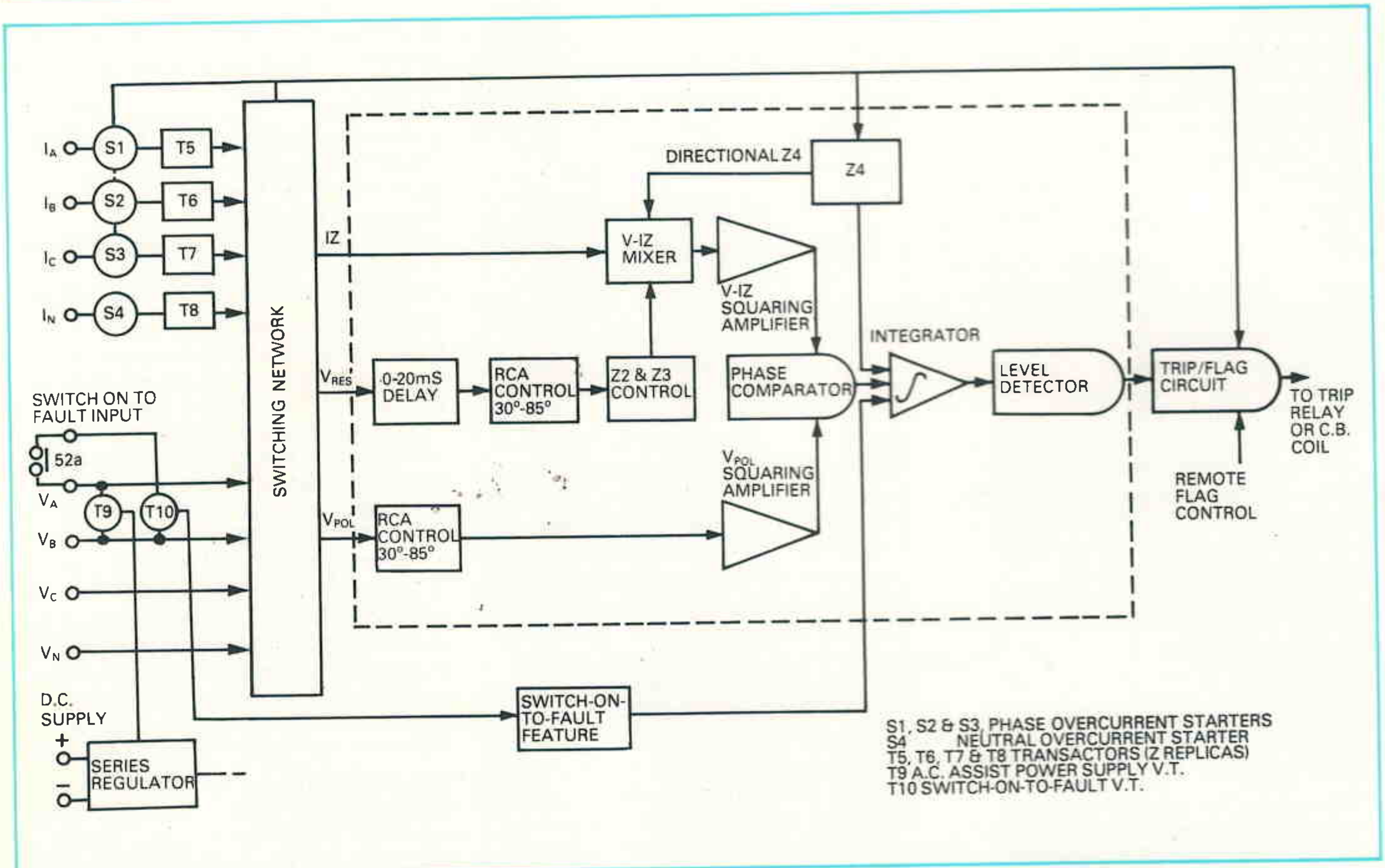
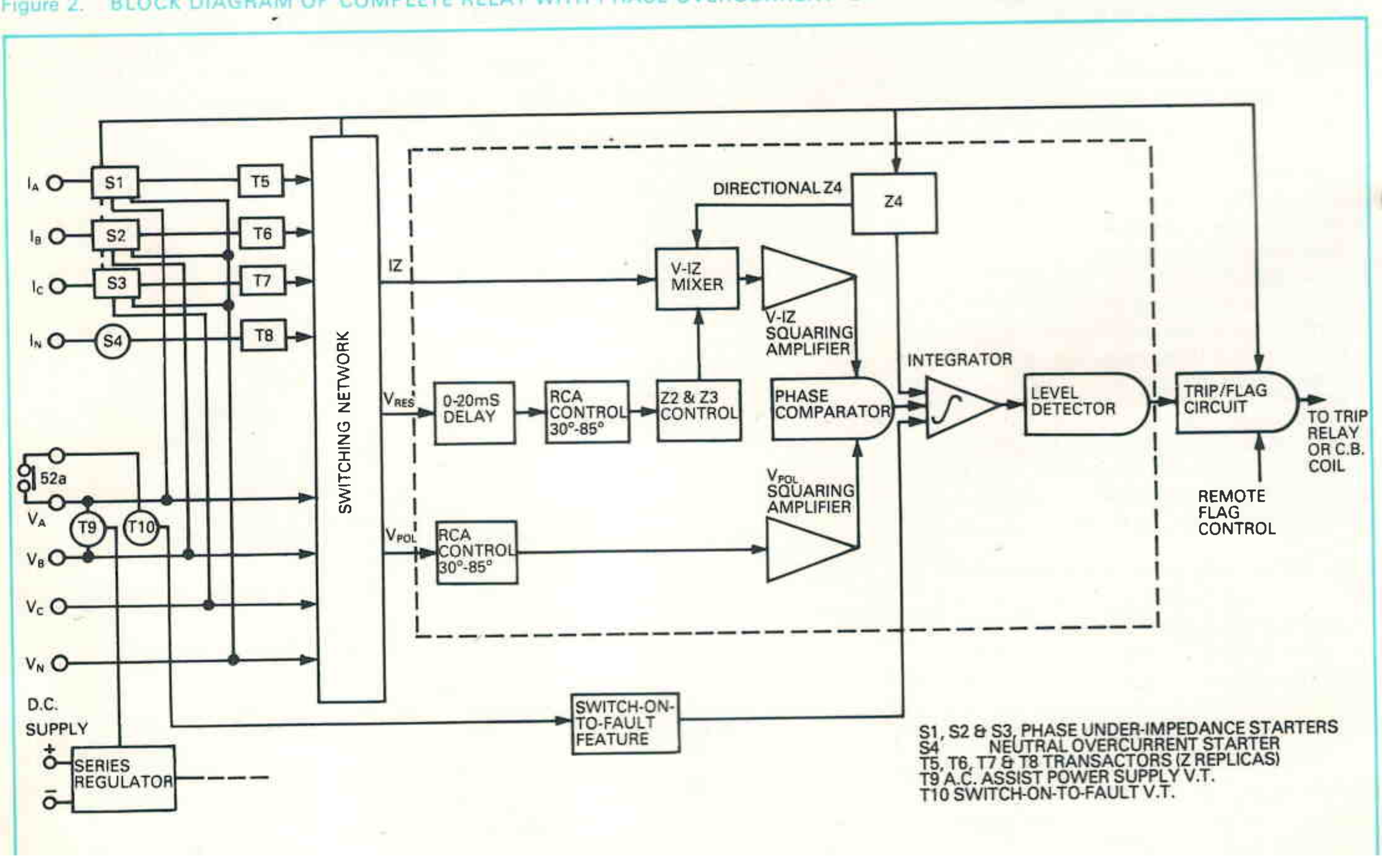


Figure 2. BLOCK DIAGRAM OF COMPLETE RELAY WITH PHASE OVERCURRENT STARTING ELEMENTS



PHASE OVERCURRENT STARTERS

Figure 4(a) shows a block diagram for the overcurrent starter.

A transactor is used which eliminates the effects of d.c. offsets. This ensures that the starter has no measurable transient overreach.

The transactor differentiates the primary current signal to produce a secondary voltage signal which is proportional to the primary signal. This signal is fed into a phase splitting network producing a three phase waveform which is then rectified to produce a d.c. operating voltage signal. This technique enables very short starter operating times to be achieved.

The d.c. operate signal is fed in parallel with a restraint voltage signal derived from the d.c. rails into an operational amplifier having a capacitive feedback loop.

The circuit is arranged so that, at the boundary of operation of the overcurrent starter, the two signals are summed to zero, causing the output of the amplifier to rise. This signal is then fed into a Schmidt-type trigger circuit which, at a predetermined level, operates to produce an output signal.

Adjustment of current setting is carried out using a potentiometer designated K which is mounted on the front plate of the starter module. The range of adjustment is 50% to 300% of rated current.

NEUTRAL OVERCURRENT STARTER

The neutral overcurrent starter circuit is similar to its phase overcurrent counterpart, the only difference being that it has a fixed current setting of 20% of rated current.

IMPEDANCE STARTER

Figure 4(b) shows a block diagram of the impedance starter which monitors phase current and Ph-N voltage and detects both phase and earth faults. The impedance starter does not have a fixed impedance characteristic and is more accurately described as a voltage controlled overcurrent device.

Figure 5 shows the voltage/current characteristic for voltage transformer secondary ratings of 110V a.c. Between 65% and 100% of rated Ph-N voltage the overcurrent starter behaves as an overcurrent unit with a fixed setting of 25% of rated current.

The a.c. current and voltage input signals are converted into d.c. operating and restraining signals respectively, using the same design techniques as described for the phase overcurrent starter.

A curve shaping circuit is employed in the a.c. voltage circuit to form the knee of the characteristic and includes the slope adjustment potentiometer designated K which is mounted on the front plate of the starter module.

The operating and restraining voltage signals together with a d.c. bias signal are added together and fed into an operational amplifier having a capacitive feedback loop.

The circuit is arranged so that, at the boundary of operation of the starter, the three signals are summed to zero causing the output of the amplifier to rise. This signal is then fed into a Schmidt type trigger circuit which, at a predetermined level, operates to produce an output signal.

Potentiometer K is calibrated to cover an impedance range of 20 ohms to 70 ohms for 1A relays and 4 ohms to 14 ohms for 5A relays, each at rated Ph-N voltage.

The three impedance starters have no residual compensation. Figures 6, 7 and 8 show the reach characteristic for three types of fault. These are applicable to voltage transformer secondary ratings of 110V a.c.

For a.c. voltage ratings of 100V, 115V and 120V, the voltage/current characteristic and hence the reach characteristics will vary. Details of these can be supplied on request.

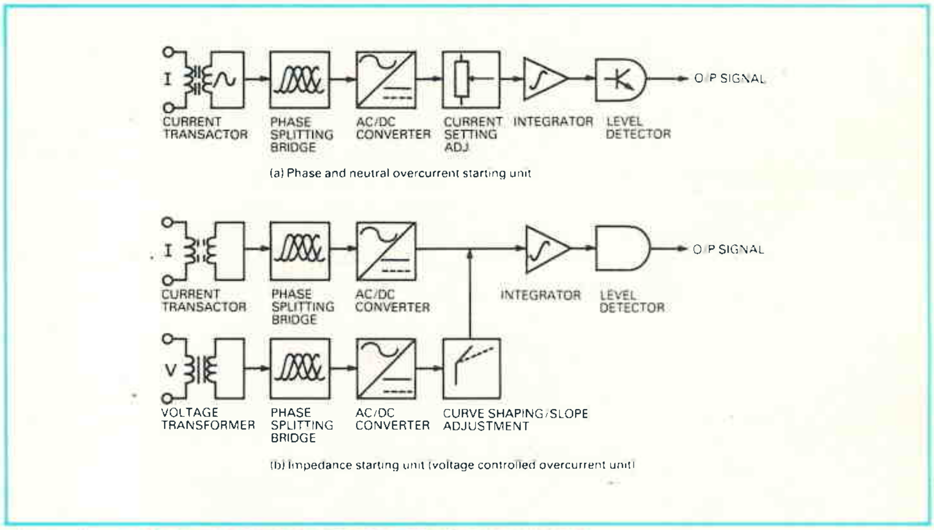
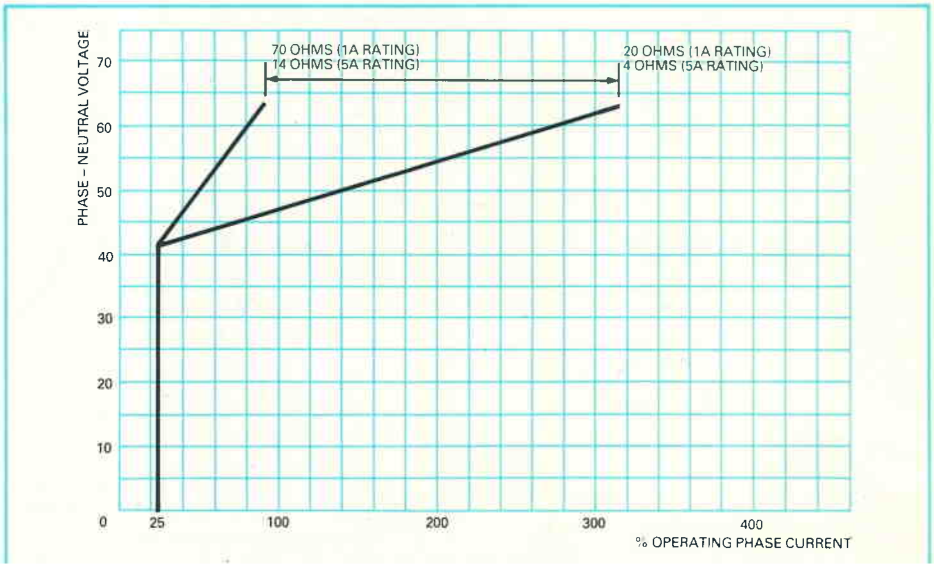


Figure 4. BLOCK DIAGRAM OF STARTING ELEMENTS



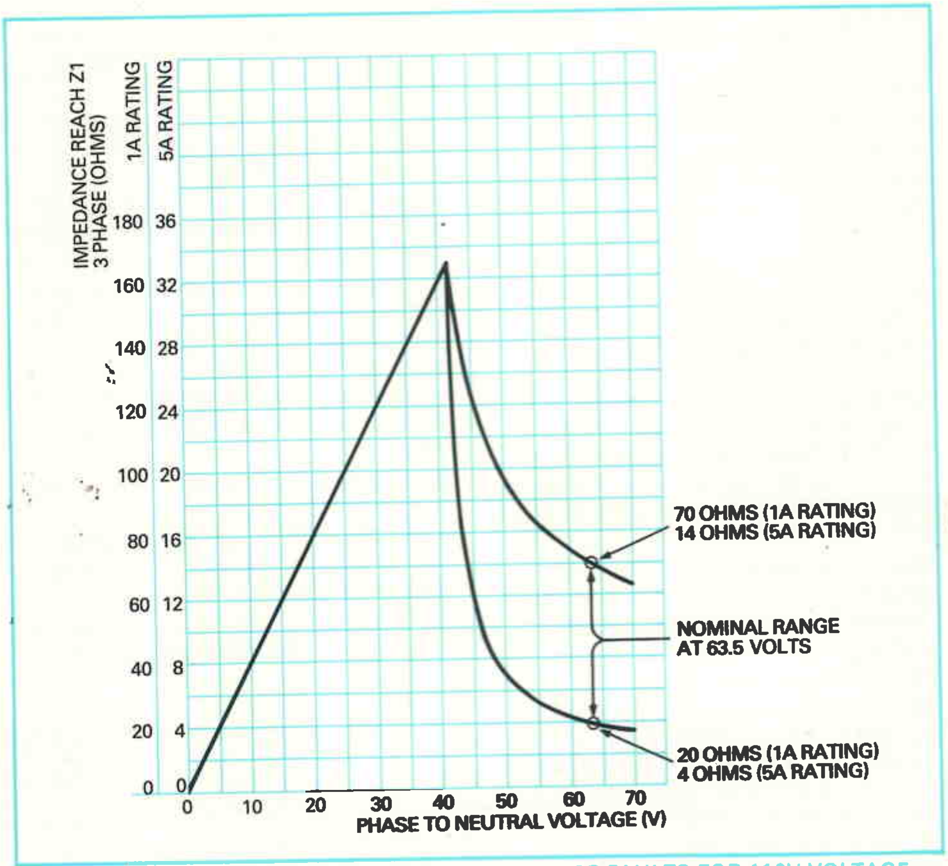
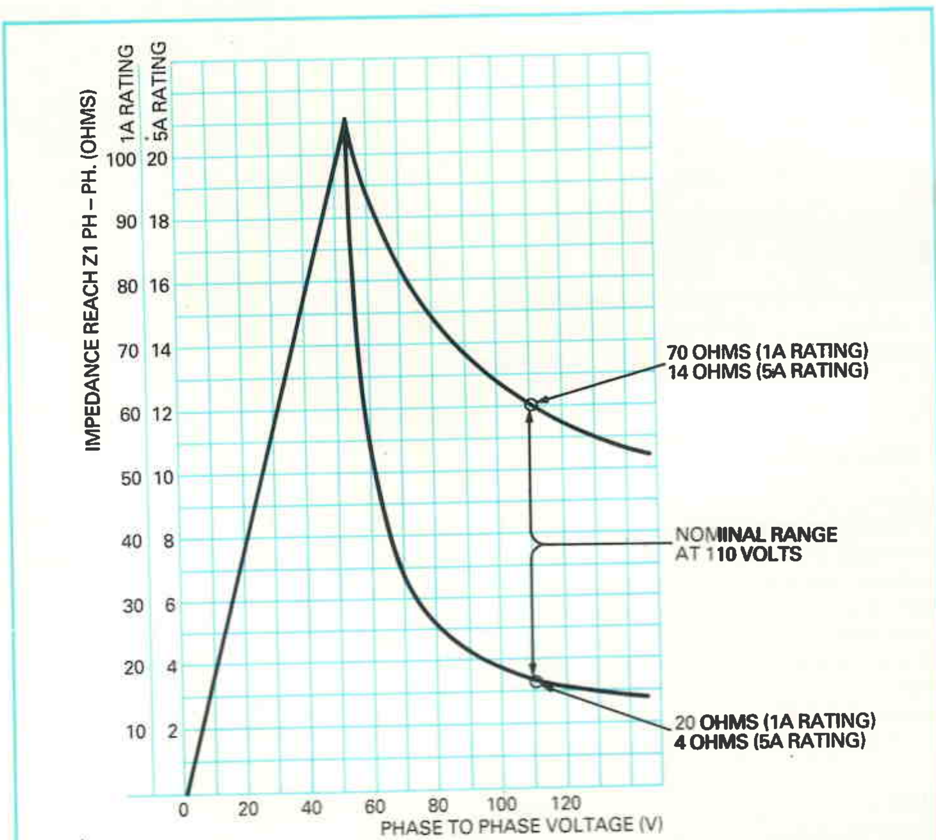


Figure 6. IMPEDANCE STARTER REACH FOR 3 PHASE FAULTS FOR 110V VOLTAGE TRANSFORMER SECONDARY RATINGS



The impedance range limiting values are nominal and refer to the 3 phase fault condition

MEASURING UNIT CHARACTERISTICS

Unbalanced faults in the forward direction

When an unbalanced fault occurs in the protected zone, the mho characteristic expands along the resistance axis, the expansion being a function of the source impedance, as shown in Figure 9. This provides an extended fault resistance tolerance.

Unbalanced reverse faults

When an unbalanced reverse fault occurs, the mho characteristic moves away from the origin to an offset position. This provides the scheme with greatly improved directional stability for reverse faults.

Balanced three phase faults

When a balanced three phase fault occurs the phase voltages collapse symmetrically and the measuring unit operates with a normal mho characteristic.

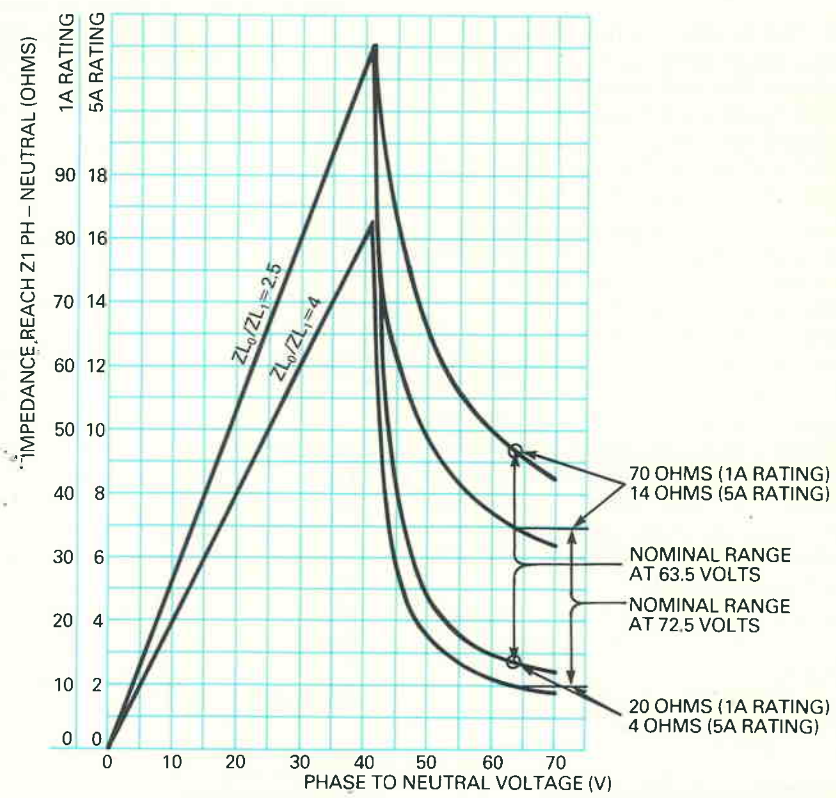
INPUT CIRCUITS

Tapped primary windings are provided on each transactor. These permit a coarse reach adjustment. Zone 1 fine reach adjustment is made in the transactor secondary circuit. The setting range is continuously adjustable from 0·05 ohms to 40 ohms for 1A relays or 0·01 ohms to 8 ohms for 5A relays.

Depending upon the fault condition, an output from the appropriate transactor is selected by the switching network.

Transformers and phase shift networks are the main components of the voltage input circuits. These provide a characteristic angle adjustment from 30° to 85° in steps of 5°. The faulty phase or phases are selected before the switching network can pass voltage signals to the appropriate amplifier.

The V-IZ and the V POL sine wave signals are both 'squared' by integrated circuit operational amplifiers before the phase angle between the two signals is compared.



The impedance range limiting values are nominal and refer to the 3 phase fault condition

Figure 8. IMPEDANCE STARTER REACH FOR PHASE-EARTH FAULTS FOR 110V VOLTAGE TRANSFORMER SECONDARY RATINGS

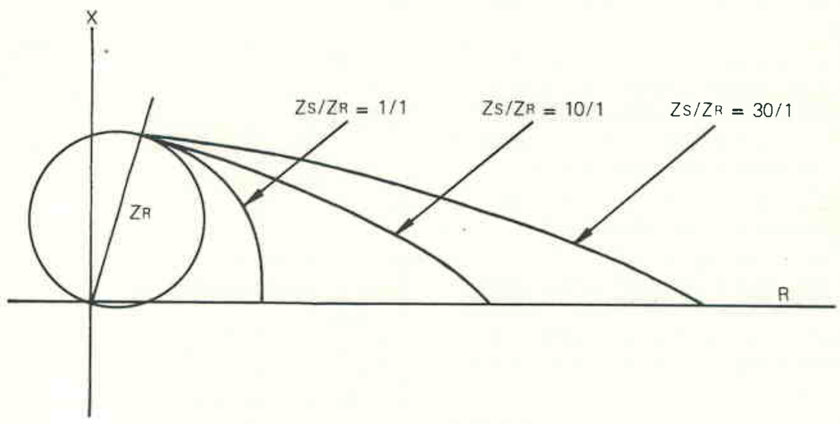


Figure 9. TYPICAL EXPANDING CHARACTERISTIC OF MHO UNIT FOR UNBALANCED FAULT IN THE FORWARD DIRECTION

PHASE COMPARATOR

The comparator is a two input coincidence detector which compares both positive and negative half cycles of the input waveforms. The circuit includes two series connected transistors which conduct when both inputs are of the same polarity.

The output from the comparator is fed to an integrator which employs an operational amplifier with a capacitive feedback loop. The integrator output is measured by a level detector which determines the boundaries of operation.

Figure 10 shows both the comparator and the integrator output waveforms, together with the appropriate trip and reset levels. The integrator waveforms are shown for a boundary condition and also for faults inside and outside the characteristics.

Figures 11, 12 and 13 show typical operating times and measuring accuracy.

INSTANTANEOUS 'SWITCH-ON-TO-FAULT' FEATURE

When a line is energized on to a close-up three phase metallic short circuit, the voltage at the relaying point will be zero. For example, this type of fault may occur when earthing clamps are inadvertently left on the lines. Faults such as these would normally be cleared by the back-up protection.

The design considerations which make the instantaneous 'switch-on-to-fault' facility possible, are based on the assumption of zero voltage on the line before the fault occurs.

When switching the line on to a fault condition resulting from earthing clamps, an instantaneous trip will occur. The voltage applied to the relay is low and this condition occurring simultaneously with the operation of the starters, will give a trip signal.

Faults occurring on an energized line will not be affected by this circuit. It is so arranged that, from a normally energized state, at least 20 seconds must elapse before a trip signal is given. This delay provides time for the operation of auto-reclose facilities and measurement through the time delayed impedance zones.

Where busbar voltage transformers are used, this circuit is energized via an auxiliary contact of the circuit breaker.

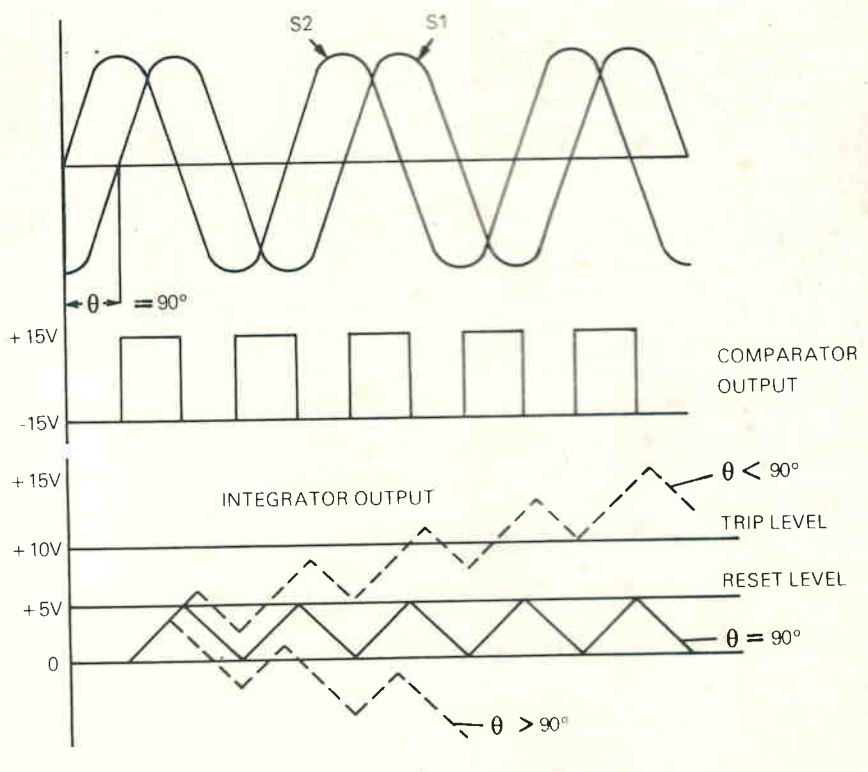
Type of fault	Overcurrent or impedance starter operated	Fault measured between
A-E	A & N	A-E
B-E	B & N	B-E
C-E	C & N	C-E
A-B	A & B	A-B
B-C	B & C	B-C
C-A	C & A	C-A
A-B-C	A, B & C	C-A
A-B-E	A, B & N	A-B
B-C-E	B, C & N	B-C
C-A-E	C, A & N	C-A

Table 1 RELAY OPERATING MODE – SOLID OR RESISTANCE EARTHED SYSTEMS

Type of fault	Overcurrent starters operated	Fault measured as
AB	A	A-B
BC	C	B-C
CA	C & A	C-A
AE & BE	A & N	A-E
	A	A-B
	N	—

Type of fault	Overcurrent starters operated	Fault measured as
BE & CE	C & N	C-E
	C	B-C
	N	—
CE & AE	C & N	C-E
	A & N	A-E
	C & A	C-A
	C, A & N	C-E

Table 2 RELAY OPERATING MODE – PETERSEN COIL EARTHED OR INSULATED SYSTEMS (PHASE PREFERENCE: C BEFORE A BEFORE B)



ZONE TIME DELAY ELEMENTS AND SETTINGS

The Zone 2 time delay element extends the reach of Zone 1 by a factor determined by the zone multiplier setting K_2 after a time delay determined by t_{Z2}.

Similarly, the Zone 3 time delay element extends the reach of Zone 1 by a factor determined by the zone multiplier setting K_3 after a time delay determined by t_{Z3}.

When a Zone 4 time delay element is included its time setting range is determined by t_{Z4}.

The Zone 4 reach setting is independent of the mho measuring element and is determined solely by the setting of the starter which is non-directional.

Internal links are provided to enable the Zone 4 characteristic to be directionalized or inhibited as required. This is shown in Figure 1.

INSTANTANEOUS ZONE EXTENSION

A zone extension feature is available which instantaneously extends the reach of Zone 1 by a factor determined by the instantaneous control setting KC.

TRIP CIRCUIT

The trip circuit utilizes a mercury-wetted reed contact which is capable of direct tripping duties.

A second electrically-separate trip contact can be provided when required.

Two auxiliary reed contacts of a lower rating are included as a standard feature, which may be used for alarm purposes.

FAULT INDICATION

Miniature rotary operation indicators are mounted on the relay front panel. These provide flag indication which identifies the phase(s) affected, and the zone in which tripping has occurred.

The indicator comprises a cylindrical permanent magnet which rotates between the poles of an electromagnet when the encapsulated coil is energized.

The magnet rotates through 180° and exposes the flag. This remains exposed when the signal is removed and is reset when an energizing signal of reverse polarity is applied.

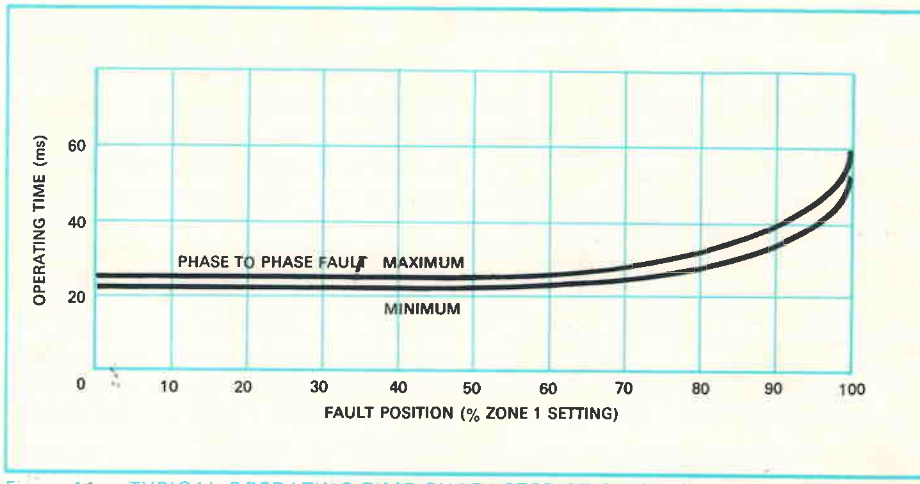


Figure 11. TYPICAL OPERATING TIME CHARACTERISTIC USING OVERCURRENT STARTERS

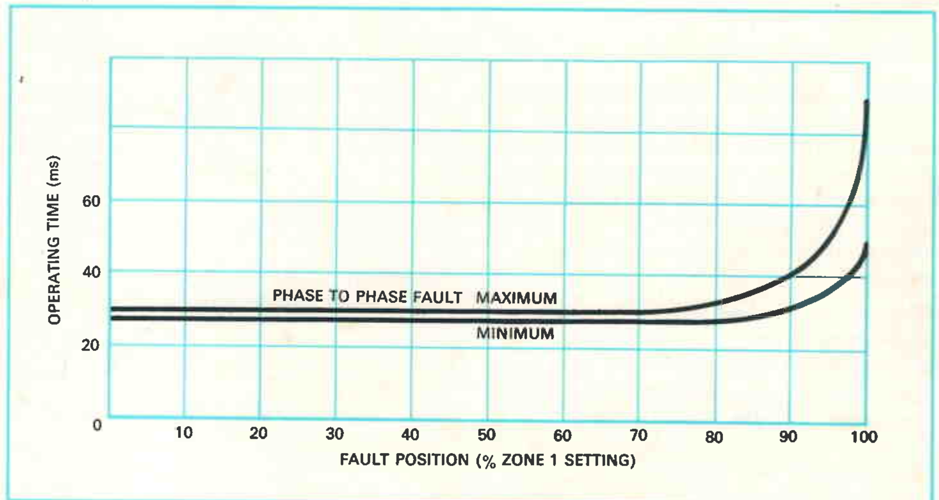


Figure 12. TYPICAL OPERATING TIME CHARACTERISTIC USING UNDER IMPEDANCE STARTERS

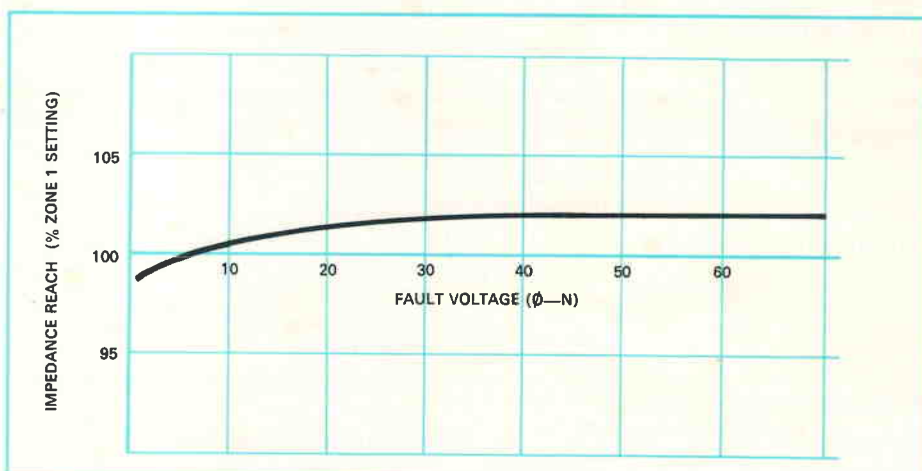


Figure 13. TYPICAL MEASURING ACCURACY CHARACTERISTIC

operate automatically at the instant of tripping.

If the relay is part of the blocking or permissive overreach scheme, a remote flag control feature can be

POWER SUPPLY

The power supply arrangement comprises a series regulator supplemented by an a.c. assisting circuit fed from the A-B phases of the line voltage transformer secondary windings, via an isolating voltage transformer mounted in the rear of the modular case. Under quiescent conditions, the load current taken by the starters, the power swing blocking unit, and the residual compensation module in the PYTC, is supplied by the a.c. assisting circuit.

Under fault conditions, the d.c. current demanded by the relay is taken from the station battery supply through the series regulator.

POWER SWING BLOCKING

An impedance starter version of the relay is used when the protection system requires power swing blocking. A fourth impedance element is included in the scheme, set so that its operating characteristic surrounds the impedance starter characteristic.

The difference between a power system fault and a power swing is detected by measurement of the time taken for the impedance locus to pass between the two impedance characteristics. Different rates of power swing are accommodated by an adjustable time setting over the range 40 ms to 80 ms.

The power swing blocking unit is automatically overridden by the residual overcurrent starter under earth fault conditions.

Override facilities are provided to allow the relay to operate in selected zones even though the power swing blocking unit has been energized. The various tripping/blocking modes can be selected by means of a selector switch P mounted on the front plate of the PSB unit.

These modes are as follows:
* Trip in all zones
* PSB in all zones
* Trip in Zone 1, PSB in Zones 2, 3 and 4
* Trip in Zones 1 and 2, PSB in Zones 3 and 4
* Trip in Zones 1, 2 and 3, PSB in Zone 4

BASIC SCHEME OPTIONS

All schemes may be provided with high speed fuse failure protection and schemes with impedance starters may be fitted with power swing blocking.

Two arrangements of each scheme are available:
* 1 phase and 3 phase tripping
* 3 phase tripping

ZONE EXTENSION SCHEME

This provides fast clearance of the end zone faults without the need for signalling equipment. It is used with auto-reclose equipment so that end zone faults are cleared quickly by an overreaching zone of the protection set to reach beyond the remote busbars. The protection reverts to the Zone 1 reach before reclosure takes place. The scheme is particularly useful for fast clearance of transient end zone faults, permanent end zone faults being cleared in Zone 2 time after reclosure.

SCHEMES USING PROTECTION SIGNALLING EQUIPMENT

Protection signalling equipment is used to provide fast clearance of end zone faults which may occur at both ends of the protected line.

The following schemes are available:
* Zone acceleration
* Permissive underreach transfer trip
* Permissive overreach transfer trip
* Blocking

Details of these schemes are available on request.

TECHNICAL DATA

The relay conforms to: British Standard 142: 1966 'Electrical Protective Relays' and International Electrotechnical Commission Standard 255: 'Electrical Relays'

Nominal ratings

Current: 1A or 5A

Voltage: 100V, 110V, 115V or 120V

Frequency (Hz):

Rating	Range
50	47–51
60	57–62

Auxiliary d.c. supply (Vx):

Rated voltage (V d.c.)	Operative range (V d.c.)
48/50	40–60
110/125	66–150
220/250	132–300

Thermal rating

Continuous: Twice rated current and 120% rated voltage on any setting

Short time: 50 × rated current for one second

Settings

Reach settings:

Zone 1 1A relays – 0·05 ohms to 40 ohms continuously adjustable
5A relays – 0·01 ohms to 8 ohms continuously adjustable

Zone 2 1 to 5 times Zone 1 setting

Zone 3 1 to 20 times Zone 1 setting

... extended by factor of 1 to 2 × setting exclusively for earth

Overcurrent starters: 50% to 300% rated current, continuously adjustable.

Residual overcurrent starter: 20% rated current (fixed setting)

Impedance starter: Pick-up current at zero volts at 0·25 × rated current. The impedance reach (Z_R) for 3 phase faults at nominal voltage is 20 ohms to 70 ohms for 1A relay or 4 ohms to 14 ohms for 5A relay.

The phase to phase reach of the units is 0·866 Z_R at the rated voltage. The impedance starters are not provided with residual compensation for earth fault measurement. Consequently, the reach is dependent upon the protected line Z_o/Z_1 impedance ratio.

The minimum earth fault reach of the units is $\frac{Z_R}{1 + K}$ where $K = \frac{Z_o - Z_1}{3Z_1}$

for a system with a single earthing point at the source behind the relay location. For practical systems the reach will be between this value and Z_R.

Power swing blocking: Pick-up current at zero volts set at 0·15 × rated current.

The impedance reach at rated voltage is:
20 ohms to 70 ohms for 1A relays
4 ohms to 14 ohms for 5A relays

Time setting (t_p): 40 ms to 80 ms continuously adjustable.

Resetting characteristics

Impedance starter and power swing blocking element	Less than 105% of setting
Overcurrent starter	Greater than 95% of setting
Transient overreach	Less than 1% of setting

Operating times

Zone 1 Minimum overall operating time 20 ms. Typical overall operating time 30 ms, see Figures 11 and 12.
Less than 40 ms, up to 80% reach with source/line impedance ratios up to 100/1 (phase faults) or 60/1 (earth faults).

Zone 2 0·2s to 2·0s continuously adjustable
Zone 3 0·5s to 5·0s continuously adjustable
Zone 4 0·5s to 5·0s continuously adjustable

Impedance starters alone	Not greater than 15 ms at 0·5 × setting
Overcurrent starters alone	Not greater than 12 ms at 2 × setting

Reset time

Less than 50 ms

Characteristic angle

30° to 85° adjustable in steps of 5°.

Residual compensation ranges

PYTS: 50 to 150% of selected neutral impedance setting
PYTC: 0 to 100% of selected neutral impedance setting and angular adjustment of 0–360° in 5° steps.
(0–400% range is available for special applications).
For further information refer to Section entitled RELAY SETTING ADJUSTMENTS.

Characteristic impedance ratios

100 : 1 for phase faults
60 : 1 for earth faults

Ambient temperature range

−5°C to +50°C

Accuracy

Impedance reach of mho measuring element

Zone	Voltage range	Accuracy*
1	Rated voltage to 5V Less than 5V to 1V	±5% ±10%
2	—	±10%
3		±15%

Starting elements:	Including Zone 4 when fitted	
	Impedance type	±5%
	Overcurrent type	±5%
Zone time delay elements:		±5% of any setting or 25 ms whichever is the greater.
Phase angle:	Relay characteristic angle (R.C.A.)	±1·2° of indicated angle setting
	Neutral compensation angle (θ_N) (PYTC Relay only)	±1·2° of indicated angle setting
Variation of ambient temperature:	Range – 5°C to +50°C	±5%
Variation of frequency:	Over stated frequency range	±5%

Burdens

A.C. voltage circuits (at rated voltage):	Under normal load conditions	5·2VA per phase maximum
	Under fault conditions	5·6VA per phase maximum
A.C. current circuits (at rated current):	Under normal load conditions	1A relay, 1·3VA to 1·8VA 5A relay, 1·8VA to 3·2VA
	Under fault conditions	1A relay, 2·5VA to 3·5VA 5A relay, 3·6VA to 6·6VA
Auxiliary d.c. supply:	Under quiescent conditions	Nominally 5 mA
	Under the most onerous fault conditions	Less than 1A

Contacts

All the contacts tabled below are of the make, or normally open pattern

Function	Number of contacts	Contact Ref.	Contact rating: Make and carry	Contact rating: Break
Trip: main	1 or 2*	86X 86Y*	30A maximum at 110V d.c. resistive, for 0·2s	5A maximum at 110V d.c. resistive
Trip: auxiliary	2	86Z	25VA d.c. with maxima of 1A and 250V.	
Starter auxiliary				
– Phase A	2	AS		
– Phase B	2	BS		
– Phase C	2	CS		
– Neutral	2	NS		
– Common repeat	2	DX		
Zone 2 auxiliary	1	AR		
Zone repeat: (remote indication)				
Zone 1	1*	Z1		
Zone 2	1*	Z2		
Zone 3	1*	Z3		
Zone 4	1*	Z4		

*Optional extras

Insulation

The relay will withstand:
2 kV, 50 Hz for 1 minute between all circuits and the case and also between all separate circuits.
1 kV, 50 Hz for 1 minute between normally open reed contacts.

Impulse withstand

The relay will withstand impulses of 5 kV peak and 1·2/50μs waveform applied both transversely and between relay terminals and earth, in accordance with IEC Standard 255–4 Appendix E.

High frequency disturbance

The relay meets the requirements of IEC Standard 255–4 Appendix E for the high frequency disturbance test in which repetitive 1 MHz bursts having an initial peak of 1·0 kV are superimposed across input circuits, and of 2·5kV are superimposed between independent circuits and circuits to earth with a decay time to half amplitude, of 3 to 6 μs. This is carried out with the relay energized.

CURRENT TRANSFORMER

To ensure that the scheme operating times are not seriously affected by CT

$$V_k = I_f \cdot \left[\frac{X}{R} + 1\right] \cdot [R_{CT} + R_L + M]$$

Where V_k = the 'knee point' voltage of the CT which is defined as the point of the magnetizing characteristic at which a 10% increase of voltage produces a 50% increase in magnetizing current (V).

$\frac{X}{R}$ = the primary system reactance/resistance ratio for a fault at the Zone 1 reach point.

I_n = rated current (A)

I_f = the secondary equivalent of the maximum fault current for a fault at the Zone 1 reach point (A).

R_{CT} = resistance of the CT secondary winding (ohms).

R_L = resistance of the secondary leads (lead and return for earth faults, lead only for phase faults) (ohms).

M = impedance of the relay current circuits (ohms/phase).

$= \frac{\text{burden (VA) at rated current}}{I_n^2}$

RELAY SETTING ADJUSTMENTS

The Zone 1 impedance setting range is continuously adjustable from 0·05 ohms to 40 ohms (1A) or 0·01 ohms to 8 ohms (5A). A particular setting is selected by means of a plug tapping K_Z on the primary of the current circuit transactors, a fine adjustment potentiometer K_1 in the transactor secondary circuit and a range multiplier switch K_D in the voltage restraint circuit. The positions of K_D are 0·1X, 1X, 2X and ∞.

The plug tapping K_Z has seven tappings of 0, 1, 2, 3, 5, 10 and 20 ohms (1A) and 0, 0·2, 0·4, 0·6, 1·0, 2·0 and 4·0 (5A).

The fine adjustment potentiometers $K_{1A,B,C}$ give continuous adjustment of 0·5 to 1·0.

A fine adjustment potentiometer K_{1N} is provided on a transactor in the residual circuit to give correct measurement under earth fault conditions.

The range of this potentiometer on the PYTS is 0·5 to 1·5 thus giving a range of 50% to 150% compensation for earth faults. The standard range of this potentiometer on the PYTC is 0–1·0 (or 0–4·0 for special applications).

On the PYTC, a further residual compensation angle adjustment is provided using a phase shift circuit incorporating two switches designated a1 and a2:

a1 covers a range of 0° to 55° in steps of 5°.
a2 covers a range of 0°, −60°, −120°, −180°, +120° and +60°.

The addition of a1 and a2 sets the residual compensation angle, θ_N.

The Zone 2 setting range is 1 to 5 times the Zone 1 setting. This adjustment is by potentiometer K_2 in the voltage restraint circuit.

The Zone 3 setting range is 1 to 20 times the Zone 1 setting. This adjustment is by means of a potentiometer K_3 in the voltage restraint circuit.

Impedance settings

Zone 1 reach setting (Z1) = $K_Z.K_1.K_D$
Zone 2 reach setting (Z2) = $K_2.K_Z.K_1.K_D$
Zone 3 reach setting (Z3) = $K_3.K_Z.K_1.K_D$

Residual compensation settings

Scalar compensation setting, for PYTS and PYTC relays:

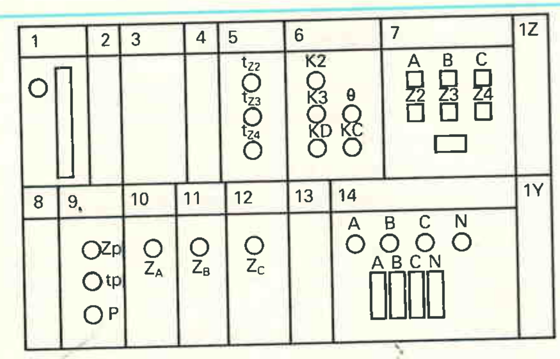
$$= \frac{Zo - Z_1}{3Z_1} \times \text{Zone 1 setting} = K_{1N}.K_{ZN}$$

where K_{1N} and K_{2N} are the fine and coarse adjustments on the neutral transactor.

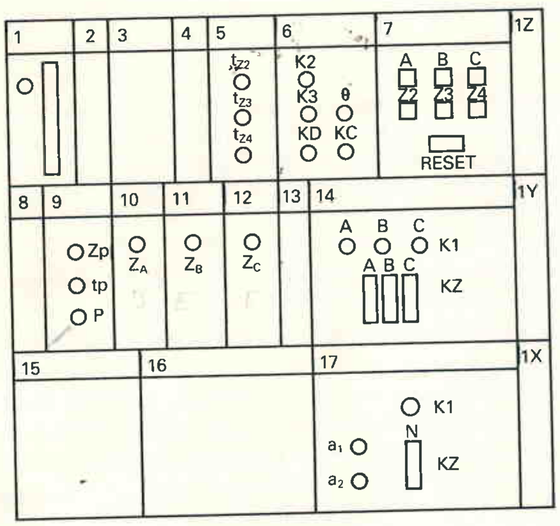
Angular compensation setting, for PYTC relay only:

$$= \frac{|Zo| \angle \theta o \; - \; |Z_1| \angle \theta_1}{3\,|Z_1| \angle \theta_1} = \frac{K_{ZN}.K_{1N}.\angle \theta_N}{K_{ZA}.K_{1A}}$$

where Z_1 = the positive sequence impedance of the protected line in ohms/km



(a) Typical distance protection type PYTS with impedance starters and power swing blocking unit.



(b) Distance protection type PYTC.

Figure 14. DIAGRAM OF MODULE LAYOUT

KEY TO NAMEPLATE SYMBOLS

I_n	Rated a.c. current (A)
V_x	Rated d.c. voltage
V_n	Rated a.c. voltage
K_Z	Coarse adjustment of reach setting
K_1	Fine adjustment of reach setting
K_2	Zone 2 multiplier
K_3	Zone 3 multiplier
K_C	Instantaneous control multiplier
K_D	Reach multiplier switch
θ	Relay characteristic angle
$I_{s(A,B,C)}$	Phase overcurrent starter setting
$I_{s(N)}$	Neutral overcurrent starter setting (fixed)
$Z_{(A,B,C)}$	Impedance starter setting
Z_p	Power swing blocking setting
P	Power swing blocking override selector switch
t_p (ms)	Time delay for power swing blocking
t_{Z2}(s)	Zone 2 time delay (seconds)
t_{Z3}(s)	Zone 3 time delay (seconds)
t_{Z4}(s)	Zone 4 time delay (seconds)
a_1, a_2	Residual compensation angle settings ($\theta_N = a_1 + a_2$) Used on PYTC only

KEY TO MODULES

Module Position No.	Module Reference No. – PYTS	Module Reference No. – PYTC	Module Function
1	RPD 03	RPD 03	D.C. power supply
2	RWR 01	RWR 01	Switching of d.c. supply
3	RWR 02	RWR 02	Switching of mho measuring element
4	RMA 03	RMA 03	Mho measuring element (comparator)
5	RTD 04	RTD 04	Zone timer delay elements
6	RFV 01	RFV 01	A.C. voltage circuits
7	RVM 01	RVM 01	Tripping and flag indication
8	RVC 02	RVC 02	Remote zone indication
9	RCB 01	ZBB 06	Power swing blocking (Blank module when PSB not included)
10 } 11 } 12 }	RSZ 01 (RSC 04)	RSZ 01 (RSC 04)	Impedance starters (Phase overcurrent starters)
13	RSC 03	RSC 03	Neutral overcurrent starter
14	RFC 02	—	A.C. current circuits (Phases and neutral)
14	—	RFC 08	A.C. current circuits (phases only)
15	—	ZBB 12	Blank
16	—	ZBB 15	Blank
17	—	RFC 07	A.C. current circuit (neutral)

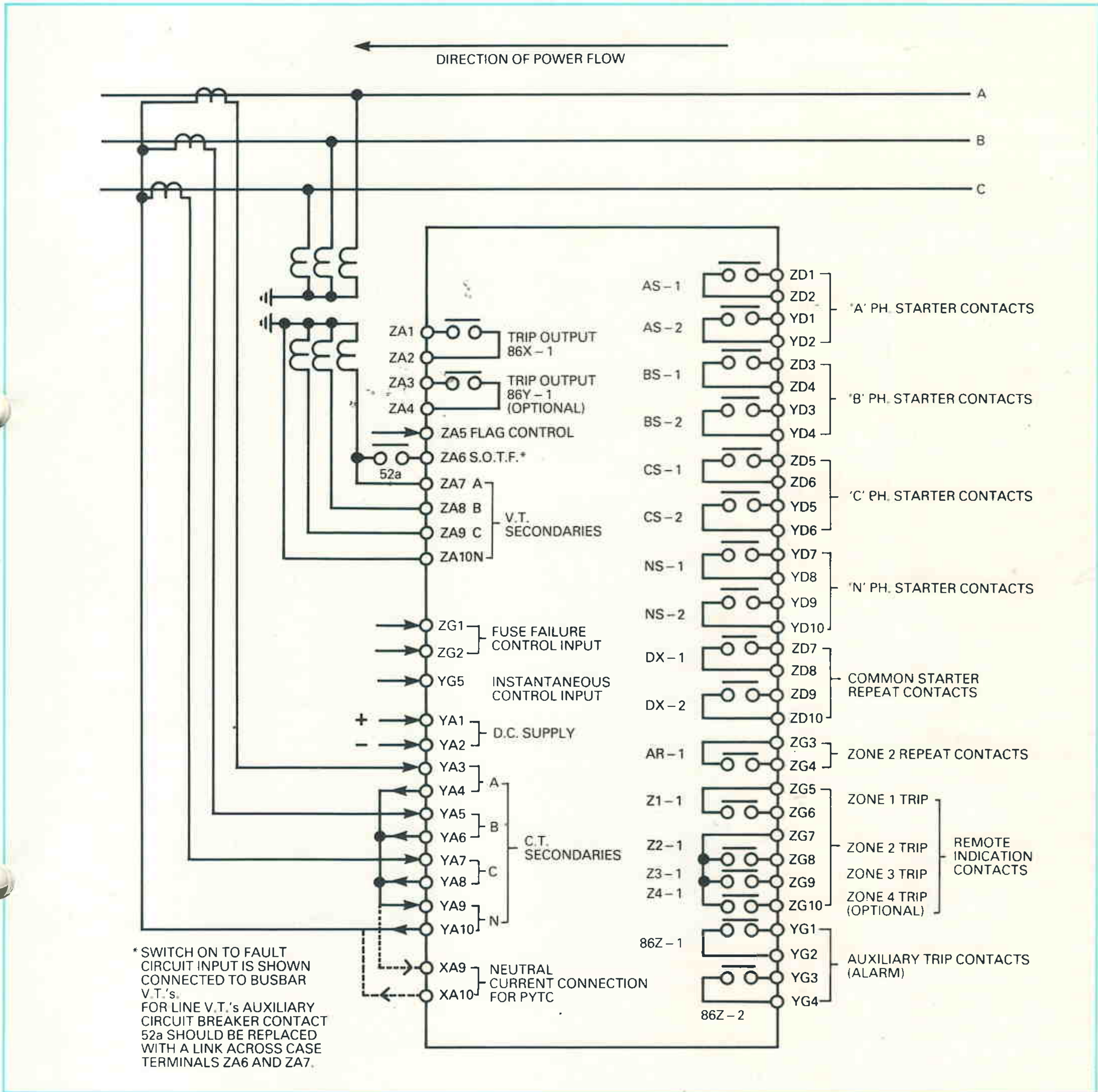


Figure 15. BASIC CONNECTION DIAGRAM FOR SWITCHED DISTANCE PROTECTION TYPES PYTS AND PYTC

CASES

The relays are housed in internationally accepted 483 mm (19") cases, in two sub-racks for the PYTS and three sub-racks for the PYTC. These are available in flush form for panel or rack mounting or in semi-projection form for panel mounting only. All cases are fitted with glazed front covers.

The cases are finished in black with front cover frames and module front

Construction

The wholly static circuitry is mounted on a series of printed circuit boards incorporated in a number of standard plug-in modules.

The electrical circuits are completed via edge connectors on the printed circuit boards. Removal of a bridging plug in each sub-rack. isolates the modular circuitry. This allows an

from the case. Basic injection tests may be carried out using a specially designed heavy current plug which temporarily replaces the bridging plug.

The equipment is fitted with monitor points which allow the various elements to be checked during detailed testing or fault finding.

INFORMATION REQUIRED WITH ORDER

Nominal current rating – 1A or 5A

Nominal voltage rating – 100V, 110V, 115V or 120V

Frequency – 50 Hz or 60 Hz

Zone 1 impedance setting (secondary ohms)

Voltage of d.c. supply

Type of starter

Method of system earthing

Optional features required

Advice on applications is available when the information requested above is difficult to specify. Requests for advice should include the following details:

Voltage transformer ratio

Current transformer ratio

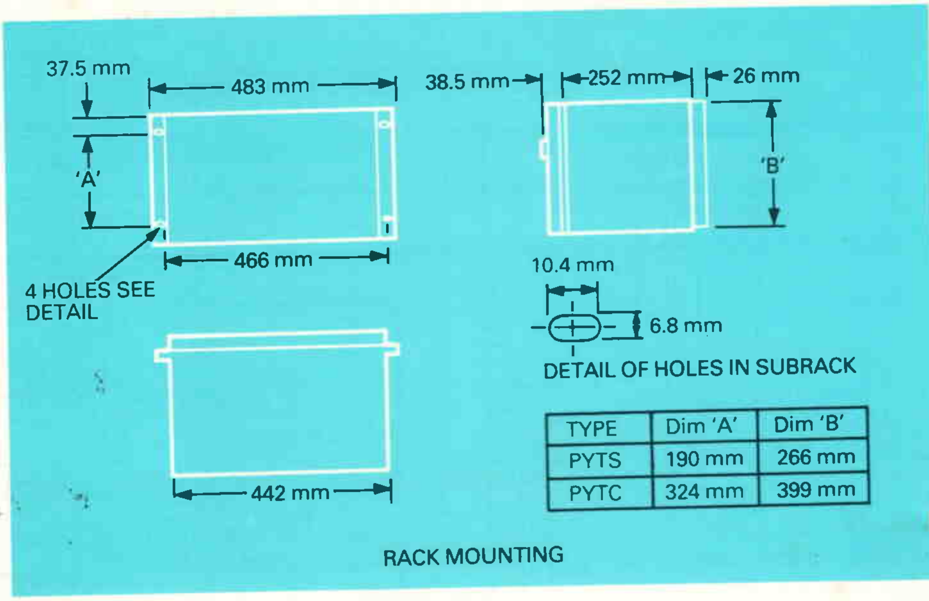
Current transformer knee-point voltage, C.T. winding resistance and lead burden

Positive and zero sequence impedances of the protected feeder or full details of feeder length and construction

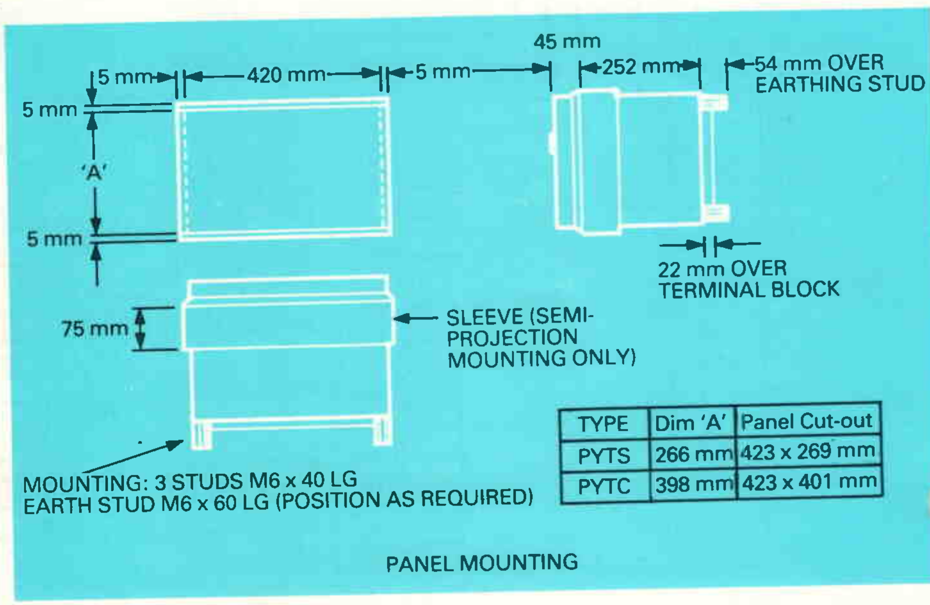
Source impedances or fault levels for both minimum and maximum plant conditions.

Method of system earthing:
If multiple and solid earthing, state maximum expected sound phase currents
If resistance earthed, give details of resistors
If Petersen-coil earthed, state if short-circuiting facilities are available

Maximum load current of the feeder



TYPE	Dim 'A'	Dim 'B'
PYTS	190 mm	266 mm
PYTC	324 mm	399 mm



TYPE	Dim 'A'	Panel Cut-out
PYTS	266 mm	423 x 269 mm
PYTC	398 mm	423 x 401 mm

Figure 16. CASE OUTLINES

GEC Measurements The General Electric Company, p.l.c., of England

St. Leonards Works Stafford ST17 4LX England

Telephone: 0785 3251 Telex: 36240 Cables: Measurements Stafford Telex