INSTRUCTIONS

GEK-34020B
Supersedes GEK-34020A

STATIC THREE PHASE
MHO DISTANCE RELAY
SLY51B

GENERAL ELECTRIC

CONTENTS

STATIC PHASE DISTANCE RELAY

TYPE SLY51B

DESCRIPTION

The Type SLY51B relay is a static, three-phase directional mho distance relay intended for use as the high-speed overreaching function in pilot relaying schemes, or as a second or third zone function in step distance schemes for the protection of transmission lines. One Type SLY51B relay will detect all multi-phase faults within its reach setting. The relay is packaged in a two-rack unit case as illustrated in Figure 1. Component locations are shown in Figure 2.

The SLY51B relay is not intended for use by itself but rather as a part of a complement of equipment to form a protective relaying scheme. For example, in addition to the SLY51B relay, a typical directional comparison scheme would also include a Type SLY53A phase carrier start relay, a Type SLYG ground relay, a Type SLC overcurrent relay, a Type SLA logic relay, a Type SLAT output relay and a Type SSA power supply to complete the protective scheme. The static circuits in the SLY51B require a $\pm$ 15 volt d-c source which is obtained from a Type SSA50 and up power supply. The outputs from the SLY51B relay are d-c logic signals that feed into a Type SLA relay, the internal circuitry of which depends upon the specific overall protective scheme. The internal connections for the SLY51B are shown in Figure 3.

The measuring functions included in the SLY51B are listed below:

MT -Three single-phase mho distance functions

MOB -Single phase mho out-of-step blocking function (optional)

For a complete description of the overall scheme in which this relay is employed, refer to the overall logic diagram and its associated logic description that is supplied with each terminal of equipment.

APPLICATION

The Type SLY51B relay is designed to provide the high-speed overreaching function required in pilot relaying schemes or the second or third zone function in step distance schemes. The relay is suitable for application with potential transformers or with coupling capacitor voltage transformers having a transient response equivalent to or better than the General Electric Type CD31 device. Since the transient overreach of the mho functions in the SLY51B is not sufficiently limited by design, this relay is not suitable for application as a first zone relay. Typical operating times of the Type SLY51B relay are shown in Figure 17. The additional relays and other equipment required to complete a specific scheme are described in the logic description that accompanies the overall logic diagram for that particular scheme. Figure 4 illustrates the external connections to the SLY51B when used in a directional comparison carrier blocking scheme.

ANGLE OF MAXIMUM REACH

The mho functions (MT) in the SLY51B have an angle of maximum reach which can be set for either 60 or 75 degrees lag by means of a jumper setting on the associated filter cards. The 60 degree angle will accomodate more arc resistance and hence is useful on lower voltage transmission lines with less lagging angles where arc resistance may be a problem. The 75 degree angle is most useful for the extra high voltage lines having highly lagging angles or on longer lines, where arc resistance is of minor importance.

When the out-of-step blocking function MOB is to be used it is recommended that the angle of the MT functions be set for 75 degrees, since this will result in the symmetrical MOB characteristic shown in Figure 8A. If the MT functions are set for the 60 degree angle the MOB characteristic will be unsymmetrical as shown in Figure 8B.

PILOT RELAYING SCHEMES

When the SLY51B relay is applied in one of the various pilot schemes, the mho tripping function should be set to reach at least 125 percent, and preferably 150 to 200 percent of the protected line section.

STEP DISTANCE SCHEMES

Zone-2 Applications - When the SLY51B relay is applied as an M2 function in a step distance scheme, its reach setting must be coordinated with Zone-1 units protecting lines out of the remote station. The M2 function should be set so that it does not reach beyond the shortest Zone-1 setting at the remote station for the condition of zero infeed.

Zone-3 Applications - When the SLY51B relay is applied as an M3 function in a step distance scheme it must be set so that it does not reach beyond the shortest Zone-2 setting of relays protecting lines out of the remote station for the condition of zero infeed.

The reach of the mho functions in the SLY51B tends to pull back slightly at low fault currents. This pull back in reach is dependent on the basic tap setting used and the magnitude of fault current available. When used on the 3 ohm basic tap the pull-back in reach for all three phase and phase-to-phase faults will not exceed 10 percent if the three-phase fault current exceeds 1.0 ampere and the phase-to-phase fault current is greater than 0.87 amperes. For smaller basic tap settings the fault current required will be inversely proportional.

The sensitivity of the mho function is defined by the relation between the three-phase fault current and the reduction of the ohmic reach as the fault current decreases. To obtain the maximum sensitivity for a desired mho function setting, the highest permissable base reach tap should be used. If the desired ohmic reach at the relay angle of maximum reach was 6 ohms, this setting could be accomplished by using the 1.2 ohm base reach tap with 20% restraint or the 3 ohm base reach tap with 50% restraint. The setting should be made with the 3 ohm base reach tap rather than the 1.2 ohm tap since for a given percent pull back the 1.2 ohm tap requires a higher magnitude of fault current.

OUT OF STEP BLOCKING FUNCTION

The MOB out of step blocking function should be set by means of a graphical analysis on an R-X diagram. This should include the swing lines for various system conditions showing the successive values of apparent impedance at known intervals of time as the fastest swing progresses for each of the system conditions. Refer to the section on OPERATING PRINCIPLES AND CHARACTERISTICS for a description of the MOB R-X diagram characteristic. Ideally, MOB should be set with as small a characteristic timer pickup setting as practical just so that it is not operated by load or minor system swings. The A/40 timer has an A adjustment range of 2 to 4 cycles. A setting of two cycles will cause the logic to set up blocking on faster swings than a setting of four cycles.

Note that when the out of step blocking function is used it is recommended that the MT angle of maximum reach be set for 75 degrees.

RANGES

The SLY51B relay has an adjustable MT/M2 function reach of .3 to 30 ohms in the tripping direction at an angle of maximum reach of 75 degrees. At the 60 degree angle of maximum reach the relay reach is .31 to 31 ohms in the tripping direction. The MOB function is dependent upon the MT setting, for explanation of this, see "Operating Principles and Characteristics."

The standard setting for the angle of maximum reach is 75 degrees. This angle can be set to either 75 or 60 degrees by means of a plug on the filter card (all three filter cards must be set the same).

RATINGS

The Type SLY51B relay is designed for use in an environment where the air temperature outside the relay case is between -20°C and +65°C.

The Type SLY51B relay requires a ±15 VDC power source which can be obtained from power supplies type 50 and up.

The current circuits of the type SLY51B relay are rated at 5 amperes; 60 Hertz, for continuous duty and have a one second rating of 300 amperes. The potential circuits are rated 120 volts, 60 hertz.

BURDENS

DC Burden - The Type SLY51B relay presents a maximum burden to the type SSA power supply of:

350 ma from the + 15 VDC supply

50 ma from the - 15 VDC supply

AC Burden - Potential circuits at 120 VØ - Ø maximum

.30 volt amp
.24 watts
.18 vars

Current circuits at 5 AØ - Ø maximum

$Z = 0.017 \measuredangle 40°$
R = 0.013
X = 0.011

OPERATING PRINCIPLES AND CHARACTERISTICS

The mho characteristic for the SLY51B relay is shown in Figure 5. All measurements are made on a phase-to-phase basis. V_a-V_b is compared with I_a-I_b in order to obtain the same relay reach for a phase-to-phase, a three phase and a double phase-to-ground fault. The principle used to derive the characteristic is illustrated in Figure 6. The axes are "IR" and "IX". The $\overline{IZ}$ quantity is a voltage proportional to the line current obtained by passing the line current through a network consisting of a current transformer and a reactor. The setting of this quantity establishes the "Base Reach" of the relay. The V quantity is line voltage at the relay location, equal to IZ_F where Z_F, where Z_F is the line impedance out to the fault. Comparison is between the polarizing voltage $\overline{V}$ and the operating quantity $(\overline{IZ-V})$. The angle B between these two quantities is greater than 90° for faults external to the relay characteristic, and is less than 90° for faults internal to the relay characteristic. For faults which cause V to terminate on the relay characteristic the angle B is equal to 90°. This is true for any angular location of $\overline{V}$, because $\overline{V}$, $\overline{IZ}$, and $(\overline{IZ-V})$ form a right triangle for any point on the relay characteristic.

The quantities $\overline{V}$ and $(\overline{IZ-V})$ are derived from the relay input quantities and are converted into +15 VDC to -15 VDC square waves on the F126 cards. These square waves have the same phase relationship as the AC quantities $\overline{V}$ and $(\overline{IZ-V})$. The square waves representing $\overline{V}$ and $(\overline{IZ-V})$ are compared on the C104 card. The output of the C104 card is a +15 VDC block equal to the duration of the coincidence of the $\overline{V}$ and $(\overline{IZ-V})$ square waves. Blocks which are 90° apart are coincident for 4.16 ms. Blocks which are less than 90° apart are coincident for more than 4.16 ms. This is illustrated in Figure 7.

MT/M2 TRIPPING FUNCTION

The MT/M2 function has a directional characteristic with the mho circle passing through the origin on an R-X diagram. See Figure 5.

If the 100% voltage tap is used, the phase to neutral reach of the relay at the angle Ø is equal to the IZ base reach tap chosen. If a voltage tap other than 100% is chosen, relay reach is increased in inverse proportion to the voltage tap. For example, if the 50% voltage tap is used, relay operation still occurs for the same voltage applied to the measuring circuit, but since the actual line voltage is twice this amount, the relay reach is twice as great. The resulting mho circle has twice the reach, at any fault angle, and still passes through the origin.

Relay reach for the MT/M2 unit at the angle of maximum reach Ø, may be calculated from the expression:

$$Z_{max} = \frac{T_B}{T} \times 100 \quad \text{(at angle Ø)}$$

where T is the restraint tap setting expressed in % and $Z_0 = Z_{max} \cos(\theta - Ø)$. Z_0 is the impedance the relay will be at any angle θ. T_B is the basic ohmic tap.

θ = Line angle

Ø = Relay maximum reach angle

The angle of maximum reach (Ø) can be adjusted by changing the position of plug 'X' on the F126 board. When points 1 and 2 and 3 and 4 are jumpered, the angle of maximum reach is equal to 60°, when points 2 and 3 and 4 and 5 are jumpered, the angle of maximum reach is equal to 75°.

To set the relay for the desired reach, it is necessary to first select the proper "Base Reach Tap". This tap should be the highest "Base Reach Tap" that is smaller than the desired ohmic reach. The setting of the Base Reach Tap" is explained under the section titled "Construction" in this book. After the "Base Reach Tap" is selected the "Percent Restraint Tap" may now be chosen to produce the required relay reach.

MOB FUNCTION

The MOB characteristic is derived from the phase 2-3 magnetics, filter card, coincidence card and a separate timer. The MOB characteristic is comprised of two lobes and has a constant chord of 75°. Figure 8 shows the relationship between the MT characteristic and the MOB characteristic at both 60° and 75° angle of maximum MT reach.

The MOB characteristic is directly dependent on the setting of the MT characteristic. The replica angle of the MT characteristic is 75°. This angle forms a constant chord for both the MT and MOB characteristics.

With the aid of Figure 8 and the following steps, the theoretical MOB characteristic can be plotted.

Step 1: Determine the length of the constant chord at 75°.

$$L = Z_{max} \cos\tau = \frac{V_{max}}{2I} \cos\tau$$

Where L = length of constant chord in ohms.

Z_{max} = reach at angle of maximum reach in ohms

τ = angle between angle of maximum reach and 75°

V_{max} = voltage pickup for current I at angle of maximum reach

I = test current used to plot characteristic. (phase-to-phase test)

Step 2: Determine the pickup time setting (usually 2 to 3 msec.) for the MOB characteristic and convert that to degrees.

$$\gamma = 21.6 \times t$$

Where γ = the pickup time expressed in degrees.

t = the pickup time in milliseconds.

Step 3: Determine the diameter angles of the two lobes.

$$D_1 = 75° - \tau + (90° - \gamma)$$
$$D_2 = 75° - \tau - (90° - \gamma)$$

where D_1 and D_2 = the angle of the diameters in degrees.

75° = the replica angle

τ = angle between angle of maximum reach and 75°.

γ = the pickup time expressed in degrees.

The center of the circle for the lobe is the point on the diameter that is equidistant from the two ends of the constant chord L.

CIRCUIT DESCRIPTION

The internal connections of the SLY51B relay are shown in Figure 3. The points on the left designated YA2, YA3, and YA4 are the voltage inputs. The points at the lower left designated YB1 through YB12 are the current inputs.

The relay input voltage is passed through a transformer which produces the polarizing voltage. This voltage is fed directly to the filter card. The other input to the filter card is (IZ-V). The IZ component comes from the input current passing through a current transformer and the secondary current being passed through a reactor to form the IZ quantity. The V portion comes directly from the tapped potential transformer.

The block-block method is used for the MT/M2 function. Blocks are formed from the (IZ-V) quantity and the polarizing voltage by means of the filter card. These blocks are then fed to the coincidence logic card where the blocks are compared on a time basis. The coincidence card will produce output blocks only when both inputs are coincident (the same polarity). The output blocks of the coincidence logic card are then fed to the 4/5 timer card. The characteristic of the 4/5 timer is to produce no output until the input blocks are longer in duration than 4.16 milliseconds or 90°. If the timer is set to pick-up at some angle B other than 90°, the resulting mho unit characteristic will not be a circle. Figure 9 shows the characteristic obtained for a timer setting of 3.0 milliseconds at an angle of maximum reach of 75°. Figure 10 shows the same characteristic at an angle of maximum reach of 60°. Figure 11 shows the characteristic for a timer setting of 6 milliseconds at an angle of maximum reach of 75°. Figure 12 shows the same characteristic at an angle of maximum reach of 60°. In general, the reach for a timer setting less than 90° is greater than the reach for a timer setting of 90° at the same fault angle. A timer setting of greater than 90° will give a reach less than the reach for a timer setting of 90°, again at the same fault angle.

The MOB function measures on phases 2-3 only. The MOB characteristic is obtained by the block-block method used for the MT characteristic. During a power swing condition, when the apparent impedance seen by the relay passes through the MOB characteristic first and later through the MT characteristic, the blocking output is obtained if the swing is slow enough for the associated A/B timer (located in the SLA unit) to operate before MT operates. The fact that MT has not operated permits A/B to begin timing because of the NOT input to the AND card which feeds the A/B timer card. If the A/B card produces an output before MT operates, the A/B output is fed back to the AND card input so that later MT operation does not interrupt the A/B output.

CALCULATION OF SETTINGS

In order to illustrate the calculations required in applying the Type SLY51B relay, assume that the transmission line to be protected has the following characteristics:

$Z_L = 48\underline{/85°}$ primary ohms, positive sequence impedance

CT RATIO = 2000/5

PT Ratio = 3000/1

$$Z_L \text{ (secondary)} = Z_L \text{ (primary)} \times \frac{\text{CT RATIO}}{\text{PT RATIO}}$$

$$Z_L \text{ (secondary)} = 6.4 \ \underline{/85°} \text{ ohms}$$

Assume it is desired that the overreaching mho function is set for 150% of the protected line length.

SETTING OF MT

1. The choice of the angle of maximum reach will depend upon the line length and the amount of arc resistance expected. The 60 degree angle will accommodate more arc resistance than a 75 degree angle. Assume the 75 degree angle of maximum reach is chosen.

2. For optimum performance, the highest possible minimum basic tap should be chosen. For this line, this would be the 3 ohm tap.

3. The restraint tap setting T is determined by the following formula:

$$T = \frac{100\ (T_B)\quad \cos\ (\theta - \phi)}{1.5\ \ (Z_L)}$$

where:

T_B = basic minimum reach tap
ϕ = relay angle of maximum reach
Z_L = impedance of protected line
θ = angle of Z_L
1.5 = overreach factor of 50 percent

With the assumed values, the restraint tap resolves to be T = 31 percent.

SETTING OF MOB

The only adjustment possible for MOB is the pickup setting of the characteristic timer. Refer to the sections on APPLICATION and OPERATING PRINCIPLES AND CHARACTERISTICS for detailed considerations.

CONSTRUCTION

The Type SLY51B relay is packaged in a metal enclosure designed for mounting on a 19 inch rack. The relay is two rack units high (one rack unit is 1 3/4 inches). The relay contains the magnetics and tap blocks for setting the base reach and the percent restraint. It also contains the printed circuit cards for protecting all three phases of a power system. The relay has a hinged front cover and a removable top cover.

The tap block portion of the Type SLY51B relay is located at the left of the unit. Figure 13 shows the setting of one phase pair. The tap block is divided into two sections, percent restraint and base reach. These sections are identified at the top.

To set the percent restraint simply put the top MT lead in the desired 10% hole and the bottom MT lead in the desired 1% hole. The setting for 74% restraint is shown in Figure 13.

To set the base reach simply put the extreme right hand MT lead in either the 1.2K or the 3K hole. K is a ratio factor and is either 1, 1/2 or 1/4. K is determined by the terminals that are selected for current input on the YB terminal block at the back of the relay. The setting for a base reach of 1.2K is shown in Figure 13.

The base reach and percent restraint settings are made by jumpers with taper tip pins on the end. Two special tools have been supplied for these pins. One is an insertion tool and the other is an extraction tool. In order to get a proper connection and not cause any damage to the pins it is important that these tools be used.

The printed circuit cards are located to the right of the tap blocks. The printed circuit cards are identified by a code number such as F126, C104 or T133 where F designates filter, C designates coincidence, and T designates time delay. The printed circuit card locations are identified by letter designations or "addresses" (D, E, F, etc.) which appear on the guide strips in front of each socket, on the component location diagram, on the internal connection diagram, and on the printed circuit card itself. The test points (TP1, TP2, etc.) shown on the internal connection diagram are connected to instrument jacks on a test card in position T with TP1 located at the top of the card. TP1 is connected to relay reference, TP2 is connected to the -15 VDC bus, and TP10 is connected to the +15 VDC bus. The other seven test points are located at selected points in the logic circuitry to permit test measurement of the outputs of the functions and to facilitate signal tracing when trouble shooting.

RECEIVING-HANDLING AND STORAGE

This relay will normally be supplied as a part of a static relay equipment, mounted in a rack or cabinet with other static relays and test equiment. Immediately upon receipt of a static relay equipment it should be unpacked and examined for any damage sustained in transit. If injury or damage resulting from rough handling is evident, file a damage claim at once with the transporation company and promptly notify the nearest General Electric Sales Office.

Reasonable care should be exercised in unpacking the equipment. If the equipment is not to be installed immediately, it should be stored indoors in a location that is free from moisture, dust, metallic chips, and severe atmospheric contaminants.

Just prior to final installation the shipping support bolt should be removed from each side of all relay units, to facilitate possible future unit removal for maintenance. These shipping support bolts are approximately 8 inches back from the relay unit front panel. WARNING: STATIC RELAY EQUIPMENT, WHEN SUPPLIED IN SWING RACK CABINETS, SHOULD BE SECURELY ANCHORED TO THE FLOOR OR TO THE SHIPPING PALLET TO PREVENT THE EQUIPMENT FROM TIPPING OVER WHEN THE SWING RACK IS OPENED.

The Type SLY51B relay contains printed circuit cards with trimmer potentiometers mounted on them. Some of these trimmer potentiometers are calibrated at the factory and sealed. These potentiometers should not be adjusted by the user.

INSTALLATION TESTS

The Type SLY51B relay is usually supplied from the factory mounted and wired in a static relay equipment. All units in a given equipment have been calibrated together at the factory and will have the same summary number on the unit nameplate.

The following checks and adjustments should be made by the user in accordance with the procedures given below under DETAILED TESTING INSTRUCTIONS, before the relays are put in service. Some of the following items are checks of factory calibrations and settings, or installation connections and hence do not normally require readjustment in the field. Other items cover settings or adjustments which depend on installation conditions and hence must be made on the installed equipment.

1. MT/M2 base reach taps
2. MT/M2 reach by voltage tap setting
3. The angle of maximum reach
4. MT/M2 characteristic timer settings

GENERAL TESTING INSTRUCTIONS

INPUT CIRCUITS

The Type SLY51B relay has two terminal blocks on the rear of the unit identified as YA and YB. Both these termianl blocks are wired through the test panel in a static relay equipment where input current and voltages can be supplied through the standard Type XLA test plug. Where other test facilities are used, input currents and voltages should be applied to test points which connect to the same YA and YB termianl points as those shown on the test circuit diagram.

Where the Type SLY51B relay is furnished in a static relay equipment, reference to the job elementary will provide information concerning customer relay inputs.

OUTPUT SIGNALS

Output signals are measured with respect to the reference bus or TPI. Outputs are continuous signals of approximately +12 to +15 volts for the "ON" condition and 0 volts for the "OFF" condition. This output can be monitored with an oscilloscope, a portable high impedance d-c voltmeter, or with the test panel voltmeter if available. To connect the test panel voltmeter, place the test lead in the proper test point pin jack and the other end in the pin jack on the test panel.

DETAILED TESTING INSTRUCTIONS

CAUTION

CAUTION

THE LOGIC SYSTEM SIDE OF THE DC POWER SUPPLY USED WITH MOD III STATIC RELAY EQUIPMENT IS ISOLATED FROM GROUND. IT IS A DESIGN CHARACTERISTIC OF MOST ELECTRONIC INSTRUMENTS THAT ONE OF THE SIGNAL INPUT TERMAINALS IS CONNECTED TO INSTRUMENT CHASSIS. IF THE INSTRUMENT USED TO TEST THE RELAY EQUIPMENT IS ISOLATED FROM GROUND, ITS CHASSIS MAY HAVE AN ELECTRICAL POTENTIAL WITH RESPECT TO GROUND. THE USE OF A TEST INSTRUMENT WITH A GROUNDED CHASSIS WILL NOT AFFECT THE TESTING OF THE EQUIPMENT. HOWEVER A SECOND GROUND CONNECTION TO THE EQUIPMENT, SUCH AS A TEST LEAD INADVERTENTLY DROPPING AGAINST THE RELAY CASE, MAY CAUSE DAMAGE TO THE LOGIC CIRCUITRY. NO EXTERNAL TEST EQUIPMENT SHOULD BE LEFT CONNECTED TO THE STATIC RELAYS WHEN THEY ARE IN PROTECTIVE SERVICE, SINCE TEST EQUIPMENT GROUNDING REDUCES THE EFFECTIVENESS OF THE ISOLATION PROVIDED.

BASIC MINIMUM OHMIC TAP SETTING

The selection of the basic minimum ohmic tap is discussed in the section "CALCULATION OF SETTINGS". The setting of the basic minimum ohmic tap is described in the section "CONSTRUCTION".

VOLTAGE RESTRAINT TAP SETTING

The selection of the voltage restraint tap is discussed in the section "CALCULATION OF SETTINGS". The setting of the voltage restraint tap is described in the section "CONSTRUCTION".

The reach of the relay at the angle of maximum reach is given by the relationship

$$Z_{MAX} = \frac{T_B}{T} \times 100$$

where: Z_{MAX} is the reach at the angle of maximum reach

T_B is the basic minimum ohmic tap

T is the voltage restraint tap in percent.

ANGLE OF MAXIMUM REACH

* The angle of maximum reach of the MHO functions is a function of the replica impedance angle of the relay and the polarizing voltage phase shift. The replica impedance angle is fixed at 75 $\pm$ 2 degrees. The polarizing voltage phase shift is adjustable for 0 or 15 degrees leading phase shift. A coarse adjustment is provided by the X-option plug on the F126 filter card; a vernier adjustment is provided by potentiometer P27 on the same filter card.

In order to set the polarizing voltage phase shift, it is necessary to properly position X-option plug on each of the three filter cards in positions G, K and P. The polarizing voltage phase shift for each X-option plug position is shown in Table A. The zero degree setting produces a 75 degree angle of maximum reach; the 15 degree setting produces a 60 degree angle of maximum reach with an increase in maximum reach of 3.5 percent.

TABLE A

X PLUG SHORTING ARRANGEMENT	DEGREES OF LEADING PHASE SHIFT
2 to 3 and 4 to 5	0 Degrees
1 to 2 and 3 to 4	15 Degrees

The polarizing voltage phase shift may be checked and, if necessary, adjusted using the test circuit for plotting the MHO characteristic given in Fig. 14 with the appropriate connections of Table I. The following procedure is recommended:

1. Start with the phase A-B connections. Set the voltage restraint taps for 100 percent. Adjust the voltage for 30 vrms. Do not apply current to the relay for these tests.

* Indicates revision

2. Observe the output at pins 8 and 9 of the F126 filter card in position G for phase A-B. The following phase angle measurements should be made using a dual trace oscilloscope with a calibrated sweep sufficiently fast to provide an accurate measurement, and with both traces carefully zeroed on the center line.

3. A) Zero Degree Polarizing Phase Shift
The square waves at pins 8 and 9 of the filter card should be exactly 180 degrees out of phase, i.e., the zero crossings of each trace should coincide at the center line and the traces should have opposite slopes. The phase shift between pin 8 and pin 9 may be adjusted by potentiometer P27 on the F126 filter card in position G. Refer to Fig. 18.

   B) Fifteen Degree Polarizing Phase Shift
   The square wave at pin 9 is now shifted 15 degrees in the leading direction (toward the left-hand edge of the screen.) The zero crossings of the square waves should now occur 15 degrees (0.694 milliseconds on a 60 HZ base) apart. Refer to Figure 18.

   The phase shift between pins 8 and 9 may be adjusted by potentiometer P27 on the filter card.

4. Repeat steps 1, 2 and 3 for phase pairs B-C and C-A. Observe the outputs of the filter card associated with the phase pair under test; for B-C adjust the card in location K, for C-A that in location P.

TIMER CARD ADJUSTMENTS AND TESTS

The pickup setting determines the amount of coincidence that must occur between the operate (IZ-V) and restraint (V) signals before a logic output occurs. The reset time delay (dropout time) of the timer provides an overlap between inputs from the coincidence logic. This produces a continuous logic signal and in some cases provides an intentional time delay before resetting. The timer outputs are DC logic signals. The settings for the timers in a particular scheme can be found on the OVERALL LOGIC DIAGRAM for that scheme.

Note: The timers in the SLY51B relay have been adjusted at the factory. If during trouble shooting or periodic maintenance, a plot of the MHO characteristic indicates an incorrect timer setting (i.e. the characteristic is too wide or too narrow) the following procedure should be used. This procedure also applies to adjustment of replacement cards.

T105

This timer is adjustable over a range of 1 to 5 milliseconds pickup and 10 to 80 milliseconds dropout. There are two potentiometers located on the card to permit time delay adjustment. The upper potentiometer, P1 is used to adjust the pickup time delay. The lower potentiometer P2 is used to adjust the dropout delay. To test the T105 card the following procedure should be used:

(a) Remove the C104 card in the "L" position.
(b) Connect the test circuit of Figure 16. Apply the input signal to TP4.
(c) Use an oscilloscope with a calibrated horizontal sweep which can be triggered externally. Connect the external trigger input to TP4 and the vertical input to TP9.
(d) With the oscilloscope sensitivity set for positive slope, open the normally closed contact. The trace should step to +12 to 15V in the desired pickup time (usually between 2 to 3 milliseconds). To increase the pickup time delay turn P1 clockwise.
(e) By setting the oscilloscope sensitivity for negative slope and closing the now open contact the desired dropout time delay (usually 16 milliseconds) can be set. The trace should step from +12 to 15V to 0 to 1 V. To increase the dropout time dealy turn P2 clockwise).

T133

The T133 timer affects the MT/M2 characteristic shape. Three potentiometers are provided for adjustment purposes. P1 the first pickup is the top potentiometer. P2 which sets the dropout is the middle potentiometer and P3 the steady state pickup which which determines the characteristic shape is on the bottom.

There are two procedures listed below to set the T133 timer. The first procedure is used if a touch-up of the characteristic shape is required. The second procedure is used when the card is replaced or when the card is suspected of being incorrectly adjusted.

Procedure 1 - If a plot of the characteristic is too wide or too narrow indicating an incorrect steady state pickup setting. P3 can be adjusted to obtain the correct shape. However, do not change the settings of P1 or P2 during this procedure as they have no effect on the shape of the characteristic.

Procedure 2 - Note all three potentiometers must be set in this procedure, follow the setting order shown below to obtain correct operation of the card

To set potentiometer P1 the first pickup:

(a) Remove the C104 card of the phase pair being tested.
(b) Connect the test circuit of Figure 16.
(c) Connect the input signal to the test point on the input of the timer being tested (TP3 for phase 1-2).
(d) Use an oscilloscope with a horizontal sweep which can be triggered externally. Connect the external trigger input to the test point on the input of the timer being tested and the vertical input to the test point on the output of the timer being tested.
(e) Set P3 fully counterclockwise.
(f) With the oscilloscope set for positive slope triggering, open the normally closed contact. The trace should step to +12 to +15 volts. Adjust P1 to obtain the pickup time specified on the Logic Diagram. Clockwise rotation will increase the pickup time delay.

To set potentiometer P2 the dropout time delay;

(a) thru (d) same as for P1.
(e) With the oscilloscope set for negative slope triggering, open the contact to allow the timer to pickup, then close the contact and the desired dropout time can be set. To increase the dropout time turn P2 clockwise.

To set potentiometer P3 the steady state pickup;

(a) Install the C104 card for the phase pair under test.
(b) Connect the AC test circuit of Figure 14.
(c) Set the current to 5 amperes.
(d) Set the voltage to 25 volts.
(e) Swing the phase shifter to the point that causes a square with an ON and OFF time, as measured with an oscilloscope at the input of the timer being tested, which is the same as the pickup time to be set.
(f) Move the oscilloscope input to the output of the timer being tested and adjust P3 to the point that makes the card's output just become a continuous DC level of over 12 volts - DO NOT READJUST THE P1 AND P2 POTENTIOMETERS.
(g) Plot the characteristic using the AC test circuit of Figure 14 and touch up the P3 setting to obtain characteristic shape desired.

TESTING MHO CHARACTERISTIC

The mho characteristic may be checked over its entire range by using the test circuit employing the phase shifter and phase angle meter shown in Figure 14. Input connections for testing any of the phase-pair characteristics should be made with Figure 14 and Table I.

TABLE I

	CONNECT YA AND YB TERMINALS TO POINTS IDENTIFIED BY LETTERS						MHO OUTPUT	MOB OUTPUT
	A	B	C	D	E	F		
PHASE 1-2	YA2	YA3	YB1	YB4	YB8	YB5	TP6	
PHASE 2-3	YA3	YA4	YB5	YB8	YB12	YB9	TP7	TP9
PHASE 3-1	YA4	YA2	YB9	YB12	YB4	YB1	TP8	

By setting the current to 5 amperes (constant) the reach at any angle becomes a function of the setting of both the base reach and restraint taps. Rotating the phase shifter provides a means of checking the reach on any point of the characteristic. Notice that as the percent value of the restraint taps decrease the phase to phase impedance increases.

To obtain any points on the relay characteristic for any one of the three phases, observe the following procedure.

(a) Set up the test circuit of Figure 14 for the particular phase being tested. Make the AC connections according to Table I.

(b) Set the test current to 5 amps RMS.

(c) Be sure that the current limiting reactor is as high as possible in ohmic value (perhaps 24 ohms) This assures the most harmonic-free current possible.

(d) Remove the coincidence cards (C104) of the phases not being tested. Jumper the test points at the outputs of these cards down to reference.
Example: When testing Ø 1-2, remove the C104 cards in positions "L" and "R" and jumper TP4 and TP5 to reference.

(e) Connect the instrumentation (preferably an oscilloscope) between the mho output of the phase under test and reference at TPI.

(f) Set the phase angle meter at the specific angle of interest by rotating the phase shifter.

(g) Adjust the variac until the mho function output fully picks up. Note that the point just at the verge of pick-up, as read on Figure 14 voltmeter (V), defines the relay mho characteristic.

The voltage at which the relay picks up can be expressed by:

$$V_{\emptyset\text{-}A} = \frac{2I\ T_B \cos\ (\theta - \emptyset)}{T} \times 100$$

where: T_B = Basic minimum ohmic tap
T = Voltage restraint tap in percent
I = 5 ampere test current
θ = angle between applied voltage and current
$\emptyset$ = angle of maximum reach

A plot of the mho characteristic can be obtained by varying the phase angle and repeating steps f and g. The pickup setting of the timer can be adjusted to obtain the desired characteristic shape.

The reach of the relay is calibrated at the factory for a 75° angle of maximum reach. If the relay is used at 60°, the reach should be readjusted. Using the test procedure outlined above, set $V_{\emptyset\text{-}\emptyset}$ for the desired pickup at the angle of maximum reach. Adjust P10 on the F126 card to obtain the pickup point of the function.

An alternate method of testing the relay characteristic is shown in Figure 15 where the R-X test combination is employed. The circuit uses the test box (102L201), test reactor (6054975) and test resistor (6158546) described in GEI-44236. Since a limited number of resistor-reactor fault impedances are available, only a few points on the relay characteristic can be checked.

TESTING MOB CHARACTERISTIC

The test circuit used to check the MT characteristic may be used to check the MOB characteristic. The phase 2-3 input connections are used. The MOB output is checked at TP9.

ANGLE OF MAXIMUM REACH CHECK

As stated earlier the angle of maximum reach, Ø, can be adjusted by changing the setting of plug X on the F126 printed circuit card. The angle is typically factory adjusted to produce a 75° angle of maximum reach. In the Type SLY51B relay the angle of maximum reach can be adjusted to 60°. A check of the angle of maximum reach can be made by using the test circuit of Figure 14. The recommended procedure is as follows:

(a) Determine what test voltage V in Figure 14 is necessary to produce output at the relays maximum reach angle for 5 amperes of current, and the particular tap setting.

The voltage V at the angle of maximum reach is:

$$V = \frac{2\ I\ T_B\ \ 100}{T}$$

I = 5 amp test current

T_B = Basic ohmic reach tap

T = Voltage restraint tap in percent

(b) Make the AC connections to the relay according to Table I. The letters A through F in Table I correspond to the letters in Figure

(c) Adjust the variac in Figure 14 until the voltmeter reads 85% of the calculated voltage in equation (3).

(d) Rotate the phase-shifter, holding the voltage at 85% of the maximum V, and record the two angles at which the output just approaches the verge of pick-up.

(e) Add, algebraically, the two angles an divide the sum by two. The resultant should be the desired angle plus or minus 1.5 degrees.

PERIODIC CHECKS AND ROUTINE MAINTENANCE

PERIODIC TESTS

All functions included in the SLY51B relay may be checked at periodic intervals using the procedures described in the section INSTALLATION TESTS. Cable connections between the SLY51B and the associated Type SLA relay may be checked by observing the test points in the SLA unit.

The following checks should be made during periodic testing:

1. Basic minimum ohmic tap
2. Voltage restraint tap setting
3. Angle of maximum reach setting
4. Characteristic timer settings

These four checks can be made at once by making a plot of the mho characteristic

TROUBLE SHOOTING

In any trouble shooting of equipment, it should first be established which unit is functioning incorrectly. The overall logic diagram supplied with the equipment shows the combined logic of the complete equipment and the various test points in each unit. By signal tracing, using the overall logic diagram and the various test points, it should be possible to quickly isolate the trouble.

A test adapter card is supplied with each static relay equipment to supplement the prewired test points on the test cards. Use of the adapter card is described in the card instruction book GEK-34158.

A dual-trace oscilloscope is a valuable aid to detailed trouble shooting, since it can be used to determine phase shift, operate and reset times as well as input and output levels. A portable dual-trace oscilloscope with a calibrated sweep and trigger facility is recommended.

SPARE PARTS

To minimize possible outage time, it is recommended that a complete maintenance program should include the stocking of at least one spare card of each type. It is possible to replace damaged or defective components on the printed circuit cards, but great care should be taken in soldering so as not to damage or bridge-over the printed circuit busses, or overheat the semi-conductor components. The repaired area should be recovered with a suitable high-dielectric plastic coating to prevent possible breakdowns across the printed busses due to moisture and dust. The wiring diagrams for the cards in the SLY51B relay are included in the card book GEK-45138; the card types are shown on the component location diagram (Figure 2).

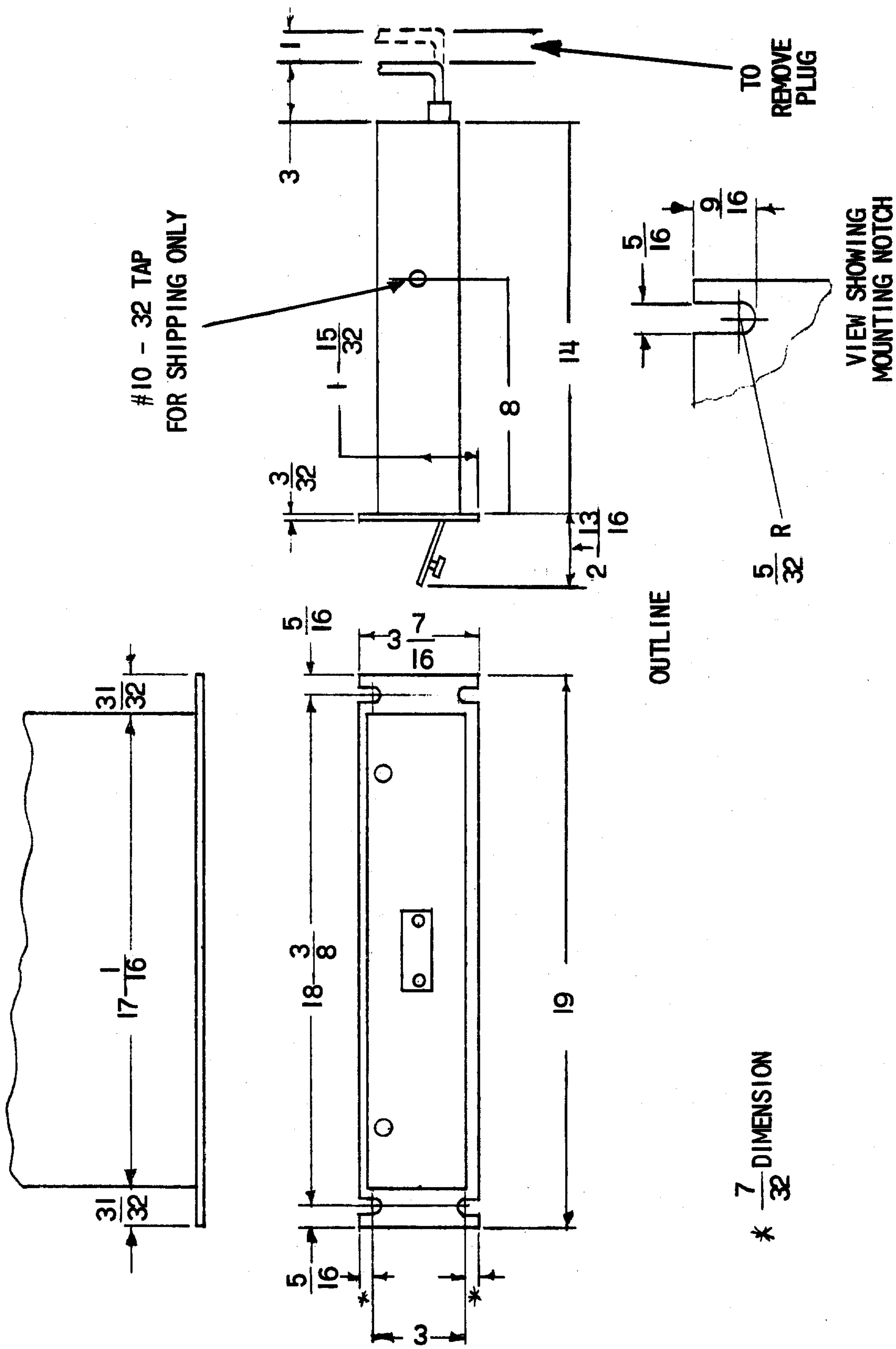
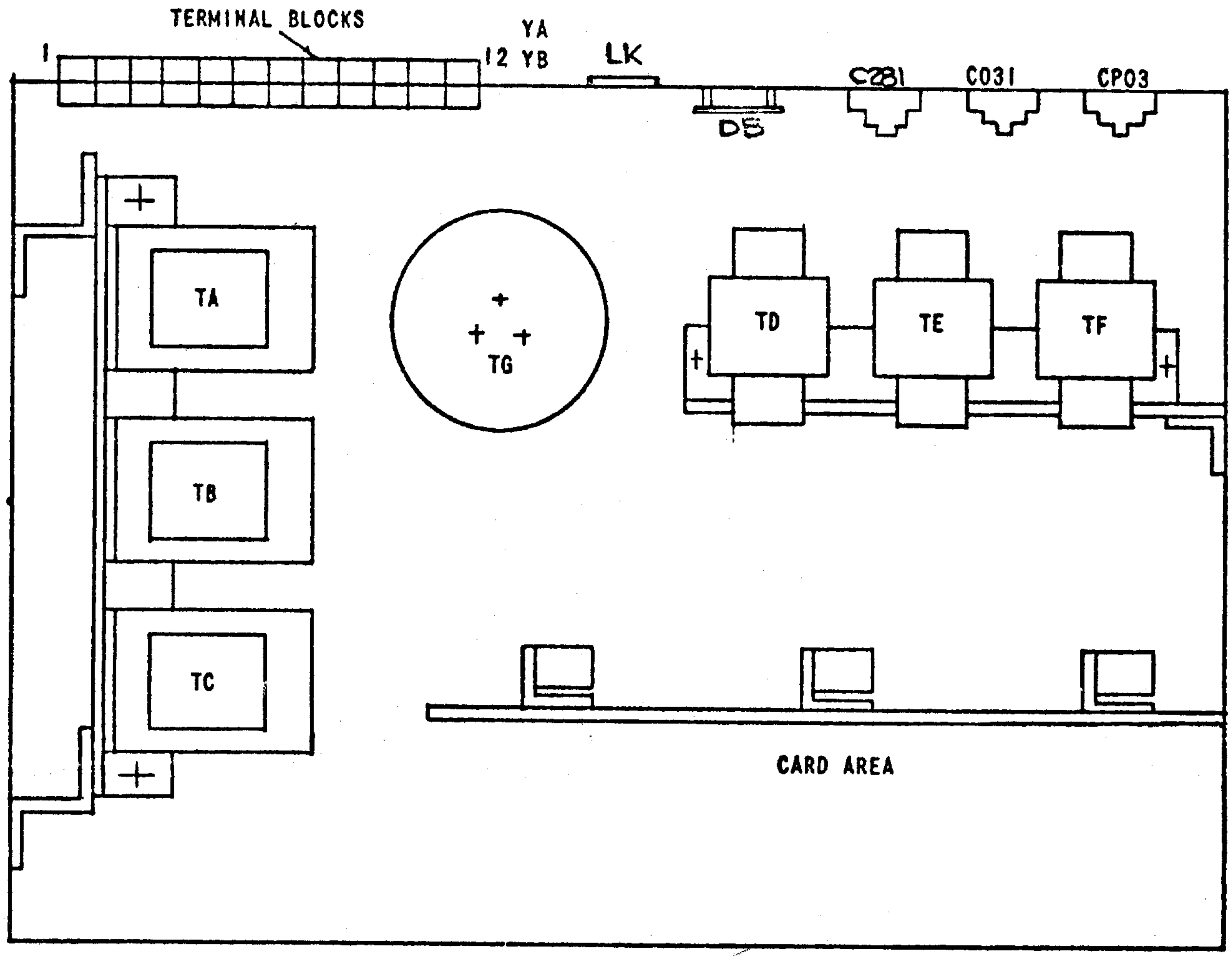
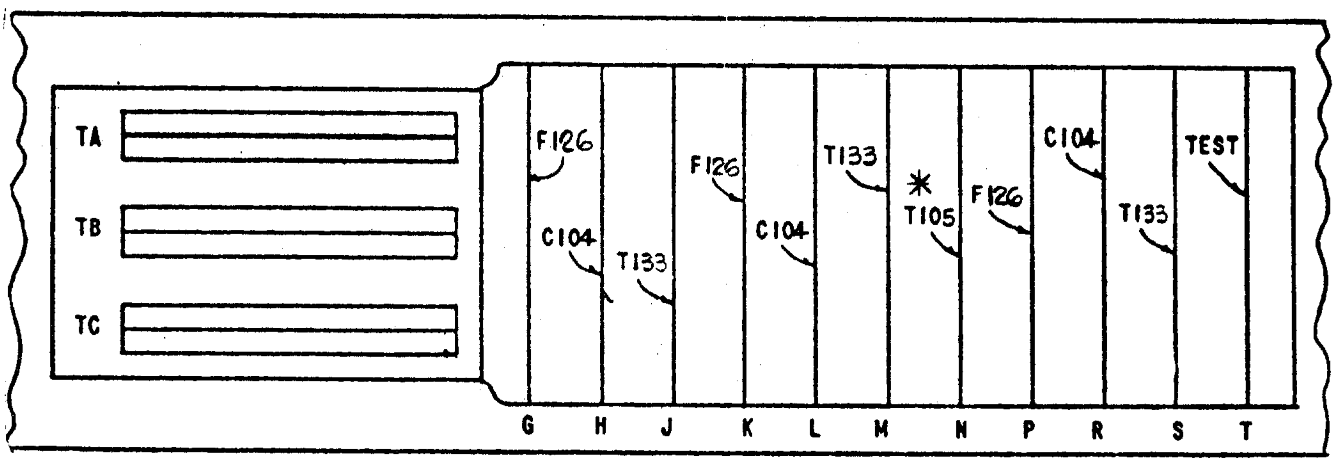


Fig. 1 (227A2036-0) SLY51B Outline and Mounting Dimensions





* OPTIONAL

Fig. 2 (257A6247-1) Component & Card Location Diagram for Type SLY51B Relay

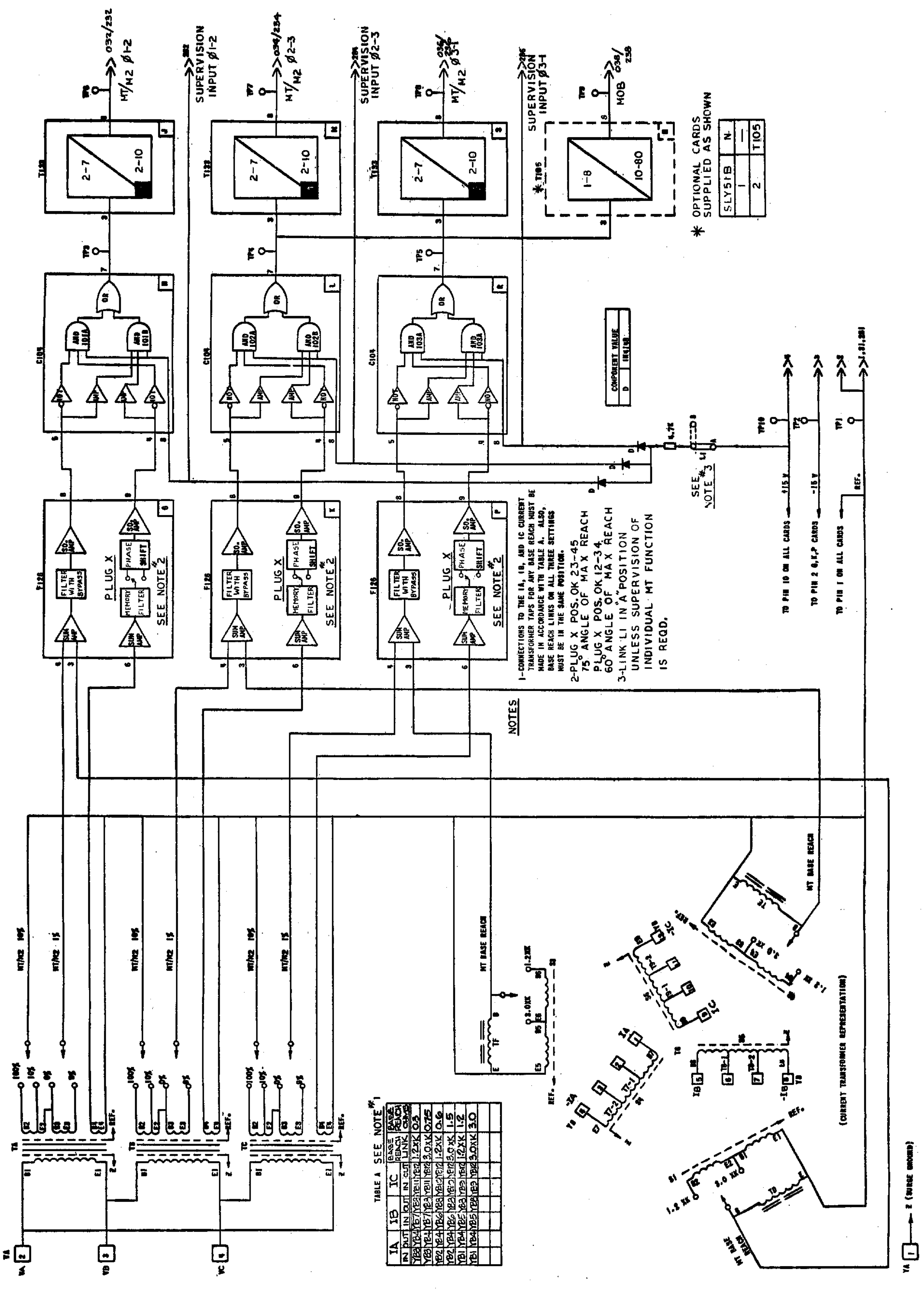


*Fig. 3 (149C7220-4) Internal Connections for Type SLY51B Relay

LEGEND

DEVICE TYPE	INCL. ELEM	DESCRIPTION
SSA		POWER SUPPLY
SLY51		CARRIER PHASE RELAY
	MT	PHASE DIRECTIONAL MHO TRIP ELEMENT
	MB	OUT-OF-STEP BLOCKING ELEMENT
SLYG51		CARRIER GROUND RELAY
	MTG	GROUND DIRECTIONAL MHO TRIP ELEMENT
SLY53	MB	PHASE OFFSET CARRIER START ELEMENT
SLC51	G1	OVERCURRENT CARRIER START ELEMENT
	G2	OVERCURRENT CARRIER TRIP ELEMENT
	G4	DIRECT TRIP INST. OVERCURRENT ELEMENT
	I3Ø	OVERCURRENT FAULT DETECTOR
	PH4	DIRECT TRIP INST. OVERCURRENT ELEMENT
SLA51		AUXILIARY LOGIC RELAY
SLAT51		AUXILIARY TRIP RELAY
	BFI	BREAKER FAILURE TIMING INITIATION
	RI	RECLOSING INITIATION

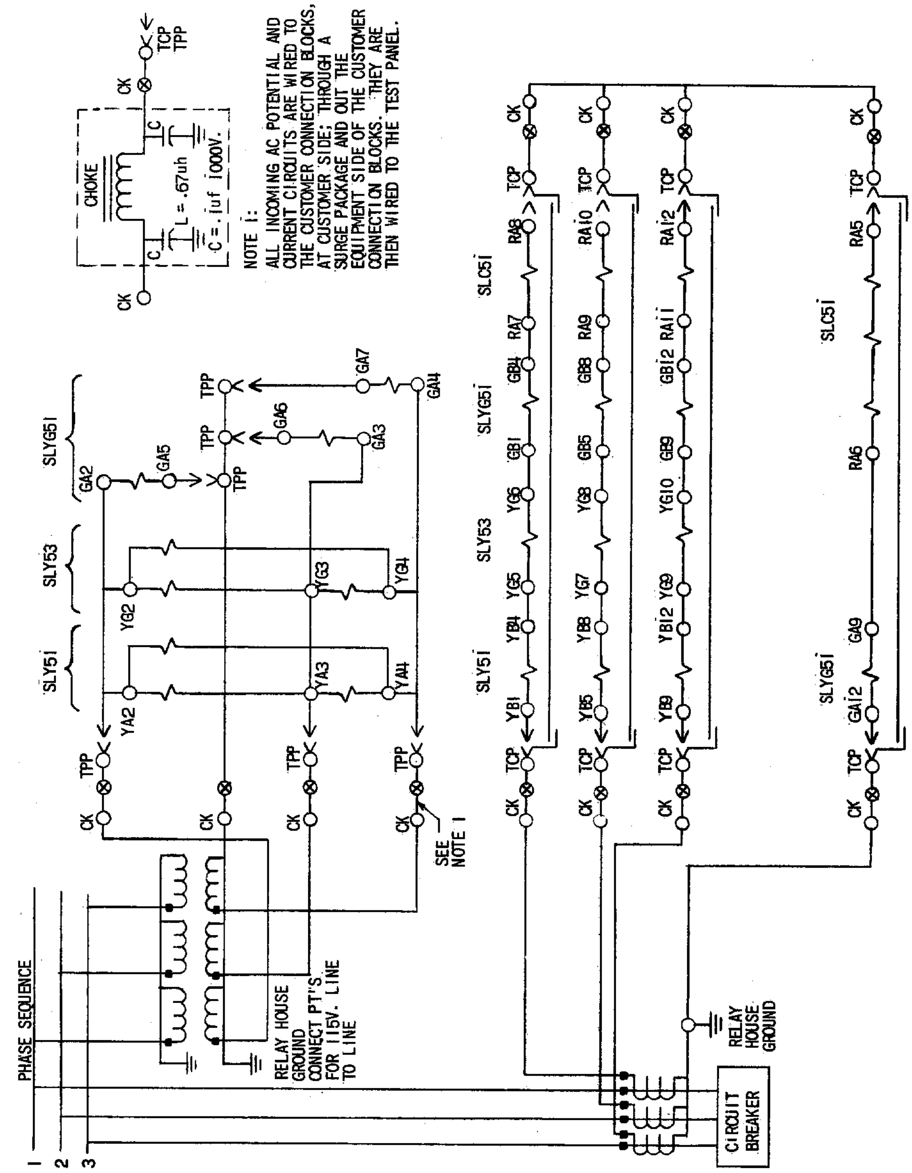


Fig. 4(108B9736-0) Typical External Connections Diagram

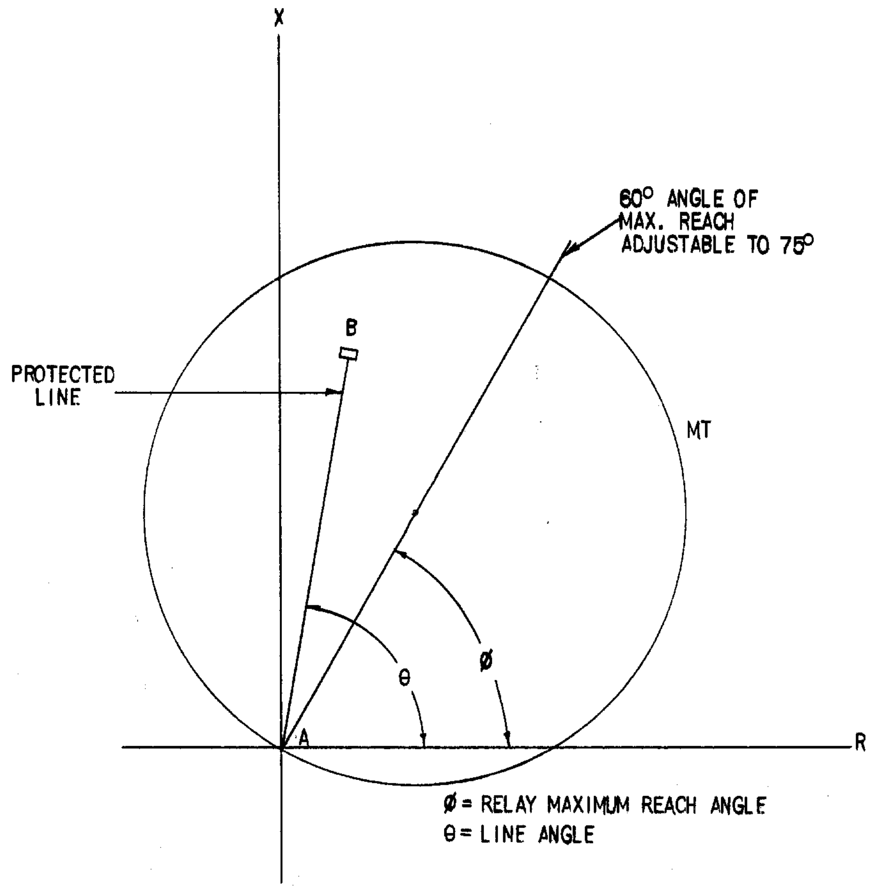


Fig. 5 (227A2089-0) Typical MT Characteristic for Type SLY51B Relay

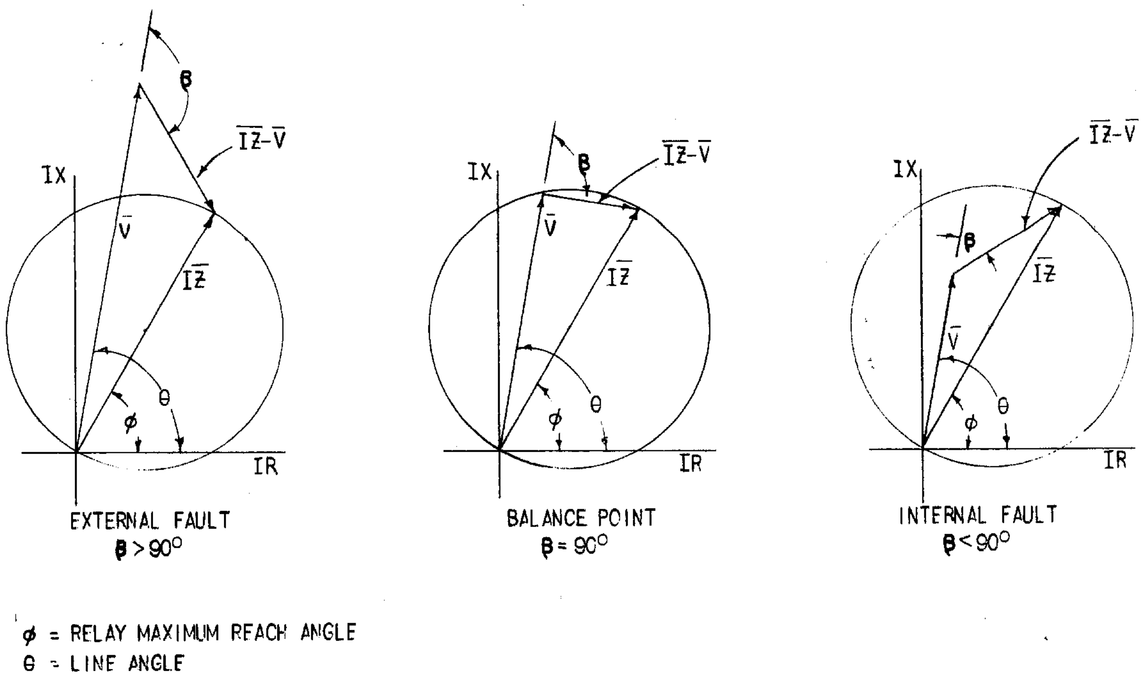
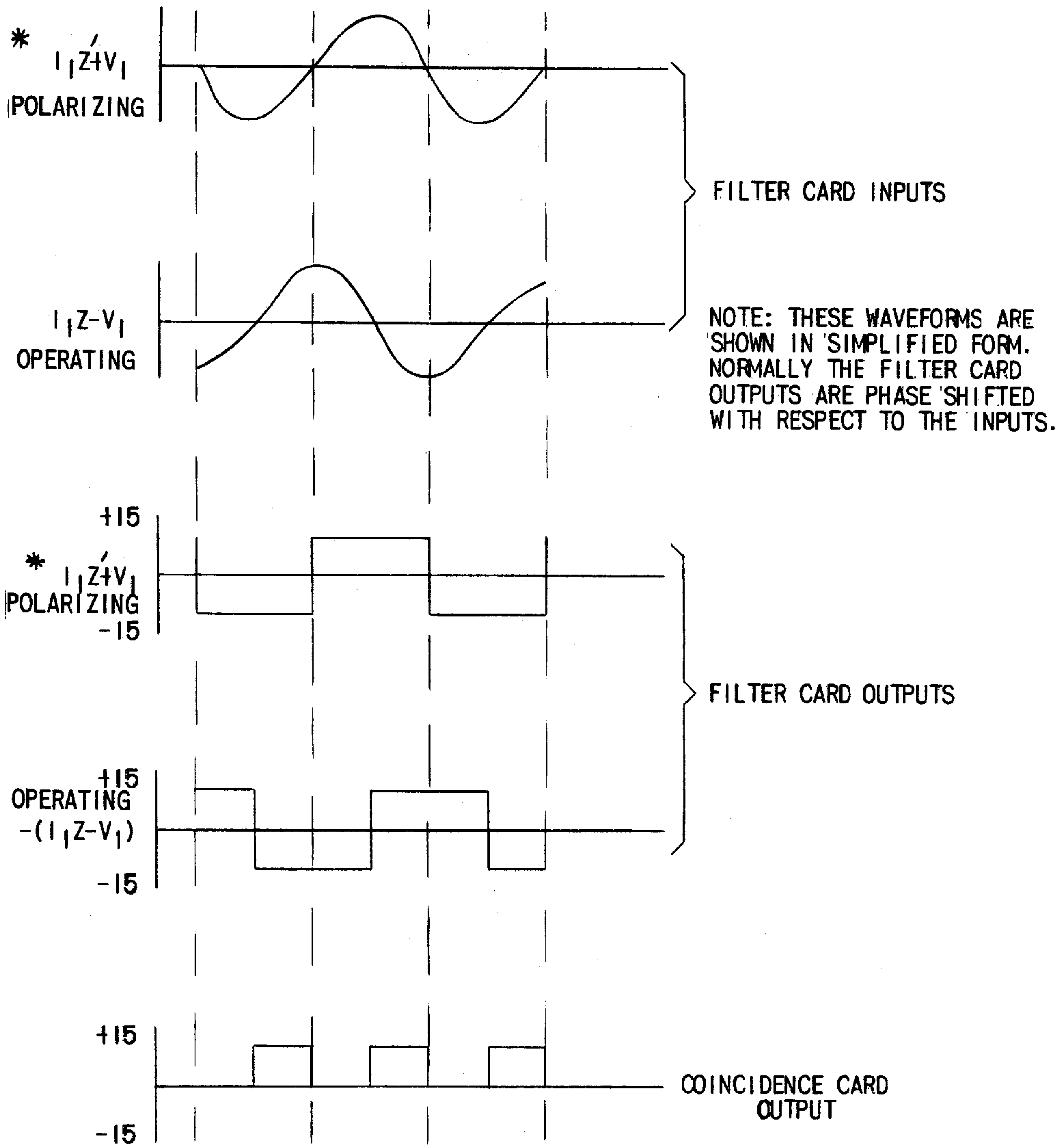


Fig. 6 (227A2090-0) MHO Characteristic by Phase Angle Measurement



* THE $I_I Z'$ TERM IS PART OF THE POLARIZING VOLTAGE ONLY IN CHARACTERISTICS WITH REVERSE REACH.

Fig. 7 (246A7985-2) MT Measurement Principles

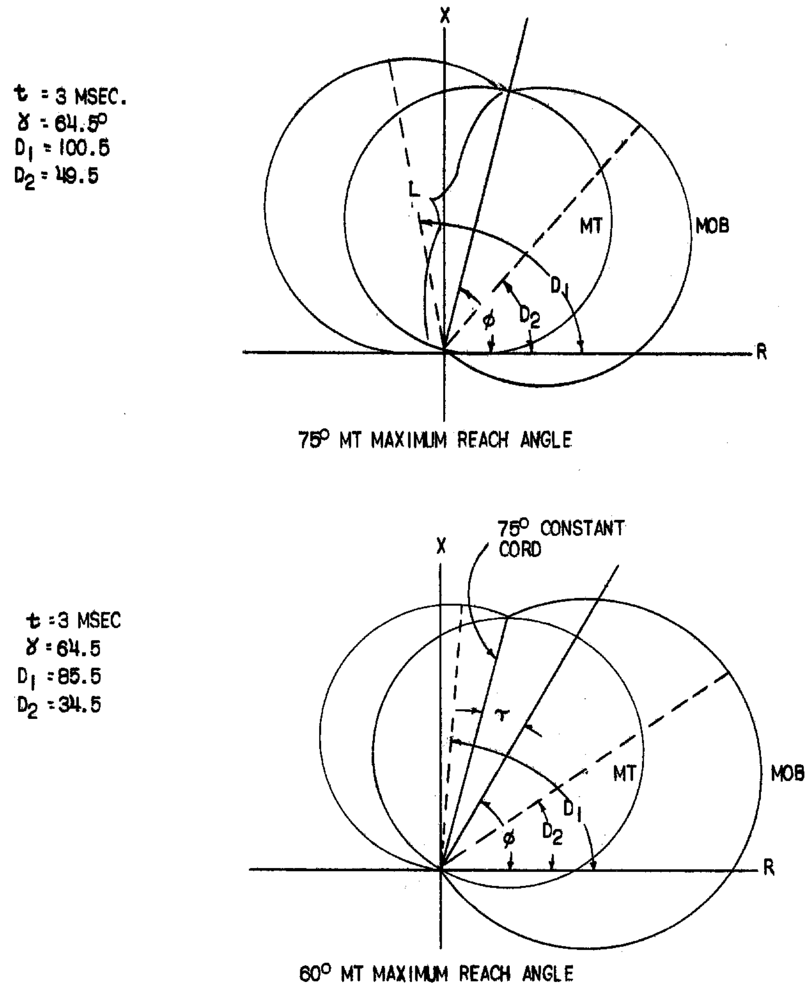


Fig. 8 (227A2092-0) MT & MOB Characteristic at 75° & 60° Angle of Maximum Reach

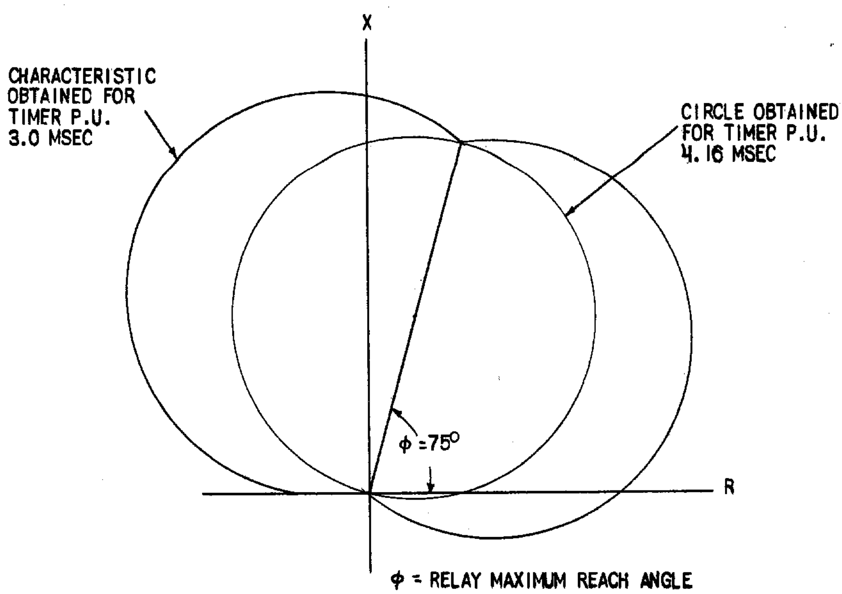


Fig. 9 (227A2093-0) MHO Characteristic at 75° Angle of Maximum Reach with Variations in Pickup Timer Settings

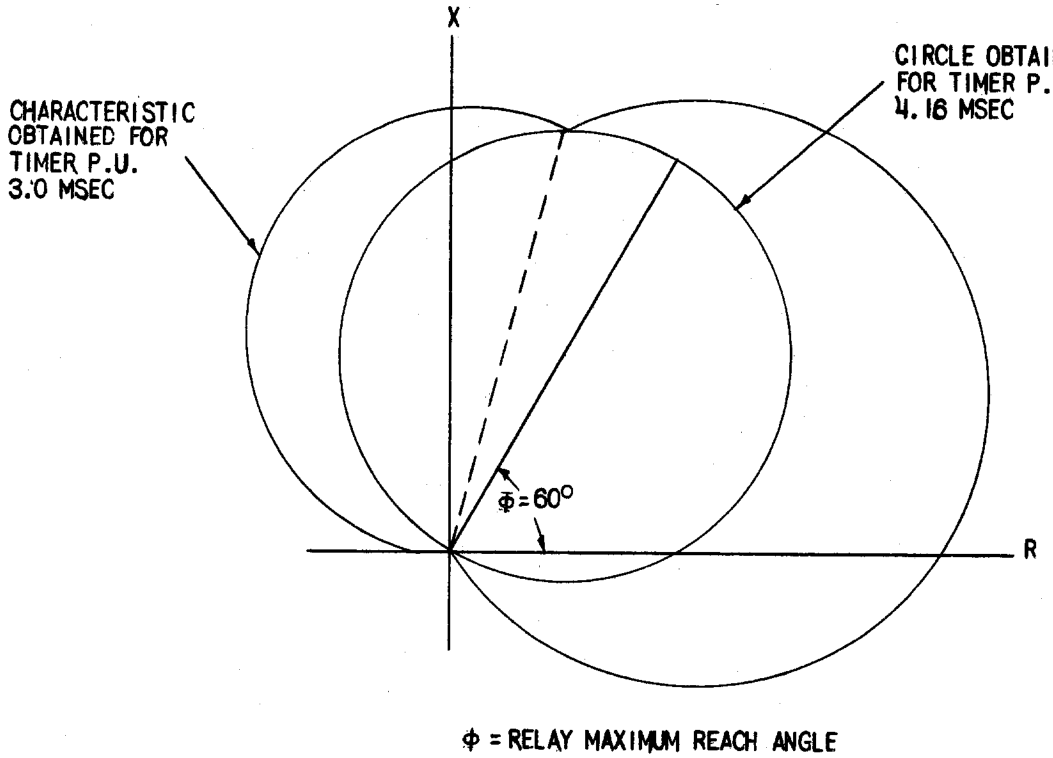


Fig. 10 (227A2094-0) MHO Characteristic at 60° Angle of Maximum Reach with Variations in Timer Pickup Settings

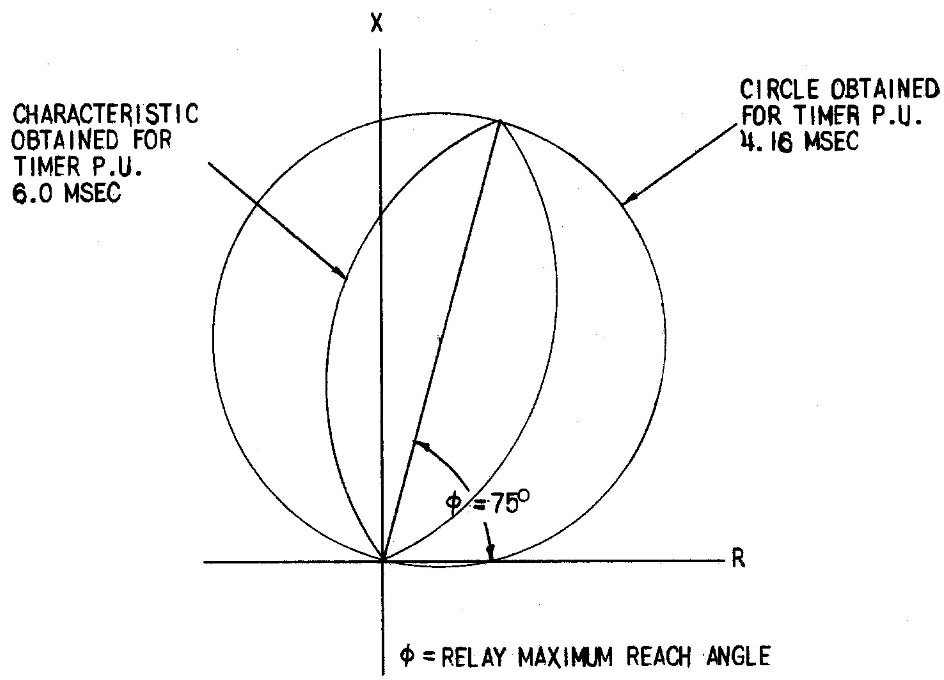


Fig. 11 (227A2095-0) MHO Characteristic at 75° Angle of Maximum Reach with Variations in Timer Pickup Settings

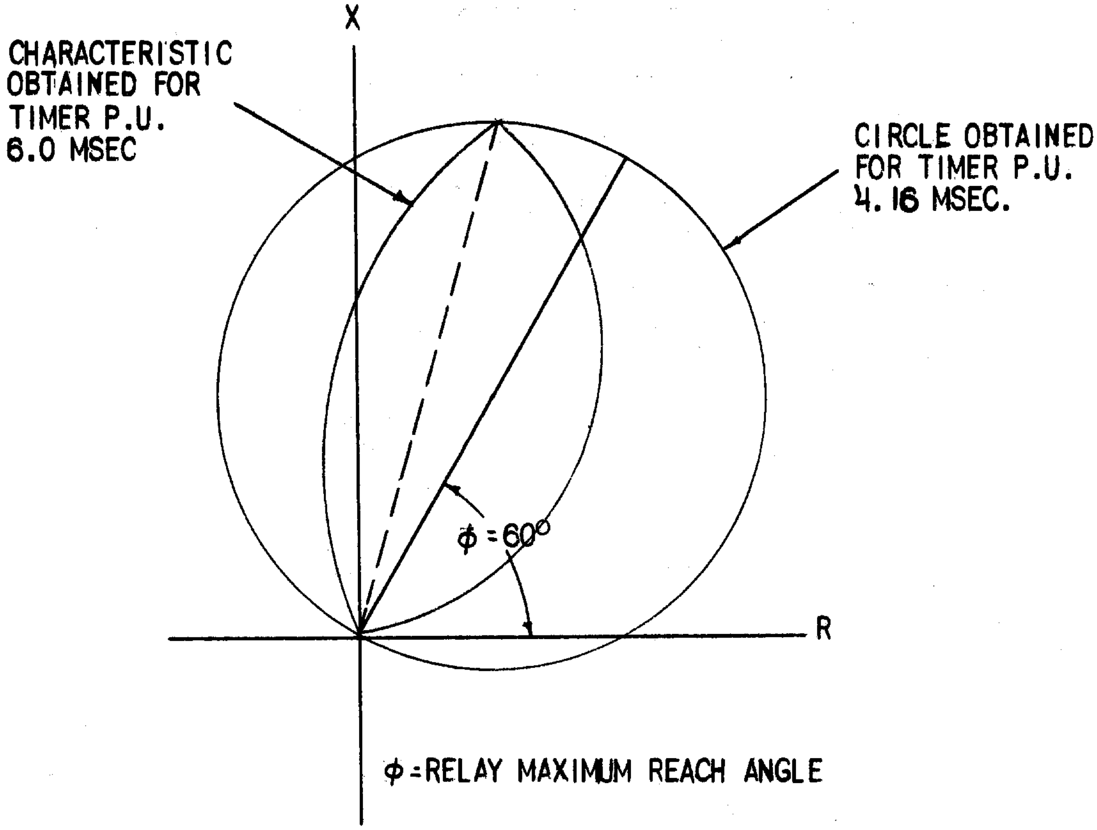


Fig. 12 (227A2096-0) MHO Characteristic at 60° Agnle of Maximum Reach with Variations in Timer Pickup Settings

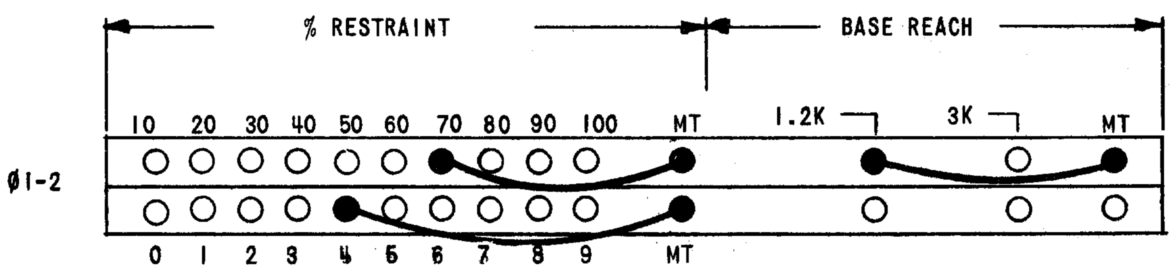


Fig. 13 (227A2097-0) Typical SLY51B Tab Block Connections

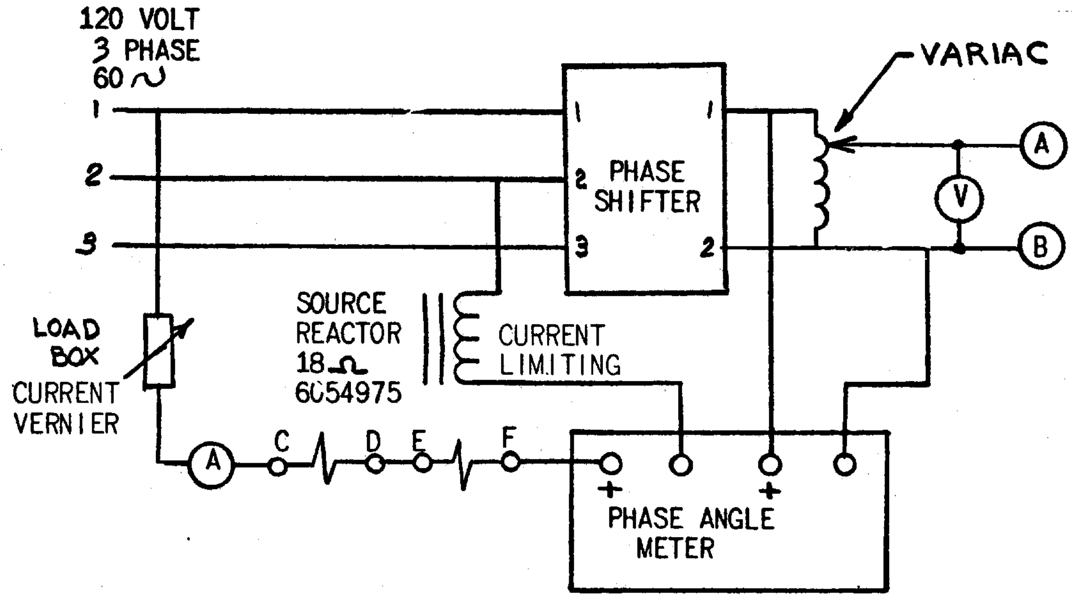


Fig. 14 (178A7029-3) Phase Shifter Test Circuit

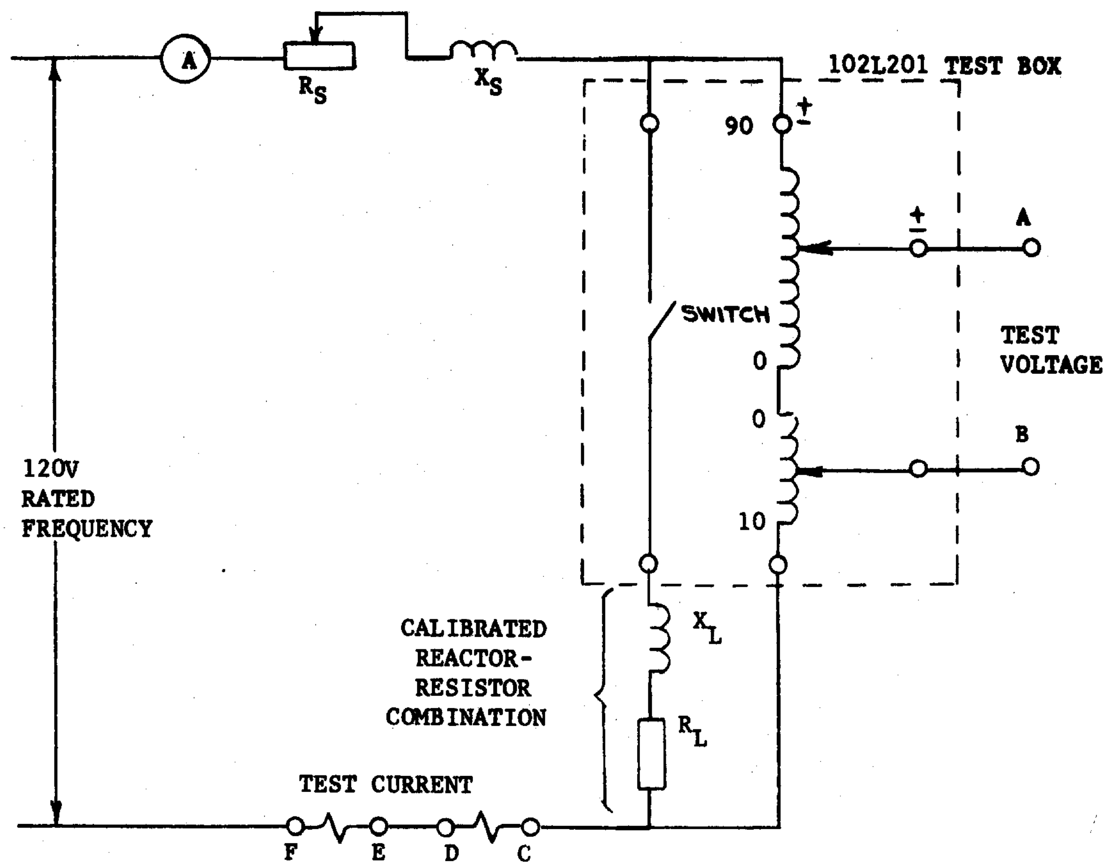
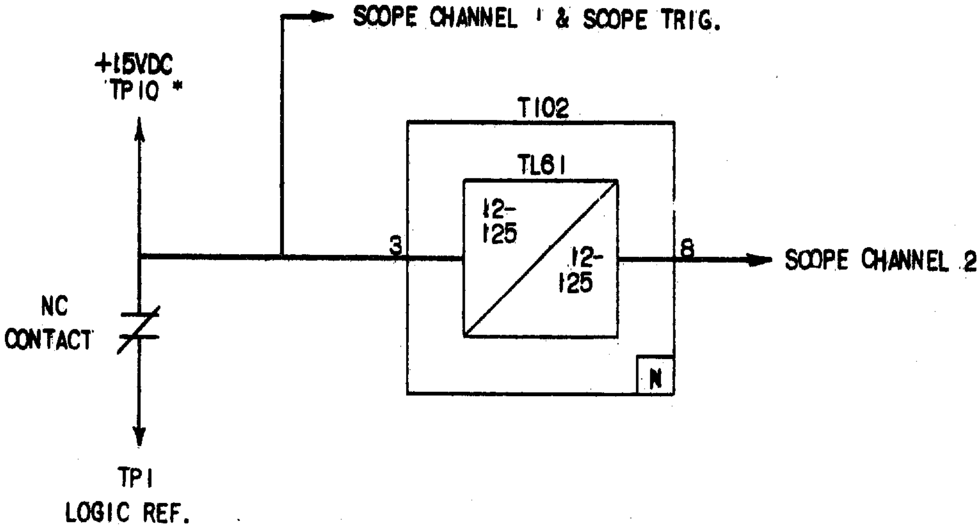


Fig. 15 (178A7028-3) Test Circuit for Characteristic Check Using Test Box, Test Reactor and Test Resistor Method



* THE 15VDC SIGNAL AT PIN 10 HAS A CURRENT LIMITING RESISTOR MOUNTED ON THE TEST CARD.

Fig. 16 (246A7987-0) Timer Test Circuit

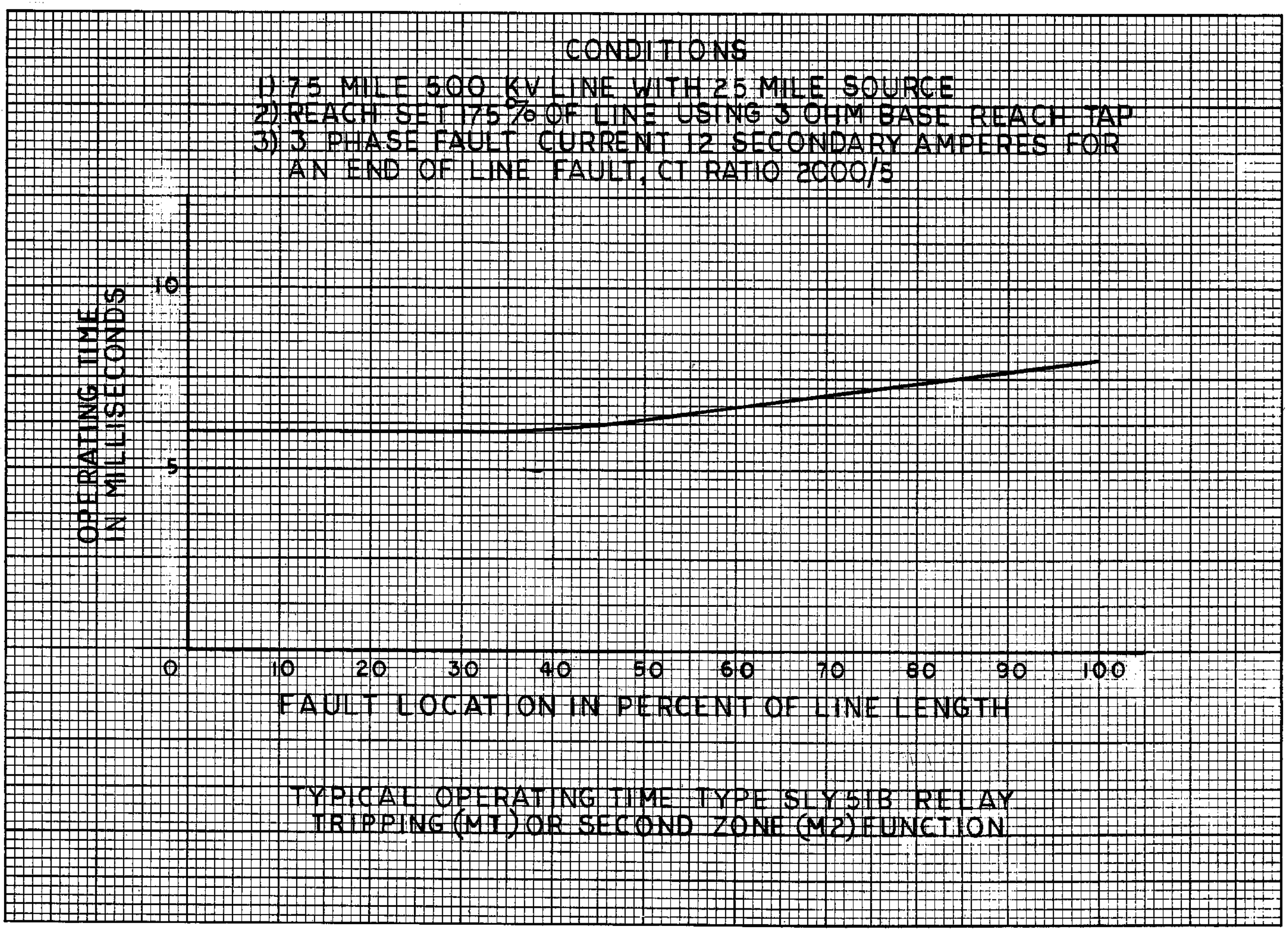
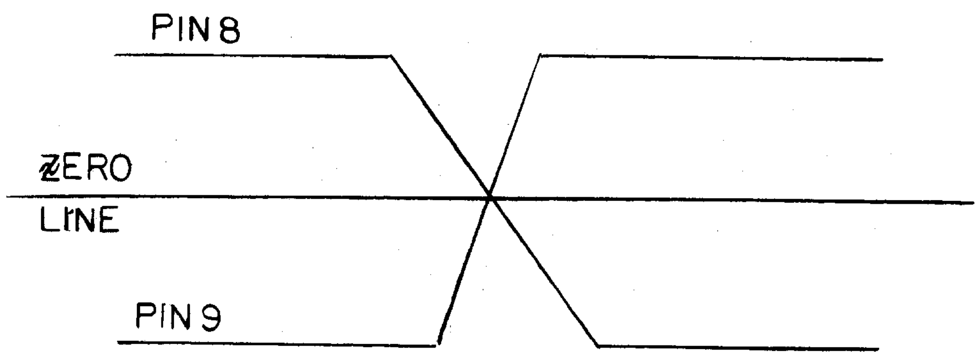
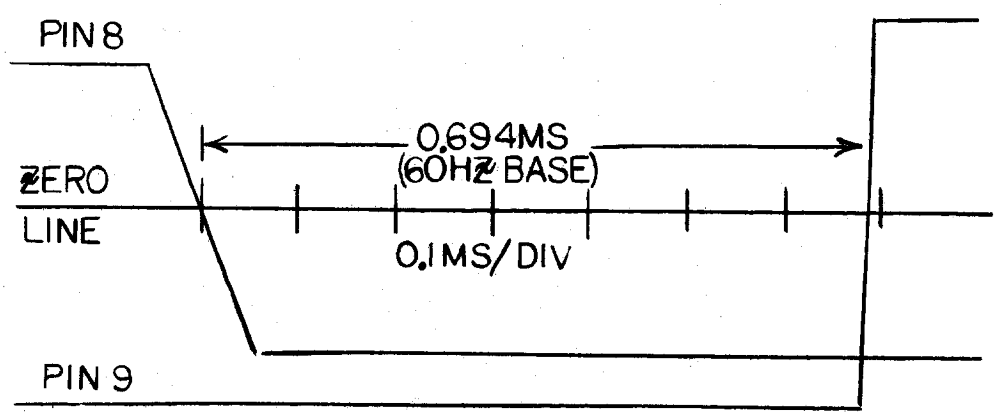


Fig. 17 (257A8490-0) Typical Operating Time Type SLY51B Relay



PROPERLY SET 0 DEGREE PHASE SHIFT



PROPERLY SET 15 DEGREE PHASE SHIFT

Fig. 18 (0257A9696-0) Polarizing Circuit Phase Shift Waveforms

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