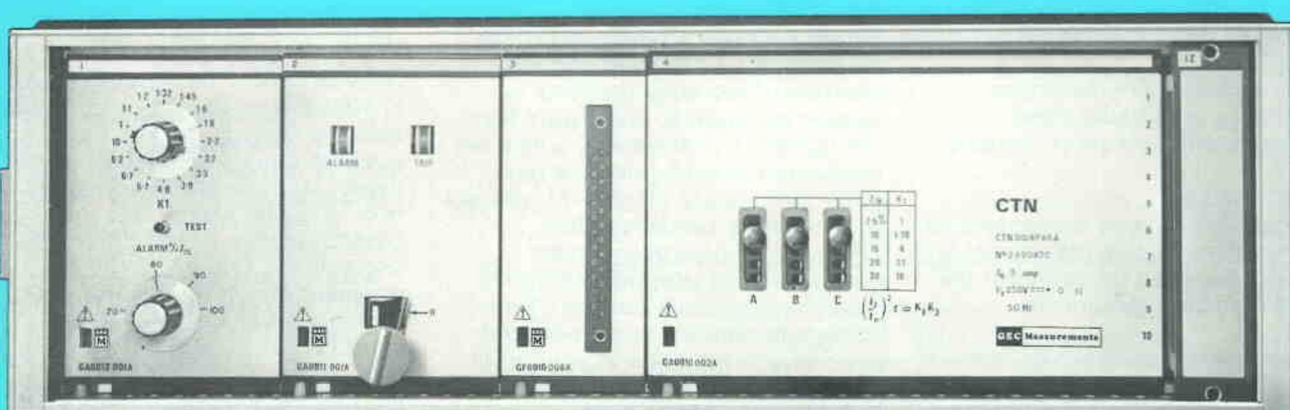
GEC Measurements

TYPE CTN

NEGATIVE PHASE SEQUENCE CURRENT RELAY



TYPE CTN

FEATURES

* Wide range of settings and operation charateristics
* Low burden
* Static design requiring no external filter box
* Fully self-contained compact assembly in modular case
* Separate trip and alarm outputs

APPLICATION

The type CTN relay is responsive to negative phase sequence current and has been designed primarily for the protection of a.c. generators.

Negative phase sequence currents in the stator of a generator, due to unbalanced loads or faults, induce double frequency eddy currents in the rotor. These currents, if allowed to persist, can cause serious over-heating, and the purpose of the CTN relay is to disconnect the machine before such excess temperature is reached. In order to avoid unneccessary tripping, the time characteristic of the relay must match the heating characteristic of the machine. Taps and a time multiplier setting give a range of time/current characteristics which cover most types of generator. The relay is also fitted with an alarm unit which has a fixed time delay of five seconds; a potentiometer controls the alarm setting between 70% and 100% of the main plug setting of the relay when ordering whether it is for rack or panel mounting.

DESCRIPTION

Figure 1 shows a block schematic diagram of a CTN relay and the location of the relay modules is shown in Figure 6. The inputs from the current transformers, which are connected in each phase of the generator supply (Figure 2), are fed to a negative sequence filter (Figure 3) which gives an a.c. output voltage proportional to the negative sequence current. This voltage is rectified and smoothed and fed into the squaring circuit of the main measuring element, the definite time delay circuit (0·3 seconds) and the alarm element.

The output from the squaring circuit is proportional to the square of the input voltage ($\propto I_2^2$) and is applied directly to the main timing circuit to give the required relationship between I_2^2 and the relay operating time t.

The voltage up to which the timing capacitors charge depends upon the voltage applied from the squaring circuit. This means that even when the negative sequence current is less than the relay setting, the timing capacitors will partly charge and reduce the relay operating time when the current by low levels of negative sequence current which may be present during nominally healthy running conditions.

The timer output is fed into a resistor chain, the output of which is selected by the K1 time multiplier selector switch. This sixteen position switch gives a far higher degree of accuracy than would have been possible using an ungraded potentiometer. When this output exceeds the reference voltage it provides one of the inputs to a two-input AND gate. The other input comes from the 0·3 seconds timer which is activated by the timer starter circuit when the negative sequence current exceeds the relay setting (I_{2s}). When both inputs to the AND gate are present, the hinged armature output relay is energised.

The starter and timer for the alarm circuit are very similar to those of the definite time delay circuit, except that a time delay of 5 seconds is provided. The starter circuit triggers the 5 second timer when the negative sequence current exceeds the alarm setting. After five seconds, two pairs of output reed contacts are operated. The alarm setting is adjustable betwen 70% and 100% of the main relay plug setting.

The type CTN relay is energised from an auxiliary d.c. supply, a

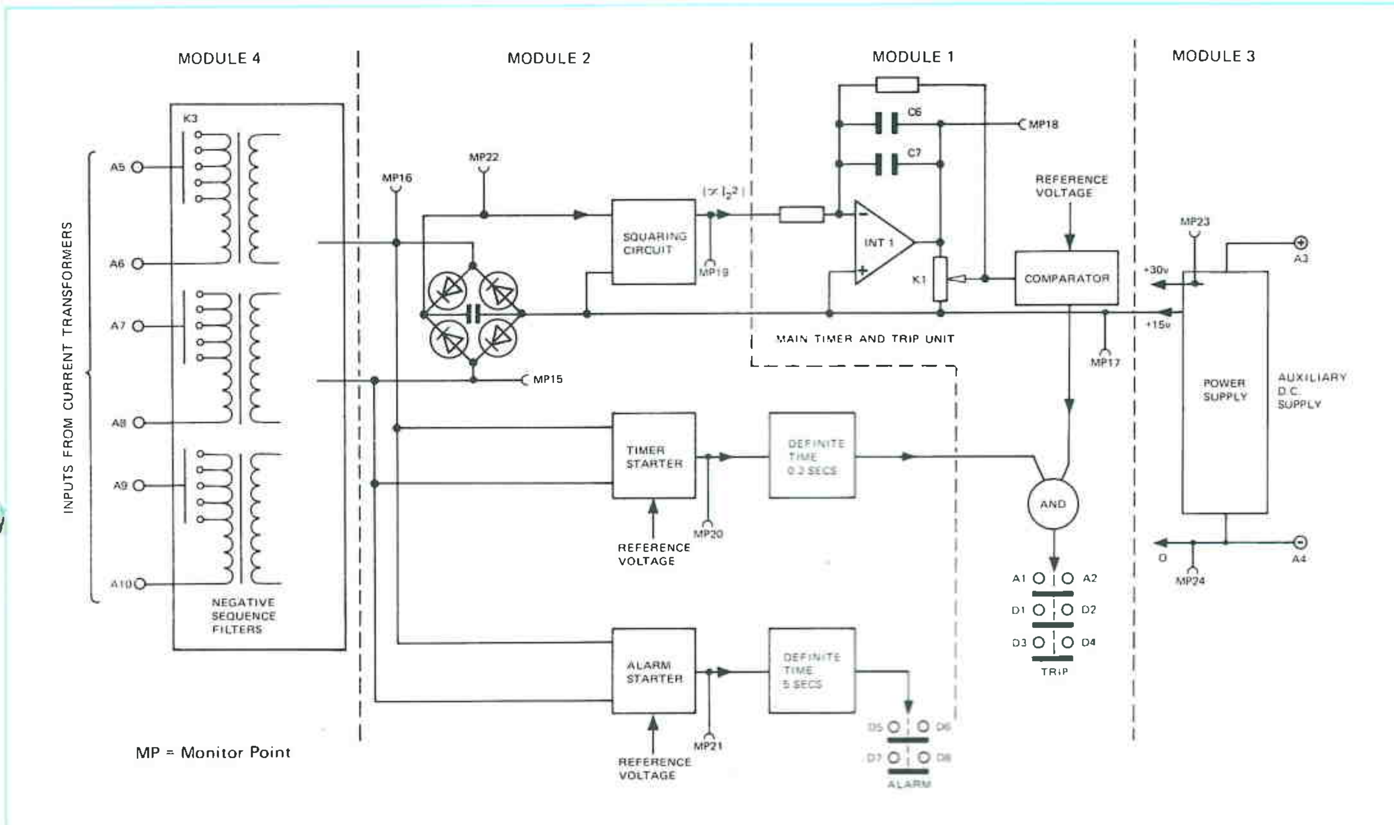


Figure 1 BLOCK SCHEMATIC DIAGRAM

OPERATION

The negative sequence filter, accommodated in module 4, is fitted with three plug boards, one for each phase. These are connected to tappings on the primaries of the input transformers which in turn allow the negative phase sequence current setting to be varied in five steps from 7·5% to 30% of rated current. The secondaries are connected in delta to eliminate the effects of zero sequence currents. A fourth auxiliary current transformer is necessary to provide a 180° phase shift in I_{C-A} (see Figure 3).

Vector diagrams of both positive and negative sequence currents in the filter are shown in Figure 4. It can be seen that an output is produced when negative sequence currents are present but is zero when the currents are of positive phase sequence only.

The vector diagram for negative sequence currents does not allow for the presence of a load resistor mounted across the two outputs of the negative sequence filter. This resistor is made equal to the source

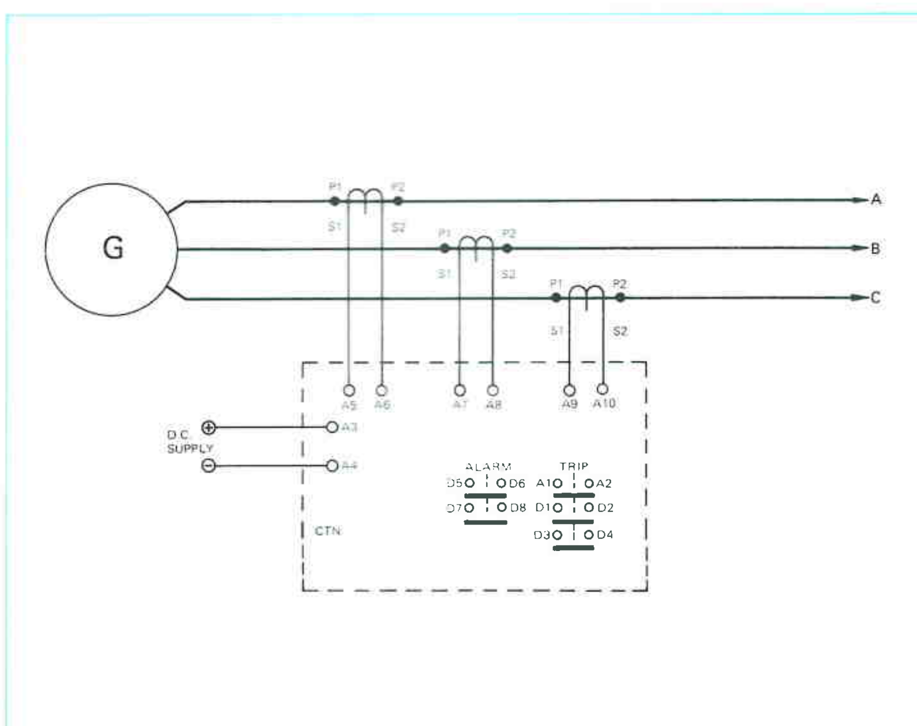


Figure 2 APPLICATION DIAGRAM

therefore half of that indicated in the vector diagram, that is:

$$V_{OUT} = \frac{\sqrt{3}}{2} (I_{C\text{-}A})\ R_S$$

The basic time characteristic of the tripping element is shown in Figure 5. A sixteen position switch (K1) controls the relay operating time/current curve over a range 1-10 times this characteristic. This allows the I_2^2t relay response (approximately K1 × K3) to be varied from 1 to 10 on the 7·5% tap setting to 16 to 160 on the 30% setting for CTN31 relays, where I_2 = negative sequence current expressed as a multiple of the rated current, and t = relay operating time in seconds.

When the tripping element operates, a hinged armature auxiliary unit and a rotary flag indicator are energised simultaneously. Contacts on the auxiliary unit are provided for trip initiation.

Similarly, the alarm circuitry energises a reed relay, and a second rotary flag indicator. Both rotary indicators are electrically reset by a hand operated switch on the front of module 2.

Monitor points to facilitate testing are provided by a multi-way socket on module 3. The reset push button on module 1 enables the timing capacitors to be discharged quickly to allow repetitive testing from an intitial condition of zero negative sequence current.

RELAY CHARACTERISTICS

The relay operating time when negative phase sequence current is present should be equal to the thermal withstand time of a generator carrying the same amount of negative sequence current.

The machine withstand approximates to I_2^2t = K but at currents just above the continuous I_2 withstand of the generator, the time given by the above formula is much lower than the actual withstand time of the machine. This is because of the heat loss from the machine which enables it to carry a certain negative sequence current continuously, for example, the relay setting current.

This consideration must also be taken into account in selecting a relay operating time/current

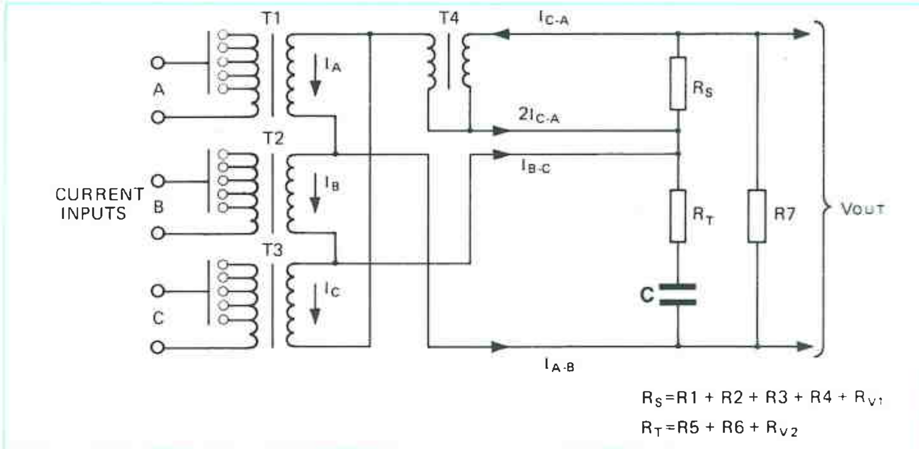
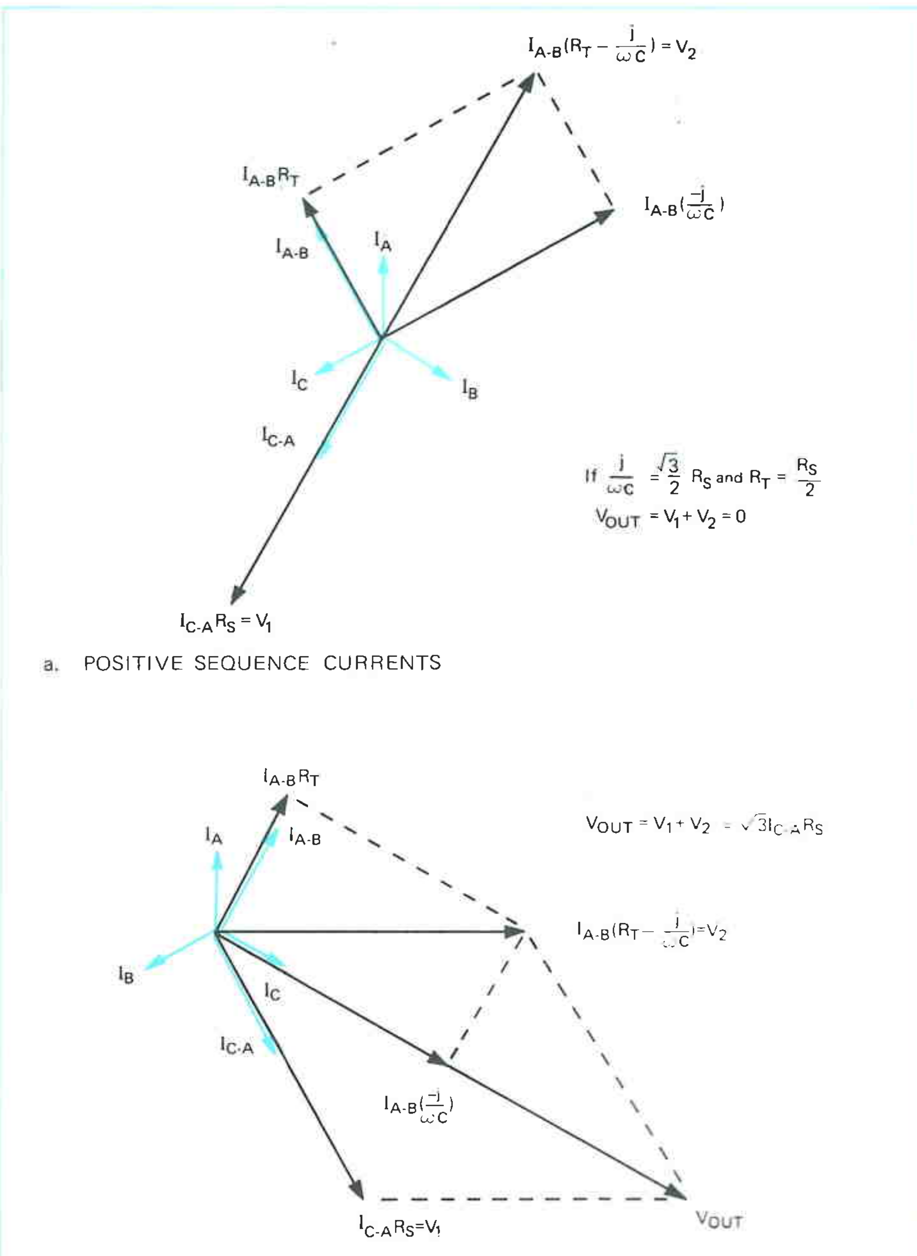


Figure 3 SCHEMATIC DIAGRAM OF NEGATIVE SEQUENCE FILTER



characteristic is given by the expression below, and approaches $I_2^2t = K$ for values of I_2 above twice the relay setting current.

$$\frac{I_2}{I_{2s}} = \sqrt{\frac{1}{1-e^{\frac{-I_{2s}^2 t}{K}}}}$$

where I_2 = Negative phase sequence current (expressed as per unit positive sequence rating)

I_{2s} = Negative phase sequence current setting (expressed as per unit positive sequence rating)

K = Relay constant

t = Relay operating time in seconds

TECHNICAL DATA

Voltage Ratings,
48V, 125V or 250V d.c.
120V a.c.
(alternative designs)
Note: a.c. version requires an external box to be used in conjunction with a 48V d.c. module.

Current Ratings (I_n)
1 amp or 5 amp a.c.
(alternative designs)

Frequency Ratings
50Hz or 60Hz
(alternative designs)

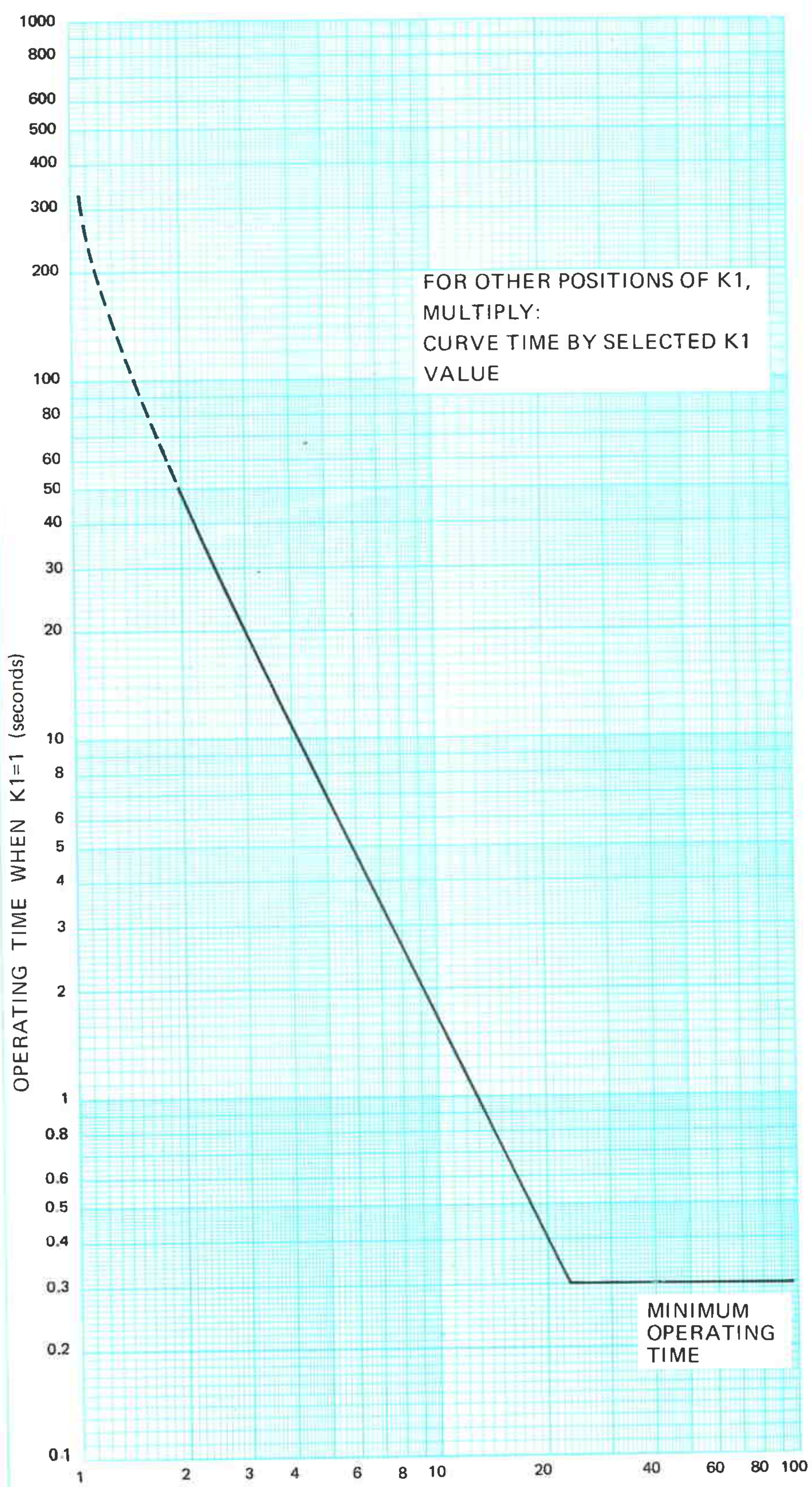
Operating Times
Main element operating time (seconds) = K1 × (operating time when K1 = 1) where K1 = the time multiplier setting.
K1 is set by means of a sixteen position switch to give any of the following values:

CTN31
K1 = 1.0, 1.1, 1.2, 1.32, 1.45, 1.6, 1.8, 2.2, 2.7, 3.3, 3.9, 4.8, 5.7, 6.7, 8.2 or 10.
Alarm element: 4 to 6 seconds

CTN 32
K1 = 3.0, 3.3, 3.6, 3.96, 4.35, 4.8, 5.4, 6.6, 8.1, 9.9, 11.7, 14.4, 17.1, 20.1, 24.6 or 30.
Alarm element 4 to 6 seconds.

Resetting Time
The resetting time is a function of the K1 settings and is 7K1 minutes.

Accuracy



Current Settings

Negative sequence current setting by five taps.

I_{2s}	7.5%	10%	15%	20%	30%
K3	1	1.78	4	7.1	16
$I_2{}^2t$	1 X K1	1.78 X K1	4 X K1	7.1 X K1	16 X K1
CTN31	1 to 10	1.78 to 17.8	4 to 40	7.1 to 71	16 to 160
CTN32	3 to 30	5.34 to 53.4	12 to 120	21.3 to 213	48 to 480

The alarm setting is continuously variable from 70% to 100% of the negative sequence setting, I_{2s}.

I_{2s} = Negative phase sequence current setting (% of rated current)

I_2 = Negative phase sequence current (multiple of relay rated current)

t = Relay operating time (seconds)

Burdens

A.C. burden:
This varies with the relay setting. The highest burdens occur on the 7·5% tap and are:
6·5VA on the A phase at rated current
2·7VA on the B phase at rated current
4·2VA on the C phase at rated current

D.C. burden:	125V d.c.	250V d.c.
Below relay setting	0·6 W	1·3 W
Above relay setting while timing	1·4 W	2·8 W
After alarm has operated	3·8 W	7·5 W
After alarm and main relay have operated	14 W	28 W
With reset in operated position	7·5 W	15 W

Thermal Ratings

Continuous, 1·5 × rated positive sequence current.

Short Time:

Setting (%)	Current rating for 3 seconds (multiple of rated positive sequence current)
7.5	5
10	6.7
15	10
20	10
30	10

Frequency variation

An additional ± 7·5% on pick up and time delay over the range –6% to +2% of normal frequencies.

Temperature Limits

For ambient –5°C to +40°C the variation of operating time is within ± 10%.
The relay will operate satisfactorily over the ambient temperature range of –20°C to +50°C.

Overshoot

For the main element, less than 75 milliseconds.
For the alarm element, less than 200 milliseconds.

Operation Indicators

A miniature rotary operation indicator is provided as standard for both the main protection and for the alarm.

Impulse withstand level.

The relay will withstand impulses of 5kV peak and 1/50 microsecond waveform applied both transversely and between relay terminals and earth, in accordance with BEAMA document number 219 and IEC draft recommendation.

High frequency disturbance

The relay meets the requirements of the draft IEC test recommendation for the High Frequency Disturbance Test, in which repetitive 1 MHz bursts having an initial peak of 1.0kV are superimposed across input circuits, and of 2·5kV are superimposed between independent circuits and circuits to earth, with a decay time of 3 to 6 microseconds. This is carried out with the relay energised.

Insulation

The relay will withstand:
2 kV, 50Hz 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 contacts.

Current transformer requirements

The minimum knee point voltage of the main current transformer is given by:

$$V_K = 6In\,(Rs + Rp) + \frac{40}{In}\ \text{Volts}$$

where:

In = relay rated current (A)
Rs = CT secondary winding resistance (ohms)
Rp = loop resistance of leads between the CT and the relay (ohms)

Contacts

Element	Number and type of contacts	Rating (d.c.)	
		Make and carry for 0·2 seconds	Break
Trip	3 make self resetting	7500W with maxima of 30A and 440V	100W resistive with maxima of 5A and 440V 30W inductive with maxima of 3A and 440V
Alarm	2 make self resetting	35W with maxima of 2A and 500V	35W resistive with maxima of 2A and 500V

APPLICATION NOTES

Procedure for the selection of tripping element setting.

1. Identify:
   Generator continuous negative phase sequence current withstand rating (% rated positive phase sequence current).
   I_2^2t value (K).
2. Select a plug board setting (I_{2s}) equal to, or the nearest below the generator continuous negative phase sequence current withstand rating. This establishes the appropriate K3 factor for the relay. See the setting table in this publication or the plug board on the front of the relay.
3. Determine time multiplier setting (K1) from the following formula:

$$K1 = \frac{K}{K3}$$

Example:
For a generator having a negative phase sequence current withstand rating of 10% and an I_2^2t value of 7·5.
The plug board setting (I_{2s}) will be 10%

$$\therefore \quad K3 = 1{\cdot}78$$
$$K = 7{\cdot}5$$

$\therefore$ Time multiplier setting

$$K1 = \frac{7{\cdot}5}{1{\cdot}78} = 4{\cdot}21$$

Set the relay time multiplier switch K1 to the 3·9 position.

Operation Time
Comparison of relay operation time and generator withstand time at say 5 × relay setting current.
Generator withstand time

$$t_m = \frac{K}{I_2^2} = \frac{7{\cdot}5}{(5\times 0{\cdot}1)^2} = 30 \text{ seconds}$$

Relay operating time

$$t_r = K1 \times \text{operating time when } K1 = 1$$

Operating time when K1 = 1 at 5 × setting current
= 7 seconds (from Figure 5)

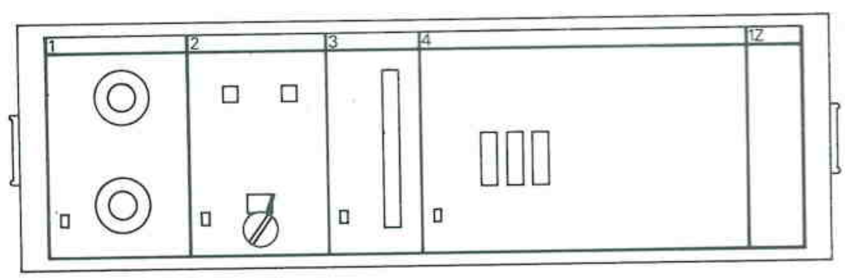
$$K1 = 3{\cdot}9$$
$$\therefore \quad t_r = 3{\cdot}9 \times 7 = 27{\cdot}3 \text{ seconds}$$

CASES

The modular case, complete with glazed cover, can be supplied for the following mounting requirements.

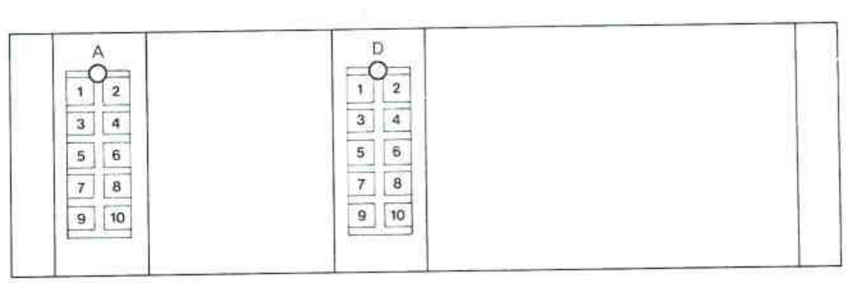
Rack mounting
These cases are finished light grey, with front cover frames and module front plates in satin finished anodised aluminium alloy.
See Figure 8.

Panel mounting
These cases are designed for flush or semi-projection mounting. They are finished in black with front cover frames and module front plates in satin finished anodised aluminium alloy. See Figure 9.



Module	Function
1	Main Timer and Trip Unit
2	Squaring, Starting and Definite Timers
3	Power Supply and Test Points
4	Negative Sequence Filter
1Z	Heavy Current Isolating Plug

Figure 6 KEY TO MODULES



INFORMATION REQUIRED WITH ORDER

Type: CTN31 or CTN32
Supply voltage
Relay current rating (1A or 5A)
Supply frequency (50Hz or 60Hz)
Whether for rack or panel mounting

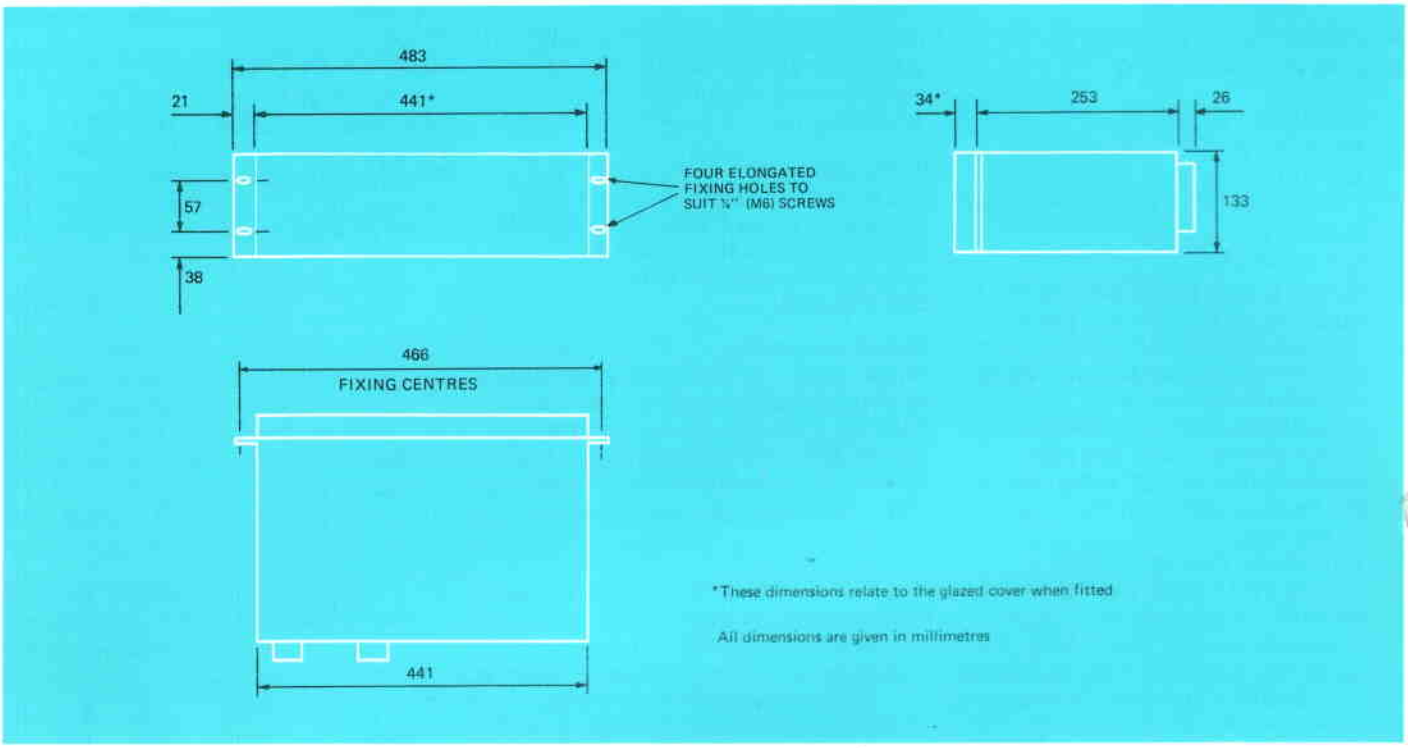


Figure 8 OUTLINE OF RACK MOUNTED CASE

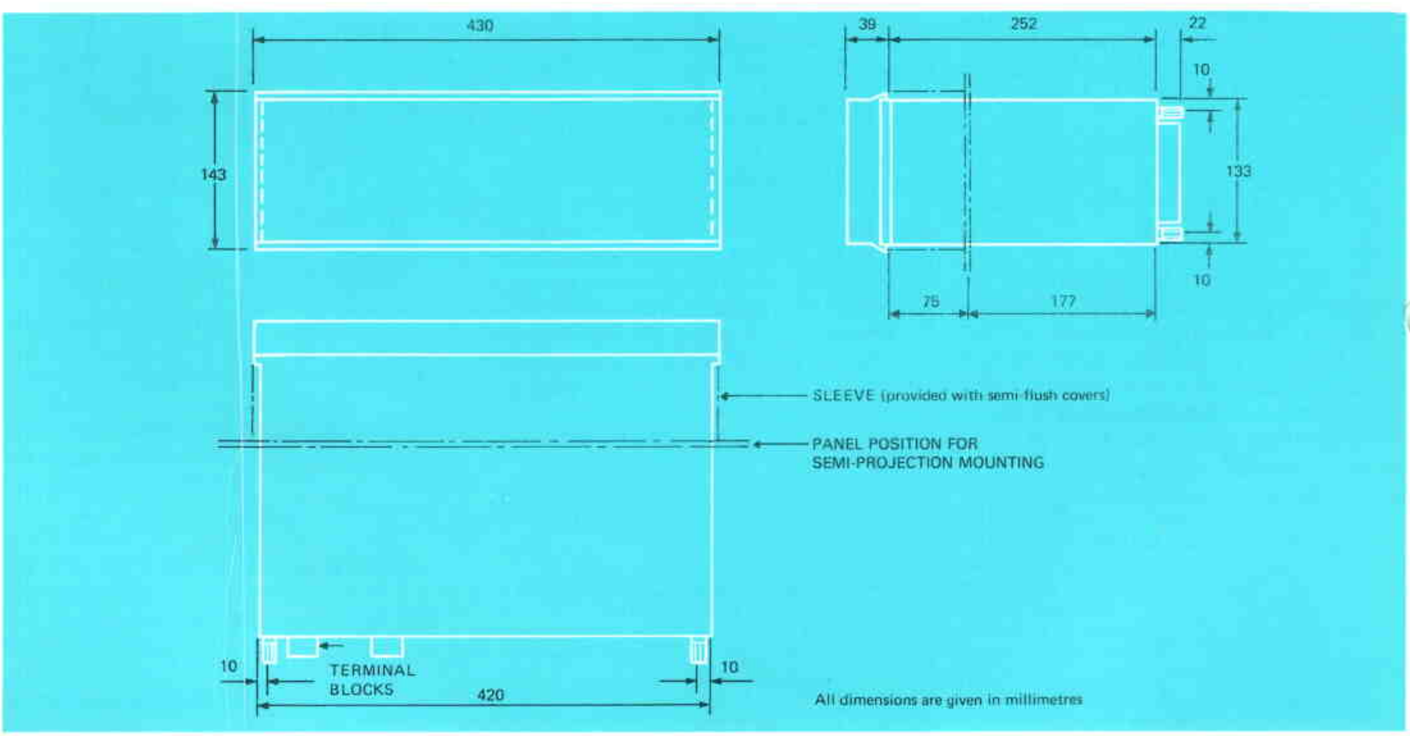


Figure 9 OUTLINE OF PANEL MOUNTED CASE

Our policy is one of continuous product development and the right is reserved to supply equipment which may vary slightly from that described.

GEC Measurements **The General Electric Company Limited of England**

St. Leonards Works Stafford ST17 4LX England
Telephone: 0785 3251 Telex: 36240 Cables: Measurements Stafford Telex