INSTRUCTIONS

GEK-45337

STATIC THREE PHASE MHO DISTANCE RELAY

TYPE SLY51C

POWER SYSTEMS MANAGEMENT DEPARTMENT

GENERAL ELECTRIC

PHILADELPHIA, PA.

CONTENTS

DESCRIPTION

The Type SLY51C relay is a static, three phase, directional mho distance relay designed to provide an overreaching function to detect multi-phase faults within its reach setting. The SLY51C is packaged in a two rack unit case as shown in Figure 1. The component and card locations are shown in Figure 3.

The SLY51C is not intended to be used by itself, but rather as part of a complement of relays that forms a protective relaying scheme. Generally, in addition to the SLY51C relay, a Type SLA logic relay, a Type SLAT output relay, additional measuring relays and a Type SSA power supply are required to complete a protective scheme. The static circuits in the SLY51C require $\pm$15 VDC which is supplied by a Type SSA50/51 power supply. The Type SLY51C relay outputs are DC logic signals that feed into a Type SLA logic relay whose circuitry depends on the overall protection scheme. For a complete description of the overall scheme in which the SLY51C relay is employed, refer to the overall logic diagram and its associated logic description that are supplied with each terminal of equipment.

The Type SLY51C relay includes three phase to phase mho distance units (MT). The internal connections for the SLY51C are shown in Figure 2.

APPLICATION

The Type SLY51C relay was originally designed to provide multi-phase fault detection in a single pole tripping scheme. The mho tripping function MT should be set to reach 150-200% of the protected line section.

The reach of the mho functions in the SLY51C 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.

The mho functions in the SLY51C have an adjustable angle of maximum reach over the range of 60 to 75 degrees. The 60 degree angle will accommodate more arc resistance, hence it is useful on the 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 with highly lagging angles and longer lines where arc resistance is of minor importance.

RATINGS

The Type SLY51C relay is designed for use in an environment where the air temperature outside the relay case is between -20^{o}C and +65^{o}C.

The current circuits of the Type SLY51C relay are rated at 5 amperes, rated frequency for continuous duty and have a one second rating of 300 amperes. The potential circuits are rated at 120 volts, rated frequency.

RANGES

The range of adjustment of the functions in the Type SLY51C are listed below:

MT - MHO TRIPPING UNIT

0.30 - 30 ohms at 75^{o} maximum reach setting
0.30 - 30 ohms at 60^{o} maximum reach setting

TB - BASIC OHMIC REACH TAP

0.30, 0.60, 0.75, 1.2, 1.5, 3.0

BURDENS

AC BURDEN

The maximum Potential Burden per phase measured at 120 VRMS line voltage is as follows:

.30 Volt Amp
.24 Watts
.18 Vars

The maximum Current Burden per phase measured at 5 amps line current is as follows:

$Z = 0.017 \angle 40^{o}$
$R = 0.013$
$X = 0.011$

DC BURDEN

The Type SLY51C relay presents the following burden to the Type SSA power supply:

350 ma from the +15 VDC supply
50 ma from the -15 VDC supply

OPERATING PRINCIPLES AND CHARACTERISTICS

The mho characteristic for the SLY51C relay is shown in Figure 4. 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 5. 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 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 F125 cards. These square waves have the same phase relationship as the AC quantities 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 6.

MT TRIPPING FUNCTION

The MT function has a directional characteristic with the mho circle passing through the origin on an R-X diagram. See Figure 4.

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 unit at the angle of maximum reach $\emptyset$, may be calculated from the expression:

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

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

θ = Line angle
$\emptyset$ = Relay maximum reach angle

The angle of maximum reach ($\emptyset$) can be adjusted by changing the position of plug 'X' on the F125 board. When points 1 and 2 and 3 and 4 are jumpered, the angle of maximum reach is equal to 75°; when points 2 and 3 and 4 and 5 are jumpered, the angle of maximum reach is equal to 60°.

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.

CIRCUIT DESCRIPTION

The internal connections of the SLY51C relay are shown in Figure 2. 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 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 7 shows the characteristic obtained for a timer setting of 3.0 milliseconds at an angle of maximum reach of 75°. Figure 8 shows the same characteristic at an angle of maximum reach of 60°. Figure 9 shows the characteristic for a timer setting of 6 milliseconds at an angle of maximum reach of 75°. Figure 10 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.

CALCULATION OF SETTINGS

In order to illustrate the calculations required, assume a transmission line to be protected with the following characteristics:

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

CT RATIO = 2000/5

PT RATIO = 3000/1

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

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

Assume it is desired that the overreaching mho function is set for 200% 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 accomodate 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:

$$T = \frac{100\ (T_B)\ \cos\ (\theta - \emptyset)}{2.0\ (Z_L)}$$

T_B = basic minimum reach tap

$\emptyset$ = relay angle of maximum reach

Z_L = impedance of protected line

θ = angle of Z_L

2.0 = overreach factor 100 percent

With the assumed values, the restraint tap resolved to T = 22.5%.

CONSTRUCTION

The Type SLY51C relay is packated in a metal enclosure designed for mounting on a 19 inch rack. The relay is 2 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 SLY51C relay is located at the left of the unit. Figure 10 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 11.

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 10.

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 connections 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 F125, C104 or T107 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 equipment. 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 transportation 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. 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 SLY51A 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 SLY51C 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 INSTRUCTONS, before the relays are put in servive. 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 base reach taps
2. MT reach by voltage tap setting
3. The angle of maximum reach
4. MT characteristic timer settings

GENERAL TESTING INSTRUCTIONS

INPUT CIRCUITS

The Type SLY51C relay has two terminal blocks on the rear of the unit identified as YA and YB. Both these terminal 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 terminal points as those shown on the test circuit diagram.

Where the Type SLY51C 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 TP1. 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 monitired 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

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 TERMINALS 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. 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.

MT ANGLE OF MAXIMUM REACH

The angle of maximum reach can be set for either 75° or 60°. The angle if selected by plug X on the F125 board. In the 75° position, pin 1 is jumpered to pin 2 and pin 3 to pin 4. In the 60° position, pin 2 is jumpered to pin 3 and pin 4 to pin 5. This setting must be made on each of the three F125 cards.

TIMER ADJUSTMENTS AND TESTS

The following information concerns items which have been covered in factory tests. This information is supplied for use in trouble-shooting or in checking the overall performance of the Type SLY51C relay. The pickup setting of the characteristic timer determines the shape of the mho characteristic. Increasing the timer pickup setting tends to narrow the characteristic; decreasing the setting widens the characteristic (see Fig. 7-10). The reset time delay (drop out time) of the timer provides an overlap of the next helf-cycle measurment and produces a continuous logic signal. The timer settings are discussed in the section "CALCULATION OF SETTINGS".

METHOD I - SWITCHED D.C. INPUT

In order to test timer cards by this method, it is necessary to remove the card previous to the timer (C104) and to place the timer card under test in a card adapter. The timer test circuit is shown in Figure 11. Opening the normally closed contact causes the output to step up to +15 VDC after the pickup delay of the timer. To increase the pickup time, adjust P2 on the T107 card clockwise. Closing the contact causes the timer output to drop to less than 1 VDC after the reset delay setting of the timer card. To increase the reset time, turn P3 on the T107 card clockwise.

The shorter pickup time of the T107 (4.16 ms) should be observed at pin 7 of the timer card. The longer pickup time is factory adjusted by P1 for a pickup 1.2 ms longer than the shorter time. This output should be observed at pin 8.

METHOD II - AC INPUTS

The test circuit of Figure 13 and the connections of Table I should be used for this method.

The test procedure is outlined below:

1) Set the current equal to five amperes.
2) Adjust the voltage until blocks of the desired width are present at the input to the timer card.
3) Turn the dropout potentiometer counter clockwise to decrease dropout time. This allows the pickup time to be observed.
4) Adjust the pickup potentiometer (P2) so that the timer just picks up.
5) Turn the dropout potentiometer clockwise until the output is continuous. At this point one additional turn should be given to the potentiometer.

Note: The switched D.C. input method, described previously, must be used to check the longer pickup setting of the T107 timer card.

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 13. Input connections for testing any of the phase-pair characteristics should be made with Figure 13 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 settings 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 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 TP1.

(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 13 voltmeter (V), defines the relay mho characteristic.

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

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

where: T_B = basic minimum ohmic tap
T = voltage restraint tap in percent
I = 5 ampere test current
= angle between applied voltage and current
ϕ = 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^{0} angle of maximum reach. If the relay is used at 60^{0}, the reach should be readjusted. Using the test procedure outlined above, set $V_{\phi-\phi}$ for the desired pickup at the angle of maximum reach. Adjust P10 on the F125 card to obtain the pickup point of the function.

An alternate method of testing the relay characteristic is shown in Figure 14 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.

ANGLE OF MAXIMUM REACH CHECK

As stated earlier the angle of maximum reach, ϕ, can be adjusted by changing the setting of plug X on the F125 printed circuit card. The angle is typically factory adjusted to produce a 75^{0} angle of maximum reach. In the Type SLY51C relay the angle of maximum reach can be adjusted to 60^{0}. A check of the angle of maximum reach can be made by using the test circuit of Figure 13. The recommended procedure is as follows:

(a) Determine what test voltage V in Figure 13 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 1. The letters A through F in Table I correspond to the letters in Figure

(c) Adjust the variac in Figure 13 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 and 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 SLY51C relay may be checked at periodic intervals using the procedures described in the section INSTALLATION TESTS. Cable connections between the SLY51C 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 SLY51C relay are included in the card book GEK-34158; the card types are shown on the component location diagram (Figure 3).

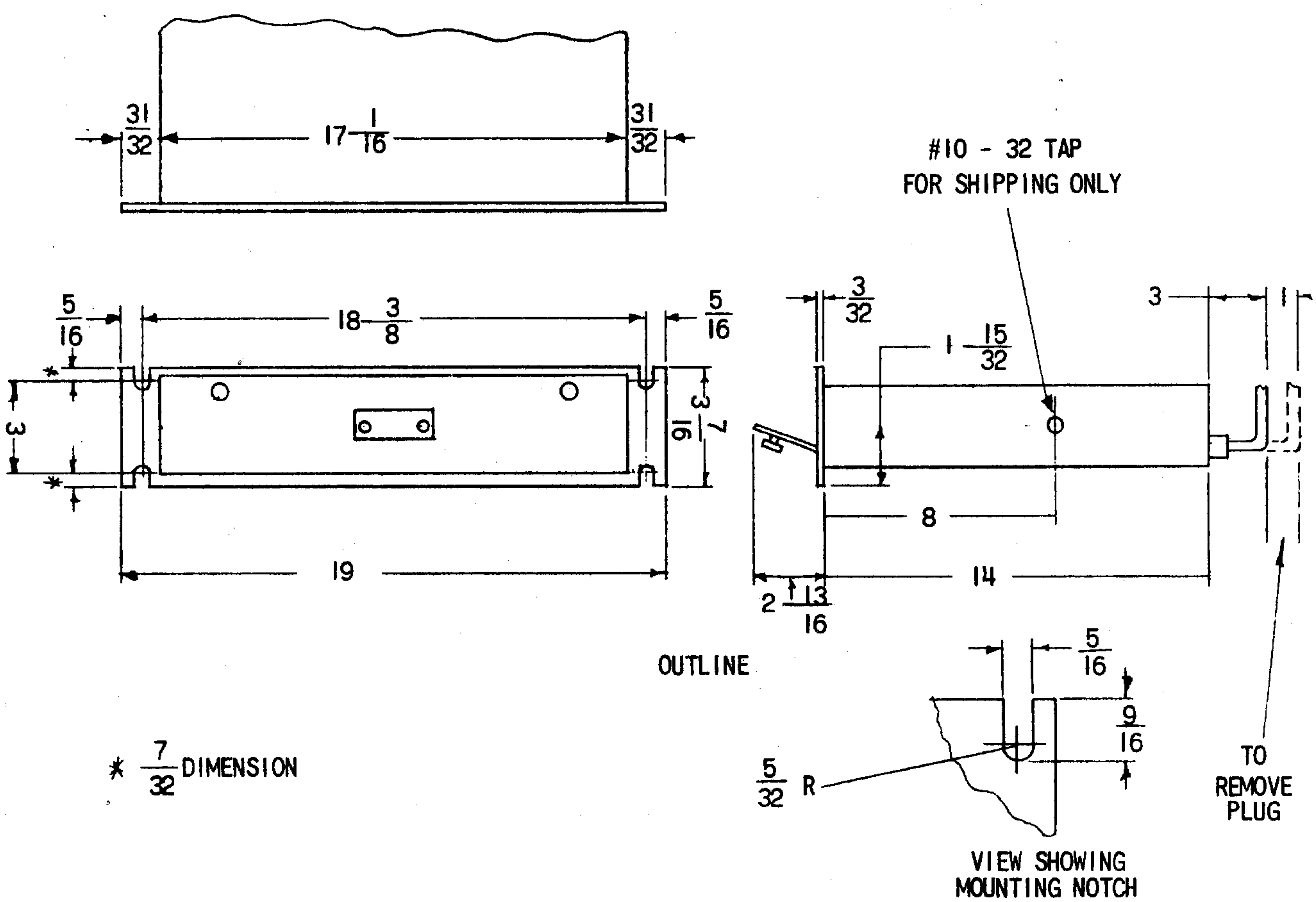


FIG. 1 (0227A2036-0) OUTLINE AND MOUNTING DIMENSIONS FOR THE TYPE SLY51C RELAY

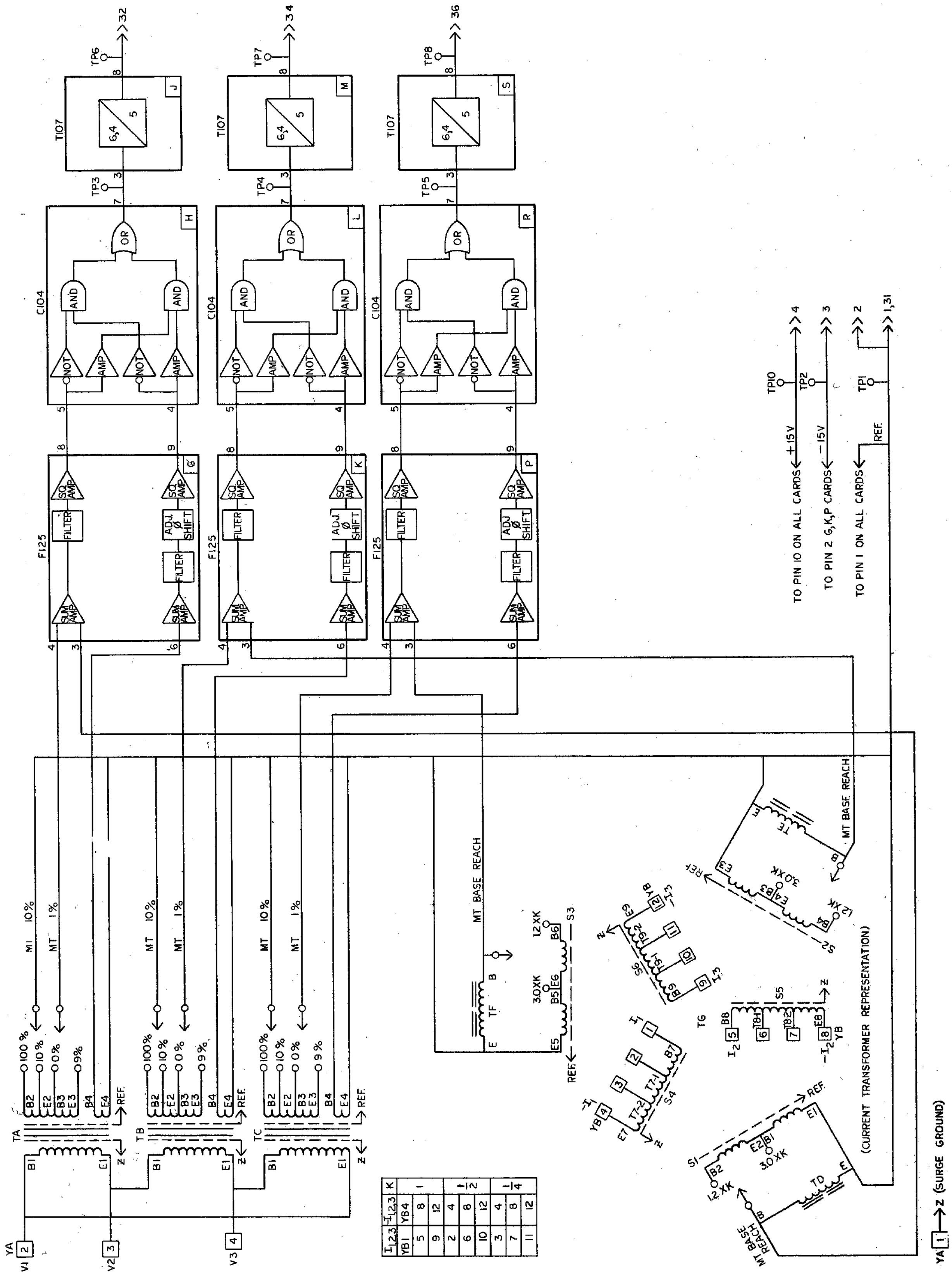


FIG. 2 (0149C7375-0) INTERNAL CONNECTIONS FOR THE TYPE SLY51C RELAY

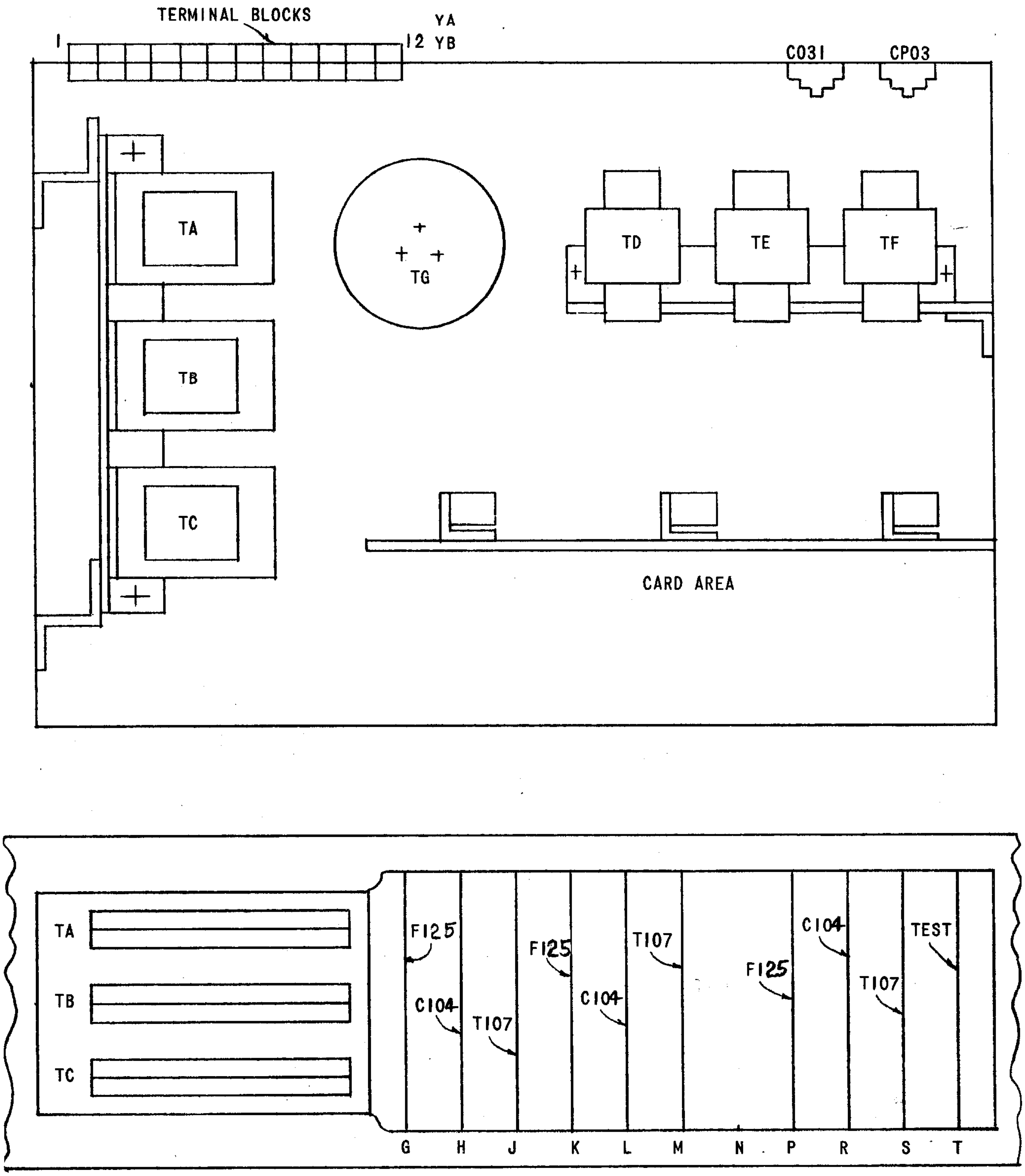


FIG. 3 (0227A2197-0) COMPONENT AND CARD LOCATION DIAGRAM FOR THE TYPE SLY51C RELAY

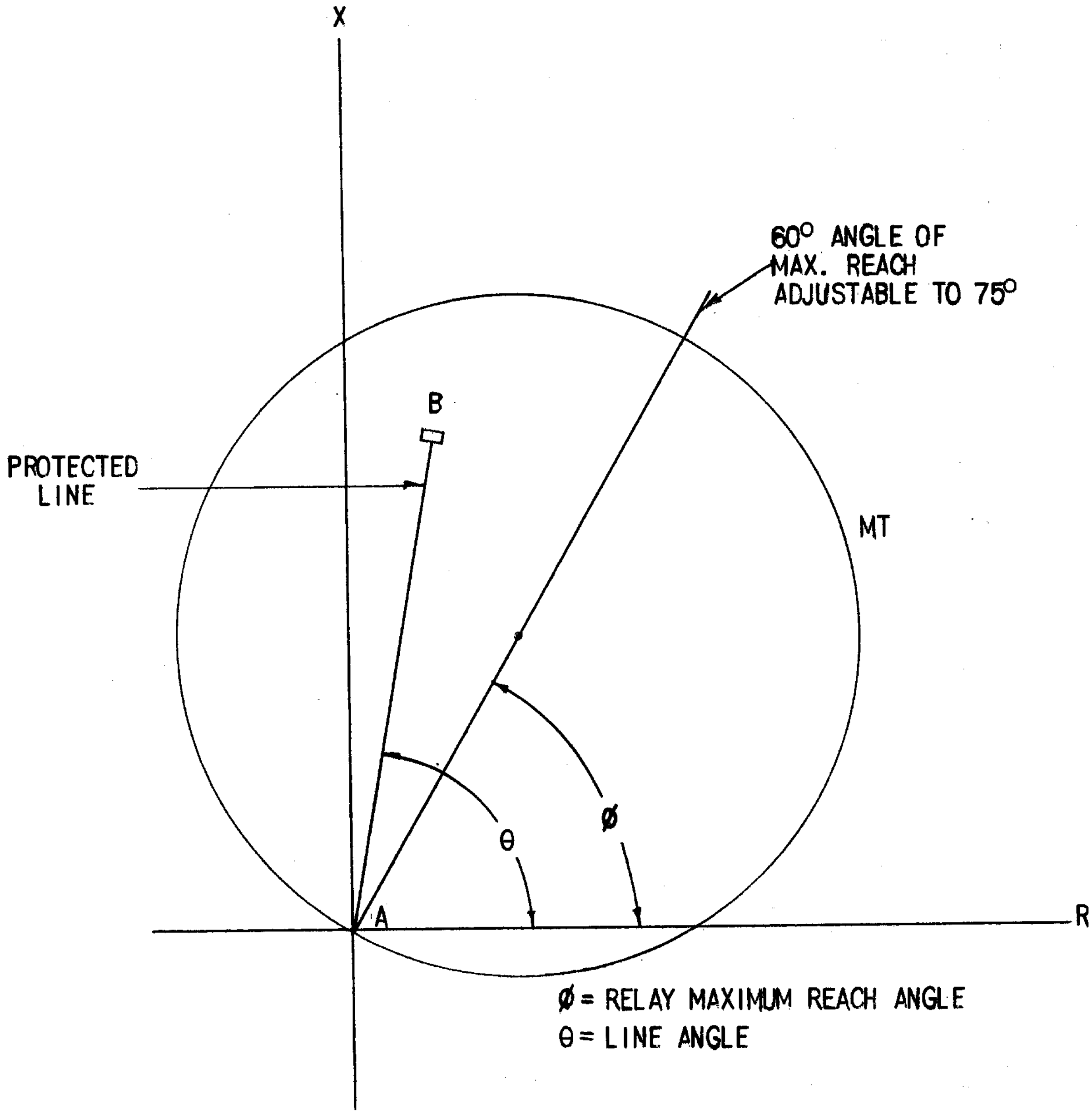
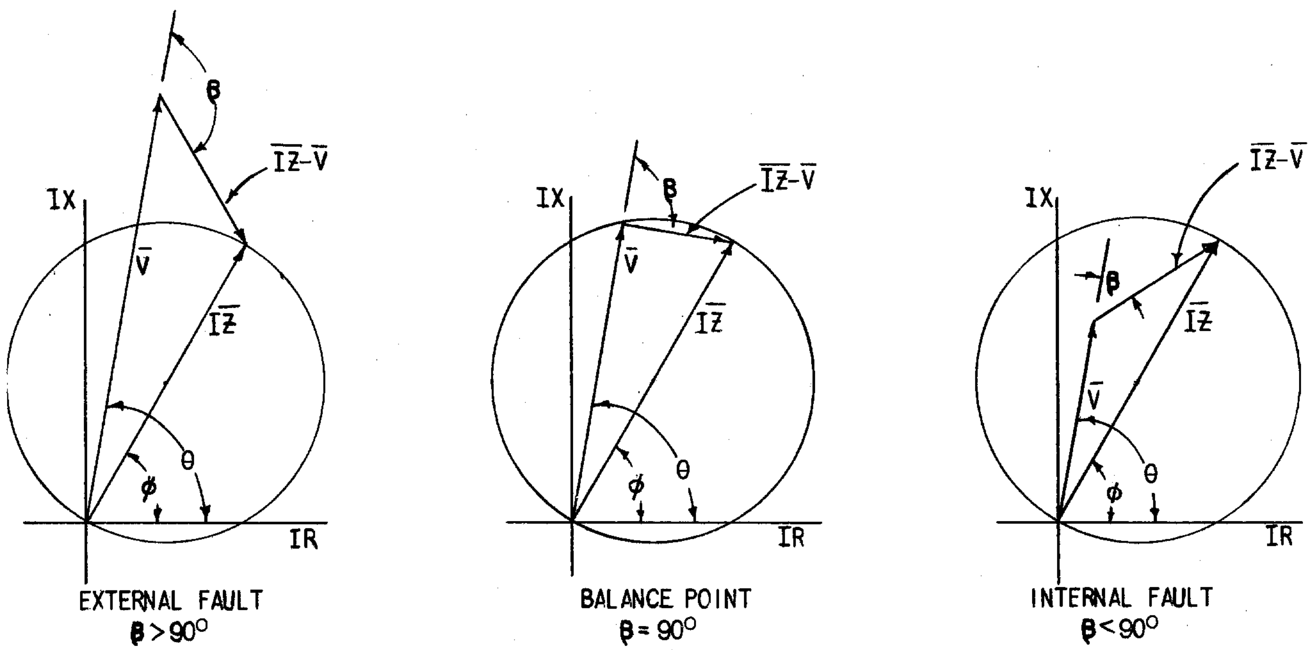
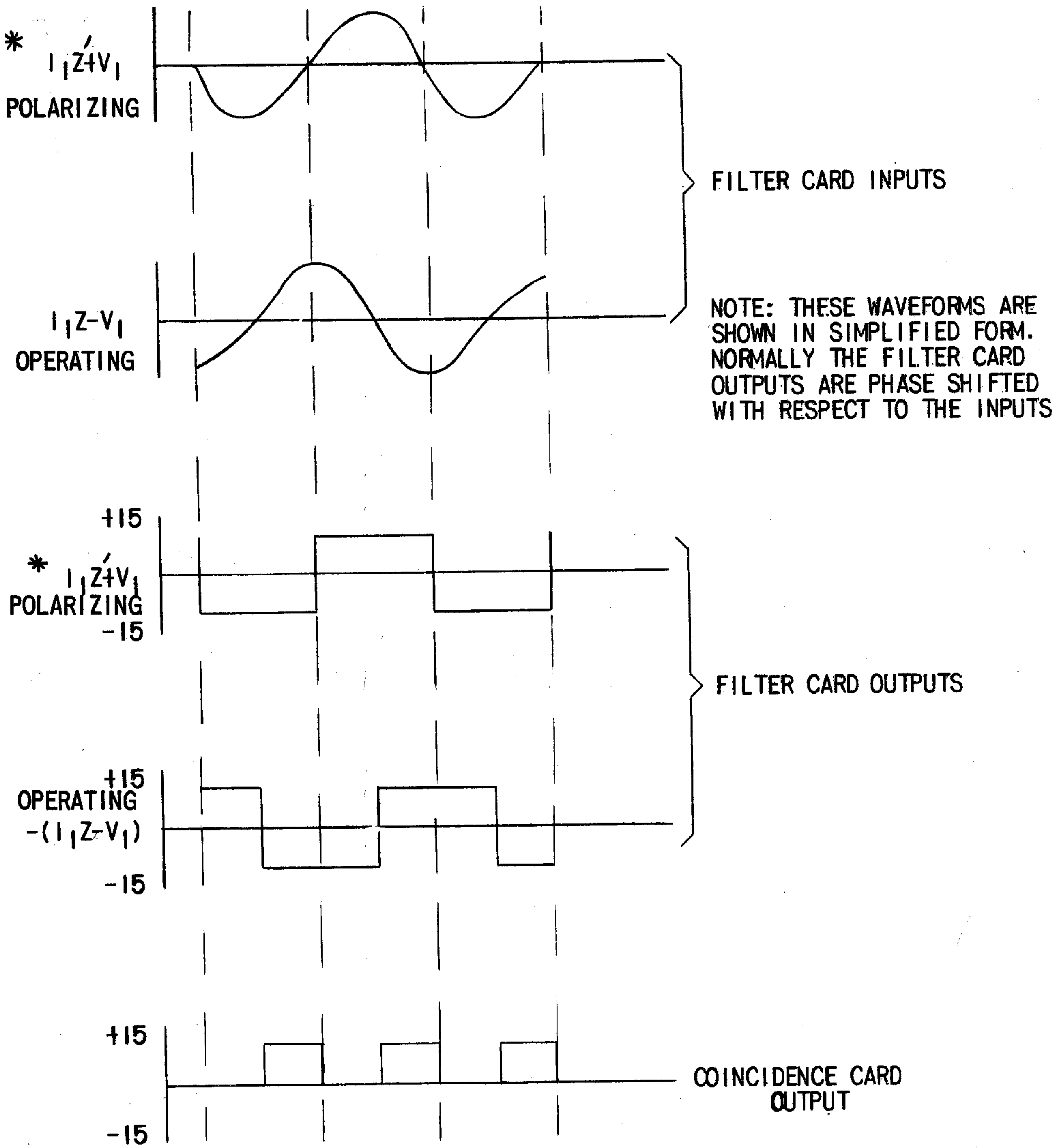


FIG. 4 (0227A2089-0) TYPICAL MT CHARACTERISTIC FOR THE TYPE SLY51C RELAY



φ = RELAY MAXIMUM REACH ANGLE
θ = LINE ANGLE

FIG. 5 (0227A2090-0) MHO CHARACTERISTIC BY PHASE ANGLE MEASUREMENT



* THE I_1Z' TERM IS PART OF THE POLARIZING VOLTAGE ONLY IN CHARACTERISTICS WITH REVERSE REACH.

FIG. 6 (0246A7985-2) MT MEASUREMENT PRINCIPLES

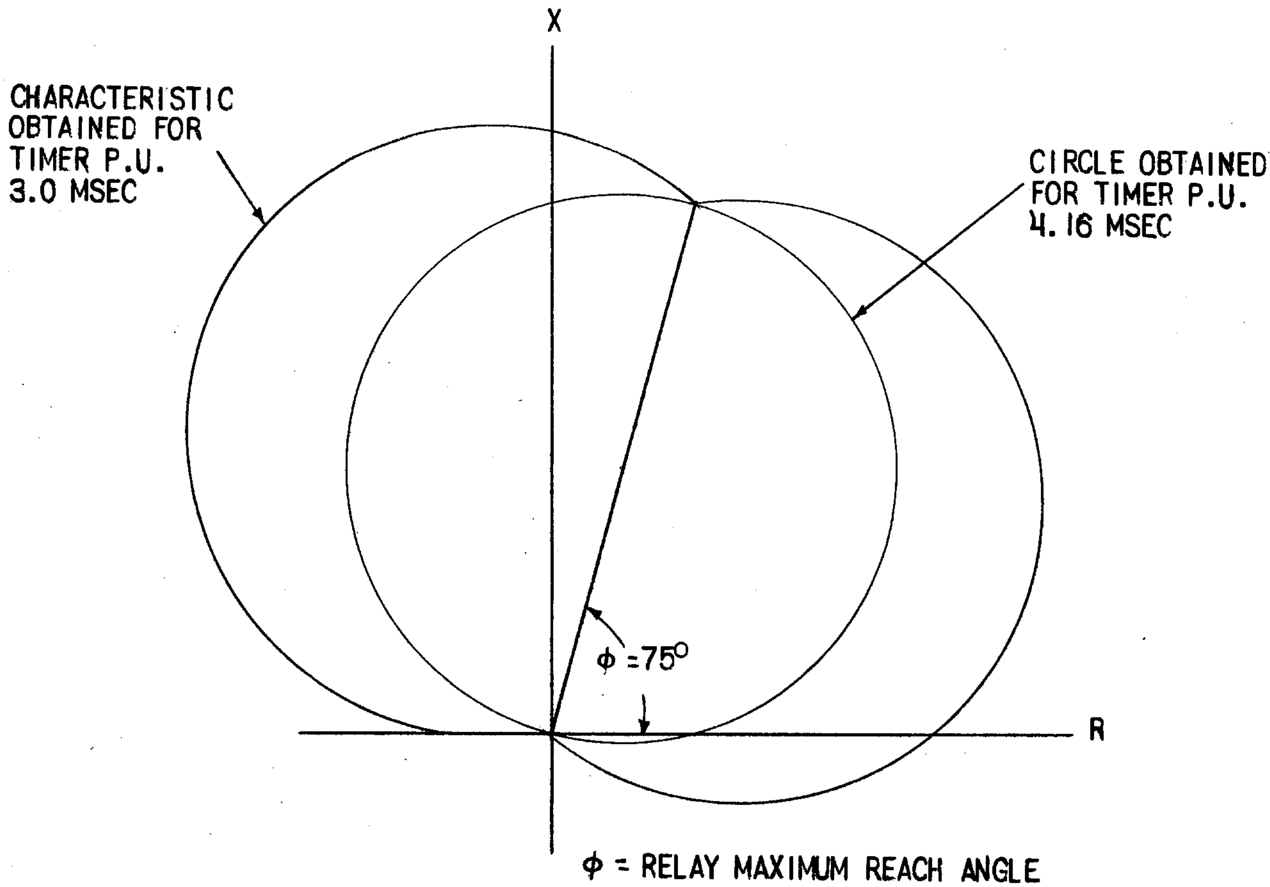


FIG. 7 (0227A2093-0) MHO CHARACTERISTIC AT 75° ANGLE OF MAXIMUM REACH WITH VARIATIONS IN TIMER PICKUP SETTING

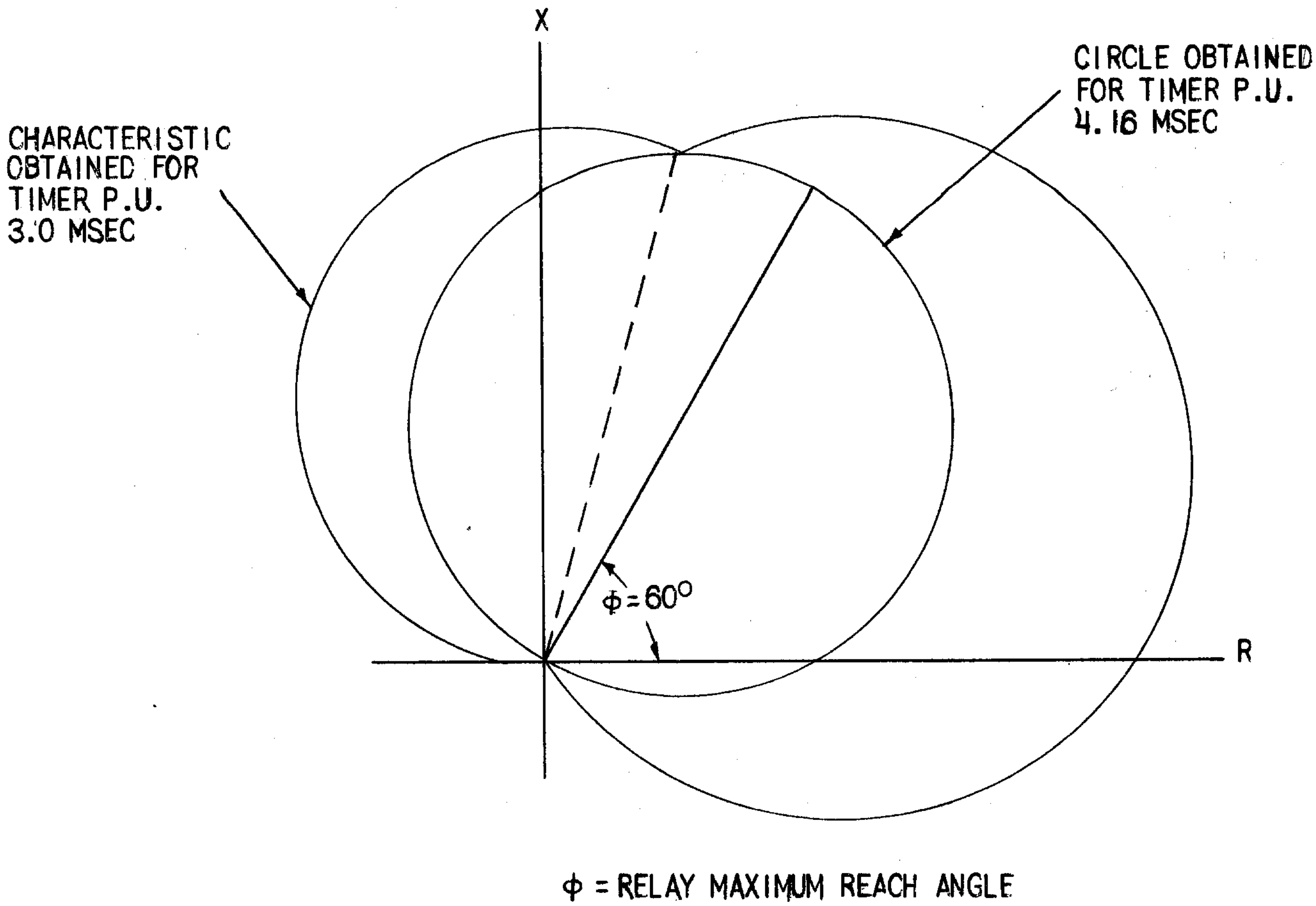


FIG. 8 (0227A2094-0) MHO CHARACTERISTIC AT 60° ANGLE OF MAXIMUM REACH WITH VARIATIONS IN TIMER PICKUP SETTING

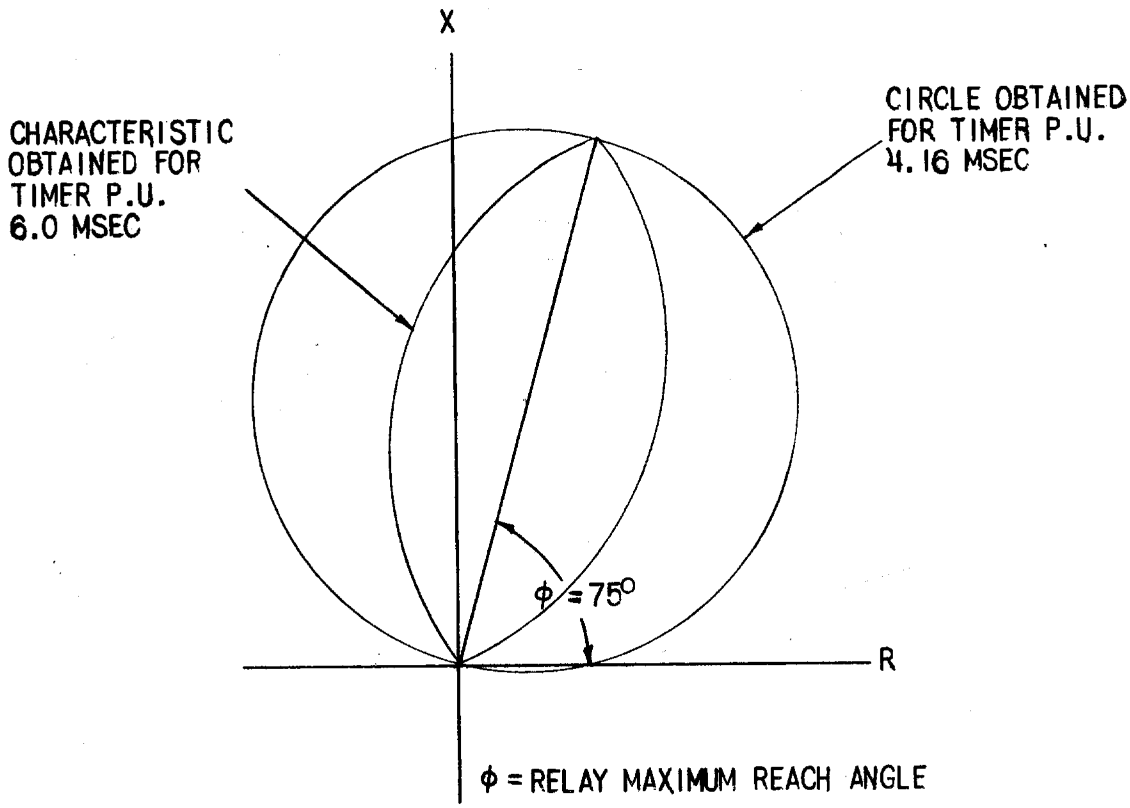


FIG. 9 (0227A2095-0) MHO CHARACTERISTIC AT 75° ANGLE OF MAXIMUM REACH WITH VARIATIONS IN TIMER PICKUP SETTING

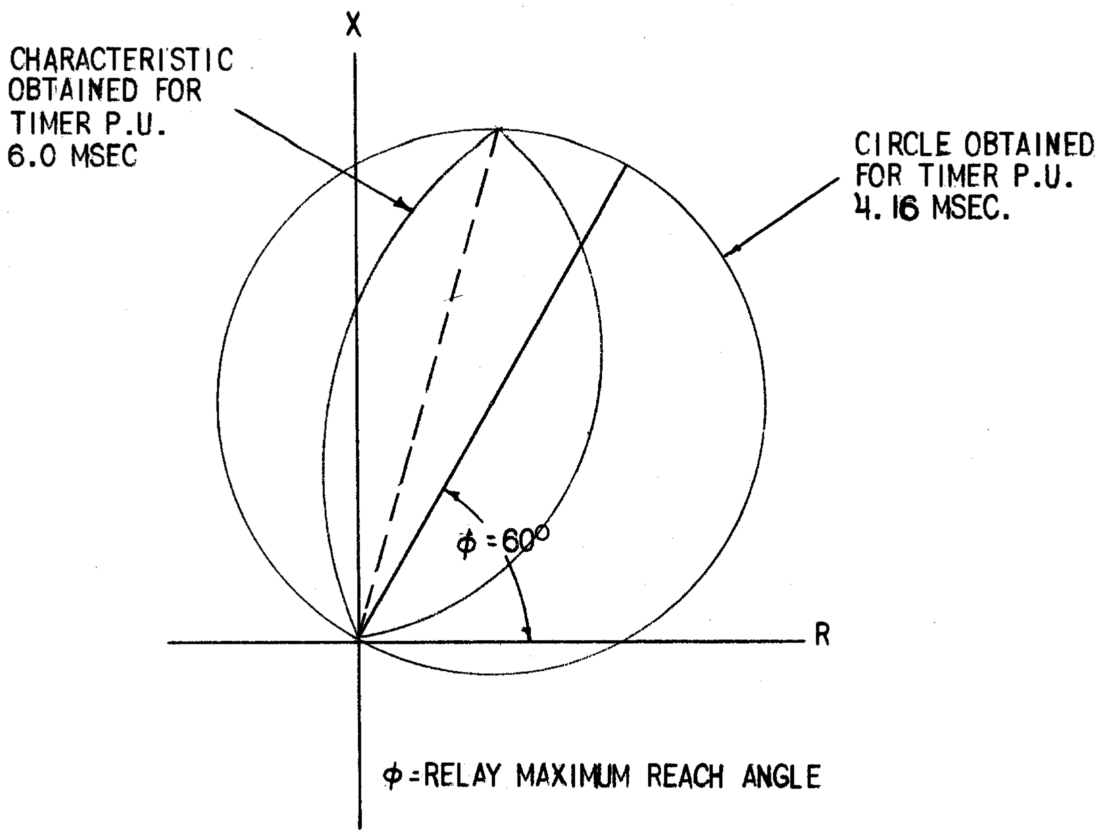


FIG. 10 (0227A2096-0) MHO CHARACTERISTIC AT 60° ANGLE OF MAXIMUM REACH WITH VARIATIONS IN TIMER

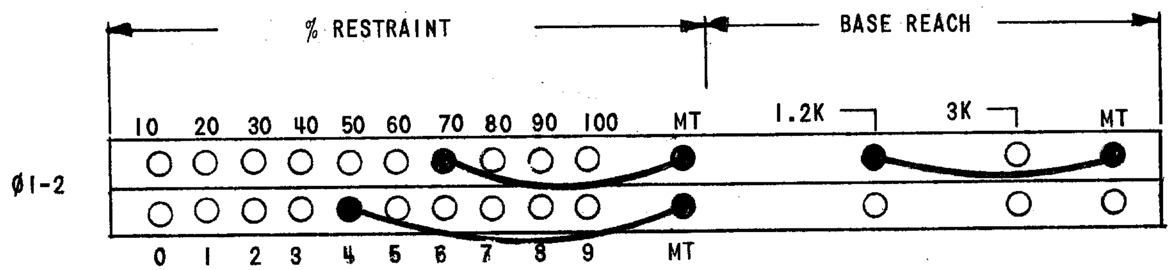
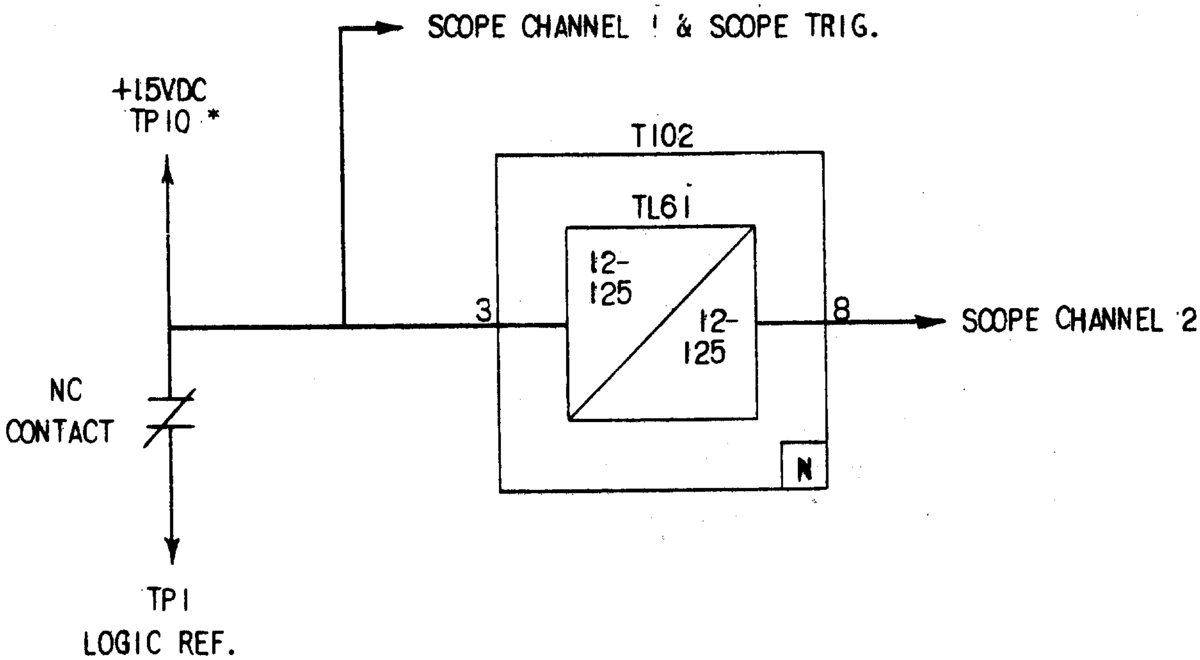


FIG. 11 (0227A2097-0) TYPICAL SLY51C TAP BLOCK CONNECTIONS



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

FIG. 12 (0246A7987-0) TIMER TEST CIRCUIT

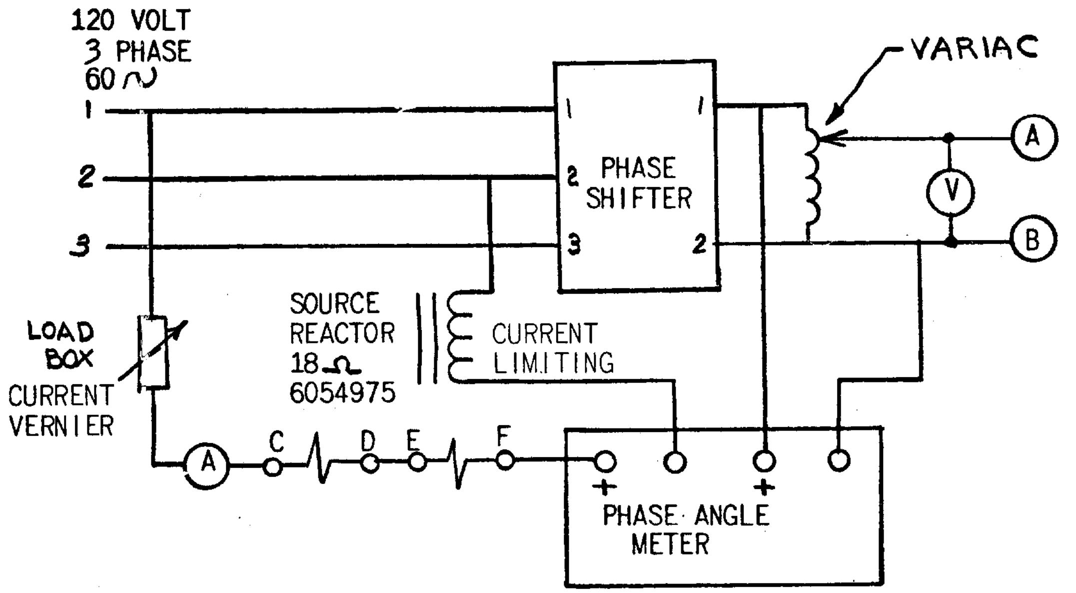


FIG. 13 (0178A7029-3) PHASE SHIFTER TEST CIRCUIT

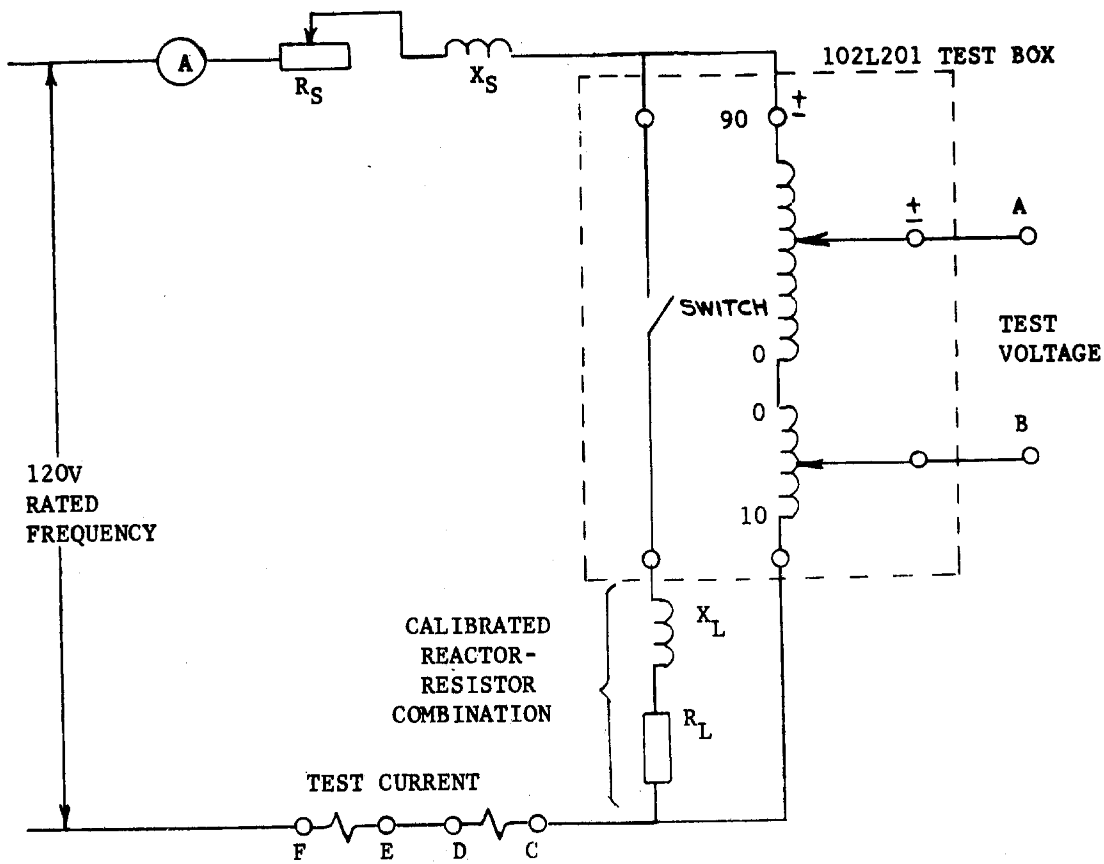


FIG. 14 (0178A7028-3) TEST CIRCUIT FOR CHARACTERISTIC CHECK USING TEST BOX, TEST REACTOR, AND TEST RESISTOR METHOD

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