INSTRUCTIONS

GEK-41959

STATIC POSITIVE SEQUENCE DISTANCE RELAY

TYPE SLYP51B

POWER SYSTEMS MANAGEMENT DEPARTMENT
GENERAL ELECTRIC
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STATIC POSITIVE SEQUENCE DISTANCE RELAY TYPE SLYP51B

DESCRIPTION

The SLYP51B is a solid state positive sequence distance relay for directional comparison protection of transmission lines. The relay is packaged in one 2 rack unit high case suitable for standard 19 inch rack mounting. The relay outline and mounting dimensions are shown in Fig. 1.

The SLYP51B includes positive sequence measuring functions are designed to respond to balanced three phase faults. The relay is normally supplied as a part of a terminal of transmission line protective equipment. Other equipment in a typical terminal would include other fault detecting and measuring relays to respond to unbalanced faults, a type SLA logic relay, a type SLAT output relay and a type SSA regulated DC power supply. The functions which may be included in an SLYP51B relay are as follows:

MT - Overreaching positive sequence directional mho tripping function for pilot or Zone 2 protection.

MB - Offset mho positive sequence blocking function.

M1 - Underreaching positive sequence directional mho tripping function for Zone 1 protection. Optional on short lines. Recommended on long lines.

MOB - (Optional) Positive sequence out-of-step distance function with characteristic concentric with MT.

V1 - (Optional) Positive sequence voltage detector for certain line pick-up and reclosing schemes.

The overall logic diagram and the relay nameplate indicate which of the optional functions are included in a particular equipment. All SLYP51B relays include the wiring and sockets for all of the above functions. When any optional function is omitted in a particular SLYP51B this function may be added in the field by obtaining the necessary printed circuit cards and inserting them in the proper sockets. However, the addition of optional functions to an existing equipment does require that any associated logic in other relays in the equipment also be present or added at that time.

The internal connections for the SLYP51B is shown in Figure 2, and the component location diagram is shown in Figure 3. Detailed information on the various printed circuit cards is included in GEK-34158.

APPLICATION

The SLYP51B is a three phase positive sequence mho distance relay for the detection of balanced three phase faults. These positive sequence functions will also respond to severe unbalanced faults. The SLYP51B is intended for use with other measuring relays capable of unbalanced fault detection to provide complete directional comparison protection for high voltage transmission lines with or without series capacitors compensation.

There are two basic types of SLYP51B relays: one for short line applications, and one for long line applications. Long lines are defined as lines greater than 100 miles in length. The following

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

discussions of settings are general and are based on uncompensated lines. Specific recommendations for both compensated and uncompensated lines are given in the applicable Logic Description for a particular equipment.

The MT, MB, and MOB positive sequence distance functions in a particular type of scheme are provided with fixed ratios of ohmic reach to assure optimum coordination. The overall reach of all of these functions may be lengthened or shortened by a common field adjustment which maintains these fixed reach ratios when the required setting is accomplished for a particular line length. This common setting is the positive sequence impedance represented by the ratio of the positive sequence voltage network output to the positive sequence current network output, and it is referred to as the "Relay System Reach".

The required Relay System Reach setting for a particular line is equal to the secondary positive sequence ohms of the line times a margin factor "R" which is related to line length. This "R" margin factor provides Relay System Reach settings that are longer than the line for short lines, and settings that approach the line length for long lines. Refer to the CALCULATION OF SETTINGS section of this book for a sample calculation of Relay System Reach. The Relay System Reach setting is accomplished by the selection of a base reach tap in the SLYP51B positive sequence current network, and a voltage restraint tap in the positive sequence voltage network. This is also illustrated by an example in the CALCULATION OF SETTINGS section of this book.

The following tables give the standard reach, angle, and characteristic timer settings for the various mho functions in the SLYP51B for uncompensated lines. Unless otherwise stipulated, the relays will be shipped with the maximum reach angles and characteristic timer settings shown in TABLES I and II for short and long lines respectively.

TABLE I

STANDARD SHORT LINE SETTINGS

MHO FUNCTION	CHARACTERISTIC		REACH IN % OF RELAY SYSTEM REACH	ANGLE OF MAXIMUM REACH
	TIMER	SHAPE		
MT	4/5	Circle	125%	75°
MB	3.5/50	Expanded MHO	25% FWD. - 175% REV.	85°
M1	4/10	Circle	20-90% ADJ.*	75°
MOB	3/16	Expanded MHO	125%	75°

*DO NOT SET M1 GREATER THAN 90% OF ACTUAL LINE OHMS.

TABLE II

STANDARD LONG LINE SETTINGS

MHO FUNCTION	CHARACTERISTIC		REACH IN % OF RELAY SYSTEM REACH	ANGLE OF MAXIMUM REACH
	TIMER	SHAPE		
MT	6, 5/5	Lens	125%	85°
MB	4/50	Circle	25% FWD. - 75% REV.	85°
M1	4/10	Circle	20-90% ADJ.*	75°
MOB	4/16	Circle	125%	85°

*DO NOT SET M1 FOR GREATER THAN 90% OF ACTUAL LINE OHMS.

Refer to Figures 4 and 5 for plots of the short and long line characteristics shown in Table I and II.

The reach of all of the mho functions except M1 are a fixed percentage of the Relay System Reach setting, as shown in Table I and II. The M1 function has a reach adjustment potentiometer in the relay which provides an adjustment range of from 20% to 90% of the Relay System Reach selected. Care must be exercised to limit the M1 reach adjustment to 90% or less of the actual line ohms. This would in general be significantly less than 90% of the Relay System Reach setting because of the margin factor "R" used to determine the Relay System Reach setting on a particular line. The M1 angle of maximum reach can be adjusted to an angle of 60° with a potentiometer in the polarizing phase shift circuit on the M1 filter card. The M1 function is optional for Zone 1 protection on short lines, but is recommended for all long line applications for use in conjunction with the MT function.

The V1 function measures the positive sequence component of the voltage supplied to the relay. This function is used to control line pick-up protection, for loss of potential detection, and for certain selective sequential reclosing schemes. The V1 function is required in the SLYP51B only if one or more of these schemes is included in the protective equipment. The V1 pick-up is adjustable over a range of 40-100% and must be set by the user for the particular application. Refer to the logic description for the particular scheme for setting considerations.

The SLYP51B will operate for positive sequence fault currents down to 1 ampere on the 3 ohm basic relay system tap. The sensitivity is 3 amperes on 1 ohm basic tap.

RANGES

The SLYP51B relay has an adjustable system reach of 1-30 ohms in the trip direction, with 1 ohm and 3 ohm base reach taps in the current circuits and 1% taps in the voltage circuits. With the exception of the M1 function, the reach of each measuring function in the SLYP51B is fixed at a specific percentage of the Relay System Reach. For example, if the Relay System Reach has been set at 4.0 ohms, and the unit nameplate indicates that the MT reach is 125%, then the reach of the MT function at the relay system angle is 5.0 ohms. The MT function is adjustable over a range of 20-90% of the Relay System Reach. The standard settings for uncompensated lines are shown in Tables I and II in the APPLICATION Section.

The standard angle setting for the Relay System Reach is 85°. This angle can be adjusted over the range of 60° to 90° for special applications. The angle of maximum reach of the various mho functions is determined by the difference between the polarizing phase shift for each function and the common Relay System Reach angle. The range of polarizing phase shift adjustment for special applications is as follows:

MT & MOB	0° to +30°
MB & M1	-15° to +30°

The pick-up range of the V1 function is adjustable over the range of 40% to 100% of rated system positive sequence voltage.

RATINGS

The Type SLYP51B 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 SLYP51B relay requires a ±15 VDC power source which can be obtained from power supplies Type SSA50 and up.

The current circuits of the Type SLYP51B 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.

CHARACTERISTIC

OPERATING PRINCIPLES

The Type SLYP51B relay uses positive sequence voltage and current networks to obtain the V_1 and I_1Z quantities. These quantities are used to derive the various mho characteristics employed in the SLYP51B relay. The operating theory is described in the following sections.

A. POSITIVE SEQUENCE VOLTAGE NETWORK

The positive sequence voltage network used in the SLYP51B relay is shown in Figure 6. The derivation of the output voltage is described below.

$$V_{out} = V_{B-C}\left(\frac{kP1 + R2}{R1+R2+P1}\right) + V_{C-A}\left(\frac{m\ \ P2}{mP2 + 1/jwc}\right)$$

where K and m are the percents of P1 and P2 used.

By design,

$$\frac{kP1 + R2}{R1 + R2 + P1} = \frac{1}{2}$$

and $$\frac{m\ \ P2}{mP2 + 1/jwc} = \frac{1}{2}\ \angle 60°$$

Therefore:

$$V_{OUT} = 1/2\ V_{B-C} + \frac{1}{2}\ V_{C-A}\ \angle 60°$$

$$V_A = V_{A0} + V_{A1} + V_{A2}$$

$$V_B = V_{A0} + a^2V_{A1} + a\ V_{A2}$$

$$V_C = V_{A0} + a\ V_{A1} + a^2V_{A2}$$

$$V_{OUT} = 1/2\left[\left(V_{A0} + a^2V_{A1} + a\ V_{A2}\right) - \left(V_{A0} + a\ V_{A1} + a^2V_{A2}\right)\right] + 1/2\ \angle 60°\left[\left(V_{A0} + a\ V_{A1} + a^2V_{A2}\right) - \left(V_{A0} + V_{A1} + V_{A2}\right)\right]$$

$$V_{OUT} = 1/2\left[\left(a^2 - a\right) V_{A1} + \left(a - a^2\right) V_{A2}\right] + 1/2\ \angle 60°\left[(a - 1)\ V_{A1} + \left(a^2 - 1\right) V_A2\right]$$

$$V_{OUT} = .866\ \left(V_{A1} \angle -90° + V_{A1} \angle 210° + V_{A2} \angle 90° + V_{A2} \angle 270°\right)$$

$$V_{OUT} = 1.5\ V_{A1} \angle 240°$$

For a pure positive sequence input:

$$V_{OUT} = .866\ V_{C-A}\ \angle 90°$$

B. POSITIVE SEQUENCE CURRENT NETWORK

The positive sequence current network used in the SLYP51B relay is shown in Figure 7. The network consists of two transactors (TB and TC), each with two primary windings and an adjustable resistive load across the secondary winding.

The term "transactor" is a contraction of a transformer-reactor. It is essentially an air-gap current transformer with secondary current (and therefore secondary voltage across the loading resistor) proportional by its transfer impedance and the associated angle.

$$Z_T = \frac{V_{OUT}}{I_{IN}} \angle \theta_T$$

Where: V_{OUT} = Secondary output voltage
I_{IN} = Vector sum of the input currents
θ_T = Angle by which V_{OUT} leads I_{IN}

The derivation of the positive sequence current network output voltage is given below. By design,

$$Z_{TC} = .85 \sqrt{3}\, Z_{TB}$$

$$\theta_{TB} = 75°$$

$$\theta_{TC} = 45°$$

$$V_{OUT} = k \left[Z_{TB} \left(I_C - I_B\right) \angle 75° \right] + Z_{TC} \left(I_B - 1/3\, I_N \right) \angle 45°$$

where k is the percentage of P3 used.

Let k = .85

$$V_{OUT} = .85\, Z_{TB} \left(I_C - I_B\right) \angle 75° + .85 \sqrt{3}\, Z_{TB} \left(I_B - 1/3\, I_N\right) \angle 45°$$

$$V_{OUT} = .85\, Z_{TB} \left[I_{A0} + a\, I_{A1} + a^2 I_{A2} - \left(I_{A0} + a^2 I_{A1} + a\, I_{A1} \right) \right] \angle 75°$$

$$+ .85 \sqrt{3} \left[Z_{TB} \quad I_{A0} + a^2 I_{A1} + a\, I_{A2} - 1/3 \left(3 I_0\right) \right] \angle 45°$$

$$V_{OUT} = .85\, Z_{TB} \left[\left(a - a^2\right) I_{A1} + \left(a^2 - a\right) I_{A2} \right] \angle 75° + .85 \sqrt{3}\, Z_{TB} \left[a^2\, I_{A1} + a\, I_{A2} \right] \angle 45°$$

$$= .85\, Z_{TB} \left(\sqrt{3}\, I_{A1} \angle 90° + \sqrt{3}\, I_{A2} \angle -90° \right) \angle 75° + .85 \sqrt{3}\, Z_{TB} \left(I_{A1} \angle 240° + I_{A2} \angle 120° \right) 45°$$

$$= .85 \sqrt{3}\, Z_{TB} \left(I_{A1} \angle 165° + I_{A1} \angle 285° + I_{A2} \angle -15° + I_{A2} \angle 165° \right)$$

$$= .85 \sqrt{3}\, Z_{TB}\, I_{A1} \angle 225°$$

By means of similar manipulations it may be shown that the positive sequence networks of the SLYP51B produce no output when pure negative sequence quantities are applied.

C. POSITIVE SEQUENCE MHO CHARACTERISTICS

1) General Operating Principles

The principle used to derive the mho characteristics is illustrated in Figure 8. The I_1Z quantity is a voltage proporational to the positive sequence current in the line, and is obtained from the positive sequence current filter. The V_1 quantity is proportional to positive sequence voltage at the relay location and is obtained from the positive sequence voltage network. The quantity $(I_1Z - V_1)$ is the phasor difference between these two quantities. I_1Z' is the reverse reach of the relay. The quantity $(I_1Z - V_1)$ and $(I_1Z' + V_1)$ is less than 90° for an impedance point internal to the relay characteristic, equal to 90° at the balance point, and greater than 90° for an extrenal impedance point for which the relay should not operate. The quantities V_1 and I_1Z are combined in operational amplifiers (filter card) and converted into blocks of voltage representing quantities $(I_1Z - V_1)$ and $(I_1Z' + V_1)$. The coincidence of these blocks is then measured. Blocks which are 90° apart are coincident for 4.17 ms. Blocks which are less than 90° apart are coincident for more than 4.17 ms. Blocks which are more than 90° apart are coincident for less than 4.17 ms. The mho function consists of a filter card, a coincidence card, and a timer card which measures the coincidence of $(I_1Z - V_1)$ and $(I_1Z' + V_1)$. These groups of cards which comprise the various mho functions are shown in Figure 2. If the characteristic has no reverse reach the operating principle remains the same as just described except I_1Z' is zero.

2) MT Function

The resistor R_B, which is mounted on the N108 card in position E, (Figure 2) determines the relationship between the reach of the MT function and the Relay System Reach. The MT reach, at the Relay System Reach angle may be calculated from the expression:

$$Z = \frac{K\,T_B}{T} \times 100$$

where:

T = Voltage restraint tap setting expressed in percent
T_B = Basic minimum ohmic tap setting

$$K = \frac{20{,}000}{R_B + 10{,}000} = \text{percentage reach of MT/100}$$

The F106 filter card (position G) is supplied with three inputs: I_1Z, $+V_1$, $-V_1$.

The outputs of the filter card are 30 VDC square waves (-15 VDC to +15VDC). The square wave output at pin 9 is the polarizing quantity derived from the $+V_1$ input, and the square wave at pin 8 is the operating quantity derived from $(I_1Z - V_1)$.

In addition to filtering, the F106 card provides an adjustment of the phase relationship between the output quantities by shifting the polarizing quantity relative to the operating quantity. MT Operation occurs when the coincidence between the outputs at pin 8 and pin 9 are equal to the characteristic timer setting.

The construction of a mho characteristic for leading and lagging polarizing voltage is shown in Figure 9. The reach at the relay system angle is a chord of all the characteristics. Adjusting the polarizing phase shift in the leading direction shifts the mho characteristic in the counter clockwise direction. The angles α_1 and α_2 are determined by the characteristic timer setting (TS) and the polarizing phase shift $\emptyset$:

$$\alpha_1 = TS - \emptyset$$

$$\alpha_2 = TS + \emptyset$$

The C101 coincidence measurement card (position L) compares the positive half of one square wave with the negative half cycle of the other; when both are present simultaneously an output is produced. The output blocks are thereby produced when V_1 and $(I_1Z - V_1)$ are coincident. Typical waveforms are shown in Figure 10.

The output blocks from the C101 card are the inputs to the timer card in position N. The timer card produces an output when the width of the input blocks exceeds the pickup setting of the timer. At a given angle (other than the relay angle) the pickup point changes when the pickup setting of the characteristic timer is changed. Increasing the pickup time decreases the fault voltage required for operation.

3) MOB Function

The MOB characteristic is derived from the MT filter card and coincidence card but a separate timer. This characteristic is comprised of two lobes and has a constant chord at the Relay System Reach angle. Figure 11 shows the relationship between the MOB characteristics at both 85° and 75° maximum reach angle. The maximum reach angle is defined as the angle of the Relay System Reach plus any lagging phase shift or minus any leading phase shift. This will be the actual angle at which maximum reach occurs only when the associated characteristic timer is set for 4.17 ms or greater.

The MOB characteristic can be plotted as follows:

Step 1: Determine the length of the constant chord at the Relay System Reach angle. This chord length Z, can be calculated from the equation above in section 1 on the MT function.

Step 2: Determine the pickup time setting, usually 3 millisecond (range 2-5 milliseconds) for the MOB characteristic and convert that to degrees.

$$\beta = 21.6 \times t$$

where:

β = the pickup time expressed in degrees
t = the pickup time in milliseconds

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

$$D_1 = 85° - \phi + (90° - \beta)$$

$$D_2 = 85° - \phi - (90° - \beta)$$

where:

D_1 and D_2 = the angles of the diameters in degrees

85° = relay system reach angle (typical)

ϕ = angle between the maximum reach angle and 85°.(ϕ is also the polarizing phase shift.)

β = 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. These lobe centers can be determined by constructing a perpendicular bisector of the reach chord L.

4) M1 Function

The operating principle for the M1 function is the same as that described for the MT function, except that a variable resistor is used at the input of the filter card to enable the user to set the M1 reach independent of the other mho characteristics. The M1 reach at the Relay System Angle may be calculated from the expression:

$$Z = \frac{KT_B}{T} \times 100$$

where:

T = Voltage restraing tap setting expressed in percent

T_B = Basic minimum ohmic tap setting

$$K = \frac{20{,}000}{P_A + R_A + 10{,}000} = \text{percentage of M1/100}$$

R_A = Value of resistor R_A on the N108 card in position E

P_A = Ohmic setting used on variable resistor P_A on the N108 card in position E

If the desired reach for M1 is known, the corresponding value of P_A can be determined from the following expression:

$$P_A = \left[\frac{20{,}000\ T_B\ 100}{Z\ (T)}\right] - R_A - 10{,}000$$

5) MB Function

The operating principle for the MB is the same as that described for the MT function, except that an addition input (I_1Z') is provided to the filter card to give a reverse reach. The reach in the tripping direction may be calculated from the expression:

$$Z = \frac{K\ T_B}{T} \times 100$$

where:

T = Voltage restraint tap setting expressed in percent

T_B = Basic minimum ohmic tap setting

$K = \frac{20{,}000}{R_C + 10{,}000}$ = percentage reach of MB/100

R_C = Value of resistor R_C on the N108 card in position E.

The same expression may be used to calculate the reach in the blocking direction if R_C is replaced in the expression with R_D.

D. POSITIVE SEQUENCE VOLTAGE DETECTOR

The V1 level detector function is operated by a single input quantity from the positive sequence voltage network. The level detector operates on the magnitude of V1,independent of phase angle. The level detector has an intentional time delay before resetting when the input V1 drops below the preset level. The level is adjusted using P1 on the detector card in position S.

E. OPERATING CHARACTERISTICS

The operate and reset times of each mho function is basically determined by the characteristic timer, the type of fault and the incidence angle. There is no significant time delay in the circuitry ahead of the timer.

A phase current of one ampere on a three phase fault will cause the SLYP51B relay to pull back to no less than 90% of the nominal reach, with the basic ohmic tap setting (T_B) of 3Ω.

BURDEN

DC BURDEN

The Type SLYP51B relay presents a burden to the Type SSA power supply of:

200 ma from the +15 VDC supply

100 ma from the -15 VDC supply

AC BURDEN

Potential circuits at 120 V Ø - Ø .

RESTRAINT	PHASE A 100%	PHASE A 0%	PHASE B 100%	PHASE B 0%	PHASE C 100%	PHASE C 0%
VOLT-AMP	7.0		11.5		5.5	
WATTS						
VARS						

Current circuits at 5A Ø - N

BASE TAP	PHASE A 3Ω	PHASE A 1Ω	PHASE B 3Ω	PHASE B 1Ω	PHASE C 3Ω	PHASE C 1Ω
R	0.0	0.0	.013		.040	
X	0.0	0.0	.013		.023	
Z	0.0	0.0	.018		.046	

CALCULATION OF SETTING

The proper settings for the measuring functions in the SLYP51B relay will depend on the type of scheme for which the relay is being supplied. It is therefore recommended that the specific application information supplied with the description of the overall Logic Diagram for the equipment be referred to for the proper considerations and settings. The three adjustments which require field setting are: Mho function reach, MOB characteristic shape, and V1 pickup. The following example is intended to illustrate a typical calculation of the Mho function settings.

The Mho function reach settings are by one common adjustment, the Relay System Reach. This Relay System Reach is typically set to be equal to the positive sequence secondary ohms of the protected line plus a margin. This margin factor, "R", is not a fixed amount, but is dependent on the length of the protected line. Figure 12 is a curve showing R, the ratio of the required Relay System Reach setting to the positive sequence impedance of the protected line as a function of the line length. The line length is expressed as the ratio of the primary positive sequence impedance of the line, Z_p, to the surge impedance of the line, Z_U.

For example, consider a 75 mile bundled conductor 500 KV line having a surge impedance Z_U = 300 ohms, and a positive sequence impedance Z_p = 0.6 ohms per mile. The CT's are 2,000/5, and the PT's are 4500/1.

$$\frac{Z_p}{Z_U} = \frac{75 \times 0.6}{300} = 0.15$$

From the curve of Figure 12,the value of R for this value of Z_p/Z_U is found to be 1.45. Thus, the Relay System Reach should be set for 1.45 times the secondary positive sequence impedance Z_{SEC} of the line.

$$Z_{SEC} = \frac{Z_p \times \text{CT ratio}}{\text{PT ratio}} = \frac{(75 \times 0.6)(2000/5)}{4500} = 4.0 \text{ OHM}$$

Multiplying the secondary ohms of the line by the margin factor, R, gives the desired Relay System Reach (RSR) setting:

$$RSR = Z_{SEC} \times R = 4.0 \times 1.45 = 5.8 \text{ OHM}$$

This setting is made by selecting the highest basic minimum ohmic tap (T_B) that will accommodate the setting. For the 5.8 ohm RSR setting the 3 ohm T_B tap should be used. To obtain the 5.8 ohm RSR the positive sequence restraint tap (T) should be selected in accordance with the following formula:

$$T = \frac{T_B \times 100}{RSR}$$

For this example, RSR = 5.9 ohm, T_B = 3 ohm, so:

$$T = \frac{3 \times 100}{5.8} = 51.7\%$$

Therefore select the 52% restraint tap.

The reach of the various mho functions at the 85° angle of this 5.8 ohm Relay System Reach setting can be determined from Table I for this short, uncompensated line.

RECEIVING, HANDLING AND STORAGE

These relays 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, and 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.

INSTALLATION TESTS

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 CONNECTION TO THE EQUIPMENT, SUCH AS A TEST LEAD INADVERTANTLY 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.

CONSTRUCTION

The SLYP51B relay is packaged in an enclosed metal case with hinged front cover and removable top cover. The case is suitable for mounting on a standard 19 inch rack. The outline and mounting dimensions of the case and the physical location of the components are shown in Figures 1 and 3 respectively.

The tap blocks for making the voltage restraint settings are located on the front panel of the unit. The method of making restraint tap settings is illustrated in Figure 13. The connections are made by means of taper pin connectors; special tools are supplied with each equipment for the removal and insertion of these pin connectors.

The current and potential enter the SLYP51B on twelve point terminal strips located on the rear of the relay case. The potential connections are made on the YA terminal strip, the current connections on the YB terminal strip.

The basic minimum ohmic tap (T_B) setting is accomplished on the YB terminal strip on the rear panel of the unit. The current connections for the 1Ω and 3Ω taps are shown in Table III.

TABLE III

	I_C		I_B		$3I_0$	
	IN	OUT	IN	OUT	IN	OUT
1Ω BASE REACH	YB1	YB2	YB4	YB6	YB9	YB10
3Ω BASE REACH	YB1	YB3	YB5	YB7	YB8	YB10

The V_1 and I_1Z test jacks, the I_1Z magnitude reach pot (P5), and the angle pot (P6) for the Relay System Reach are located on the front of the unit above the voltage restraint taps. The positive sequence filter potentiometers (P1, P2, P3, P4) are located inside the relay case as shown in Figure 3.

The independent reach adjustment pot P_A for the M1 function is located on the N108 card in position E.

The independent adjustment (P71) of polarizing phase shift for each mho characteristic is located on the associated filter card.

The SLYP51B relay also contains printed circuit cards identified by a code number such as F106, C101, D101, T101, N108, where F designates filter, C designates coincidence, D designates level detector, T designates time delay, and N designates network. The printed circuit cards plug in from the front of the unit. The sockets 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 position T with TP1 at the top of the card. The internal connections of the printed circuit cards are shown in the Printed Circuit Card Instruction Book GEK-34158.

Pin number 1 on the test card in position T is connected to relay reference, number 2 to -15 VDC, and pin number 10 to +15 VDC. Output signals are measured with respect to the reference bus on the test card (TP1). Logic signals are approximately +15 VDC for the ON or LOGIC ONE condition, and less than 1 VDC for the OFF or LOGIC ZERO condition. Filter card outputs are either +15 VDC or -15 VDC for the ON condition.

These outputs can be monitored with an oscilloscope, a portable high impedance DC voltmeter, or the test panel voltmeter if available. When the test panel meter is supplied, it will normally be connected to the reference bus. Placing the relay test lead in the proper test point pin jack will connect the meter for testing. When time delay cards are to be adjusted or checked, an oscilloscope which can display two traces simultaneously and which has a calibrated horizontal sweep should be used.

TEST AND ADJUSTMENTS REQUIRED

The SLYP51B relay is usually supplied from the factory, mounted and wired as part of a complete static relay equipment. The relay includes the following adjustments, some of these have been preset at the factory, others must be set by the user. The factory adjustments should be rechecked by the user per the procedures under Detailed Testing Instructions to insure that no shipping damage has occurred. The steps must be performed in the order shown.

1) Basic minimum ohmic tap setting (user setting).
2) Voltage restraint tap setting (user setting).
3) Network General Calibration Check (user check).
   NOTE: If this step does not give the results indicated, four additional checks are necessary before proceeding. These checks will enable the user to determine which part of the networks require readjustment. The checks are:
   a) Voltage Sequence Network Balance and Output.
   b) Current Sequence Network Balance and Output
   c) Current Sequence Network Output Magnitude Adjustment (P5)
   d) Relay System Reach Angle Adjustment (P6).
4) Individual mho characteristic polarizing phase shift setting (user setting).
5) Individual mho characteristic timer setting (user check).
6) M1 Reach Setting (user setting).
7) Mho characteristic plotting on R-X Diagram (user check).
8) Voltage Level detector, V1, pickup setting (user setting).

DETAILED TESTING INSTRUCTIONS

A. BASIC MINIMUM OHMIC TAP SETTING

The arrangement of the basic ohmic taps is described under Construction, and the choice of tap setting is discussed in separate write-up titled Overall Logic Description. The reach at the Relay System Angle is given by the following relationship:

$$Z = \frac{T_B \text{ X } 100}{T}$$

where:

T = Voltage restraing tap setting in percent.

T_B = Basic minimum ohmic tap setting.

B. VOLTAGE RESTRAINT TAP SETTING

The arrangement of the voltage restraint tap blocks is described under construction, and the choice of tap settings is discussed in the section on calculations of settings and a separate write-up titled Overall Logic Description. The pickup voltage at the Relay System Angle given by the following relationship:

$$V_1 = \frac{I_1 \text{ X } T_B \text{ x } 100}{T}$$

where:

T = Voltage restraint tap setting in percent

T_B = Basic minimum ohm tap setting

I_1 = Positive sequence current

C. GENERAL NETWORK CALIBRATION CHECK

Be sure the DC power supply to the SLYP is turned on. This is a check of both the voltage and current network balances and network output calibration. Perform the checks as outlined in Figure 14. If the required outputs can not be obtained, it is an indication that the original network adjustments have been disturbed. The following four checks are required only if the network adjustments have been distrubed.

1) Voltage Sequence Network Balance

This test, described in Figure 15, consists of two parts, V_1 null and V_1 output checks. It should be noted that this test requires a 3-phase test source of equal voltages (within 1-2%). Alternate readjustment of pots P1 and P2 is required to obtain the 60 Hertz null since the pots are interdependent. When the fundamental frequency has been completely nulled, it is normal for some harmonic voltage to be evident at the test jack, V_1. The magnitude of the harmonic voltage depends on the harmonic content of the test source but usually is less than 0.2 V_{p-p}.

When performing the V_1 output tests, the exact value of voltage obtained will vary from relay to relay depending on component tolerances but will be approximately as shown in Figure 15. This value should be noted very precisely since it is the reference for making another setting in this relay equipment.

2) Current Sequence Network Balance

This test, described in Figure 16, consists of two parts, I_1Z null and I_1Z output checks. Ammeters used in this test should first be calibrated in series to insure that the current used in each phase of the test circuit is equal. Alternate readjustment of pots P3 and P4 is required since they are interdependent. Adjust for 60 Hertz null leaving only harmonic voltage at the I_1Z test jack. Also check that the I_1Z output is approximately as shown in Figure 16. The exact value will be set in the next step.

3) Current Sequence Network Output Magnitude Adjustment

NOTE: The DC power supply to the SLYP relay must be on for this test and adjustment. Use the test circuits of Figure 17 and adjust P5 until the I_1Z magnitude is equal to the V_1 magnitude. Pot P5 is located on the front of the relay and is identified as I_1Z magnitude adjustment.

4) Relay System Reach Angle Adjustment

The DC power supply must be turned on for this test. Use test Figure 17 and adjust P6 until the I_1Z and V_1 quantities are exactly in phase. Pot P6 is located on the front of the relay and is identified as angle adjustment. Since there is some interaction between P5 and P6, it may be necessary to readjust P5 at this time to maintain an I_1Z magnitude equal to V_1. The magnitude should be recorded at this time for use later in rechecking this relay. If this equipment also includes a type SLYN relay, the magnitude of the V_1 and I_1Z voltage must be known for calibration of the SLYN relay.

D. INDIVIDUAL MHO CHARACTERISTIC POLARIZING PHASE SHIFT SETTING

Each filter card, positions F, G, and H, has an adjustment, P71, for the phase shift in the polarizing circuit. The setting of the polarizing quantity with respect to the operating quantity is discussed in the Ranges section of this book and in the Overall Logic Description. Refer to the specific Overall Logic Diagram for the drawing number of the specific overall Logic Description.

The effects of leading and lagging polarizing quantities are shown in Figure 9. A leading phase shift rotates the characteristic clockwise as a R-X diagram. A leading phase shift is defined as the filter card (codes F ___) output at pin 9 leading pin 8.

A 4.17 millisecond characteristic (circle) remains circular if the polarizing voltage is shifted leading or lagging. The area of the circle, however, increases.

Figure 18 describes the test connections to check the phase shift and the outputs given are to obtain the angle of maximum reach listed for each of the functions in the Application section of this book.

The User's specific requirement may be different from the typical values listed in Figure 18.

E. INDIVIDUAL MHO CHARACTERISTIC TIMER SETTINGS

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. The reset time delay (dropout time) of the timer provides an overlap of the next half cycle measurement and in some cases provides an intentional time delay before resetting. Timer outputs are DC Logic signals. Timer settings are discussed in separate instructions titled Overall Logic Description.

It should be noted that the characteristic timers have been set at the factory to provide the normal characteristics. Timer settings can be easily checked in two ways. The pickup and dropout times may be set as described below with a DC logic test signal. The pickup line of the timer may also be checked by plotting the characteristic and noting the shape. This is especially easy if the pickup time is 4.16 ms which yields a circular characteristic. The following DC timer test method should be used if the timer is suspected to be significantly off the intended pickup or reset value, i.e., when first installing a replacement card.

First it is necessary to remove the card before the timer and to place the timer card in a card adapter. The timer test circuit is shown in Figure 19. Opening the N.C. contact causes the output to step up to +15 VDC after the pickup delay of the timer. To increase the pickup time, turn the upper potentiometer (on the T101 and T107 cards adjust P2) on the timer card clockwise. Closing the contact causes the timer output to dropout after the reset delay setting of the card. To increase the reset time, turn the lower potentiometer (on T101 and T107 cards adjust P3) on the card clockwise.

The shorter pickup time of the T107 card can be observed at pin 7 on the card. The longer pickup time is factory adjusted by P1 for a pickup 1.2 milliseconds longer than the shorter time. This output must be observed at pin 8.

Details of the other timer cards used in this relay are given in Printed Circuit Card Instruction Book, GEK-34158.

Final settings for all the timer pick-up values should be determined by plotting the characteristic and noting the shape.

F. M1 REACH SETTING

The reach of the M1 characteristic must be set at a specific value for the line being protected by adjusting pot P_A on the N108 card in position E. Use the AC test connection in Figure 20.

1) Set the current in each branch for a constant 5 amperes.

2) Set the voltage per the following expression for the specific M1 reach setting.

$$V_{\emptyset-\emptyset} = \frac{\sqrt{3}\, I\, T_B\, Z_{M1}}{T}$$

where:

$V_{\emptyset-\emptyset}$ = Relay input voltage per Figure 20.

I = Branch current per Figure 20.

T_B = Basic minimum ohmic tap setting.

T = Voltage restraing tap setting in percent.

Z_{M1} = Desired reach setting of M_1 in percent of relay system reach.

3) Set the phase angle meter to 30° less than the angle of the relay system reach. (Example: phase angle meter = 85° - 30° = 55°.)

The above procedure establishes a balance point for the operation of the M1 function. This procedure assumes a 0° polarizing phase shift setting has been used.

4) An oscilloscope should be connected to pin 8 of the M1 filter card in position F.

5) Observe the square wave output (60 Hertz) at pin 8. Adjust the pot, P_A on the N108 card until the square wave goes to zero. This sets the reach of the M1 characteristic at the relay system reach angle.

NOTE: Due to the loading effect, there is interaction between the adjustment of the M1 reach and the sequence network calibration (pots P5 and P6). Therefore the network calibration should be rechecked at this time per the previous procedure in section C, titled "General Network Calibration Check". Next, repeat step 5 above.

If desired, a preliminary setting of the pot, P_A may be made by removing the N108 card from the relay and setting the pot, using an ohmmeter, to the value calculated from the expression in the M1 part of the Operating Principles section of this book.

6) A final check of the reach of the M1 characteristic should be made by starting at 100 volts and lowering the input test voltage until an output is noted from the M1 timer card at TP6. The output should occur at the value of Ø-Ø input voltage given by the expression above.

G. MHO CHARACTERISTIC PLOTTING

Each of the relay characteristics may be checked over its entire range by using the test circuit of Figure 20. By setting the current in each branch for a constant 5 amperes the reach at any angle becomes a function of the calculated settings of both the base reach and the voltage restraint taps. Rotating the phase shifter provides a means of checking the reach on any point of the characteristic.

To obtain any points on the relay characteristic observe the following procedure:

1) Set up the test circuit of Figure 20.

2) Set currents 5 amperes RMS.

3) Connect the instrumentation (preferably an oscilloscope) between the characteristic output test point (TP_) and reference TP1.

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

5) Adjust the gang variac until the characteristic function output fully picks up. Note that the point just at the verge of pickup, as read on the voltmeter (V), defines the characteristic.

All necessary points can be obtained by simply repeating steps (4) and (5) until the characteristic is clearly defined. The characteristic when plotted can be compared to characteristics given for short lines or long lines, depending upon the relay model being tested, refer to Overall Logic Description.

The voltage at any angle may be calculated by the following expression: (valid only for circular characteristic)

$$V_{\phi-\phi} = \frac{\sqrt{3}\, I\, T_B\, Z \cos(\alpha - \phi)}{T}$$

$V_{\phi-\phi}$ = Relay input voltage per Figure 20.

I = Branch current per Figure 20.

T_B = Basic minimum ohmic tap setting.

T = Voltage restraint tap setting in percent.

Z = Maximum reach of characteristic being tested in percent of reach of relay system. Z will be equal to the value given in Table I and II if the polarizing phase shift is zero.

α = Angle of maximum reach

ϕ = Test angle

For any other value of polarizing phase shift, Z may be calculated by the expression:

$$Z = \frac{Z_0}{\cos \beta}$$

Z_0 = Relay reach in percent from Table I or II.

β = Degrees of polarizing phase shift.

For non-circular characteristic, it is recommended that the actual characteristic plot be compared with a theoretical plot constructed per the instructions given in the section on Operating Principles - MOB Characteristics. Also see Figures 9 and 11.

H. V1 LEVEL DETECTOR ADJUSTMENT

The positive sequence voltage pickup level is discussed in the Overall Logic Description write-up. Using the test circuit of Figure 19, apply the desired voltage to the relay. Adjust P1 until an output signal is noted at pin 8 of the detector card in card position S. Clockwise rotation of P1 increases the pickup level. P1 is located on the detector card in position S.

Note from the internal connection diagram, Figure 2, that the card in the S position has an intentional time delay on reset. This may be checked just as if the card was a timer card by using the test circuit of Figure 19 and DC test method for timers as described in the section on MHO Characteristic Timer Settings.

PERIODIC CHECKS AND ROUTINE MAINTENANCE

PERODIC TESTS

All functions included in the SLYP51B relay may be checked at periodic intervals using the procedures described in the section covering Detailed Testing Instructions. Cable connection between the SLYP51B relay and the associated type SLA relay can be checked by observing the SLYP51B outputs at test points in the SLA relay.

The following checks are suggested as periodic checks/routine maintenance.

1) Network General Calibration Check - See Detailed Testing Instruction "C".

2) MHO Characteristic Plotting on R-X Diagram - See Detailed Testing Instruction "G".

3) V1 Level Detector Pickup Setting - See Detailed Testing Instruction "H".

TROUBLE SHOOTING

In any trouble shooting 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 (0149C7259G-2) 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 SLYP51B relay are included in the card book GEK-34158; the card types are shown on the component location diagram, Figure 3.

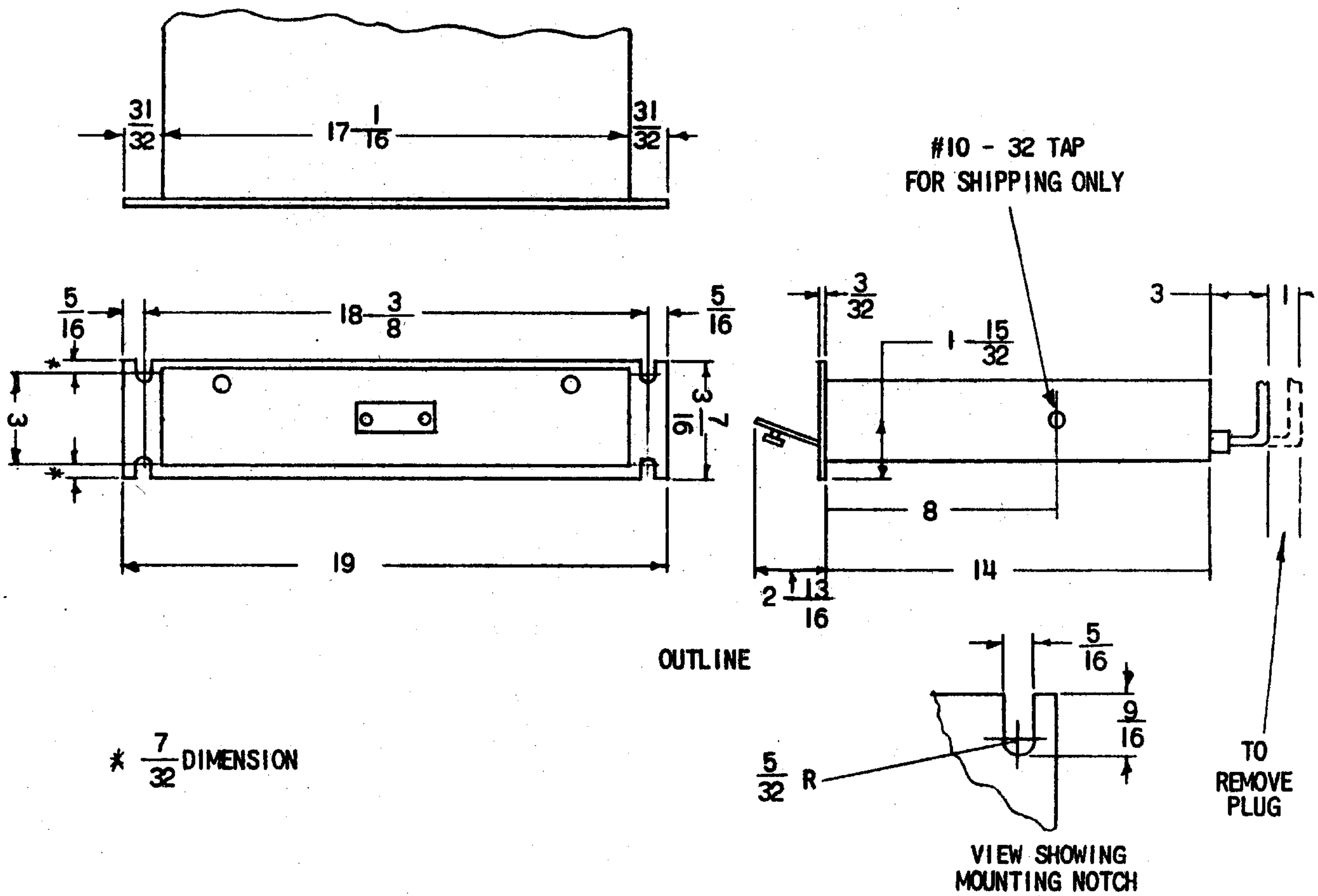


FIG. 1 (0227A2036-0) OUTLINE AND MOUNTING DIMENSIONS FOR THE TYPE SLYP51B RELAY

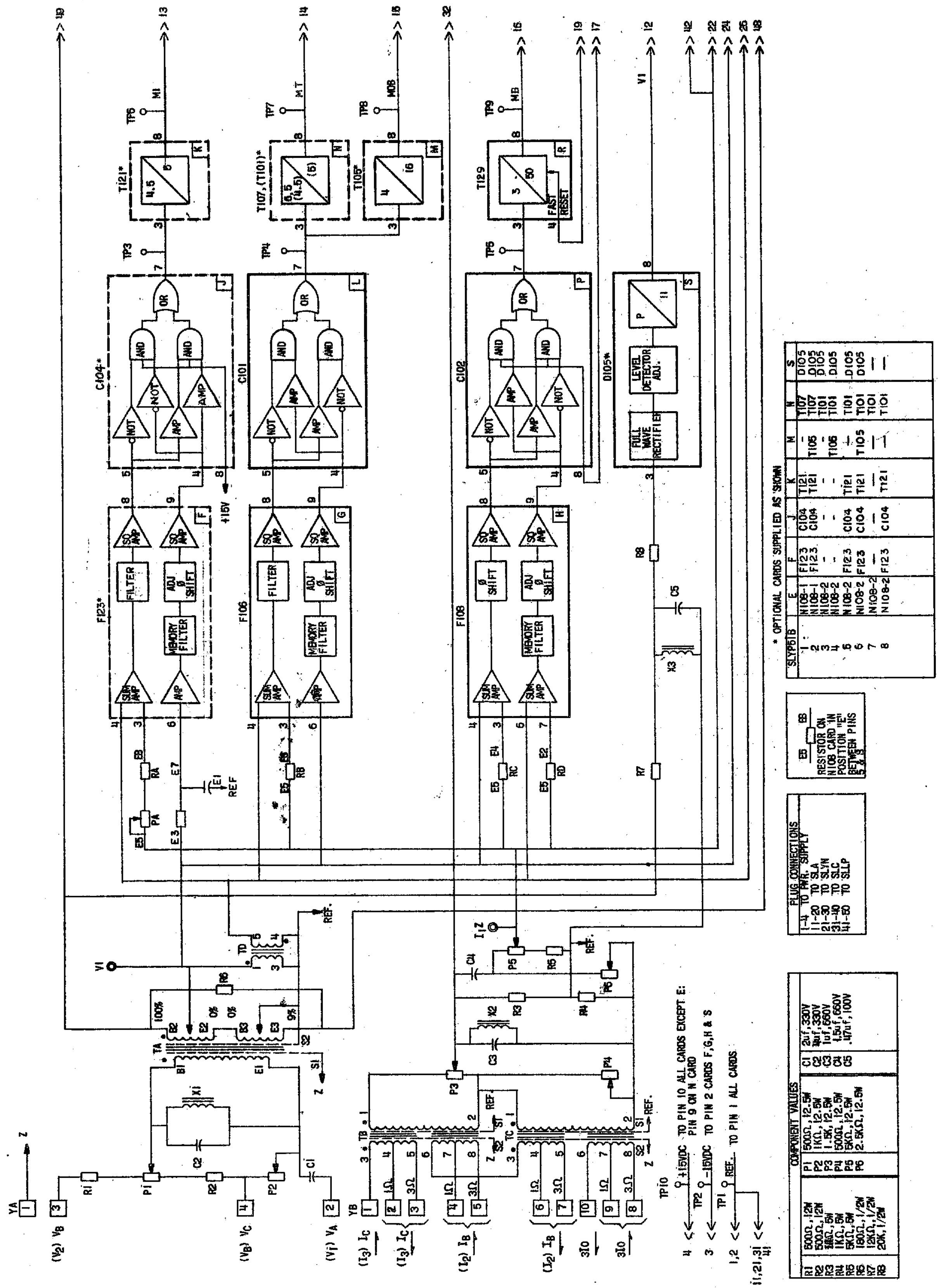
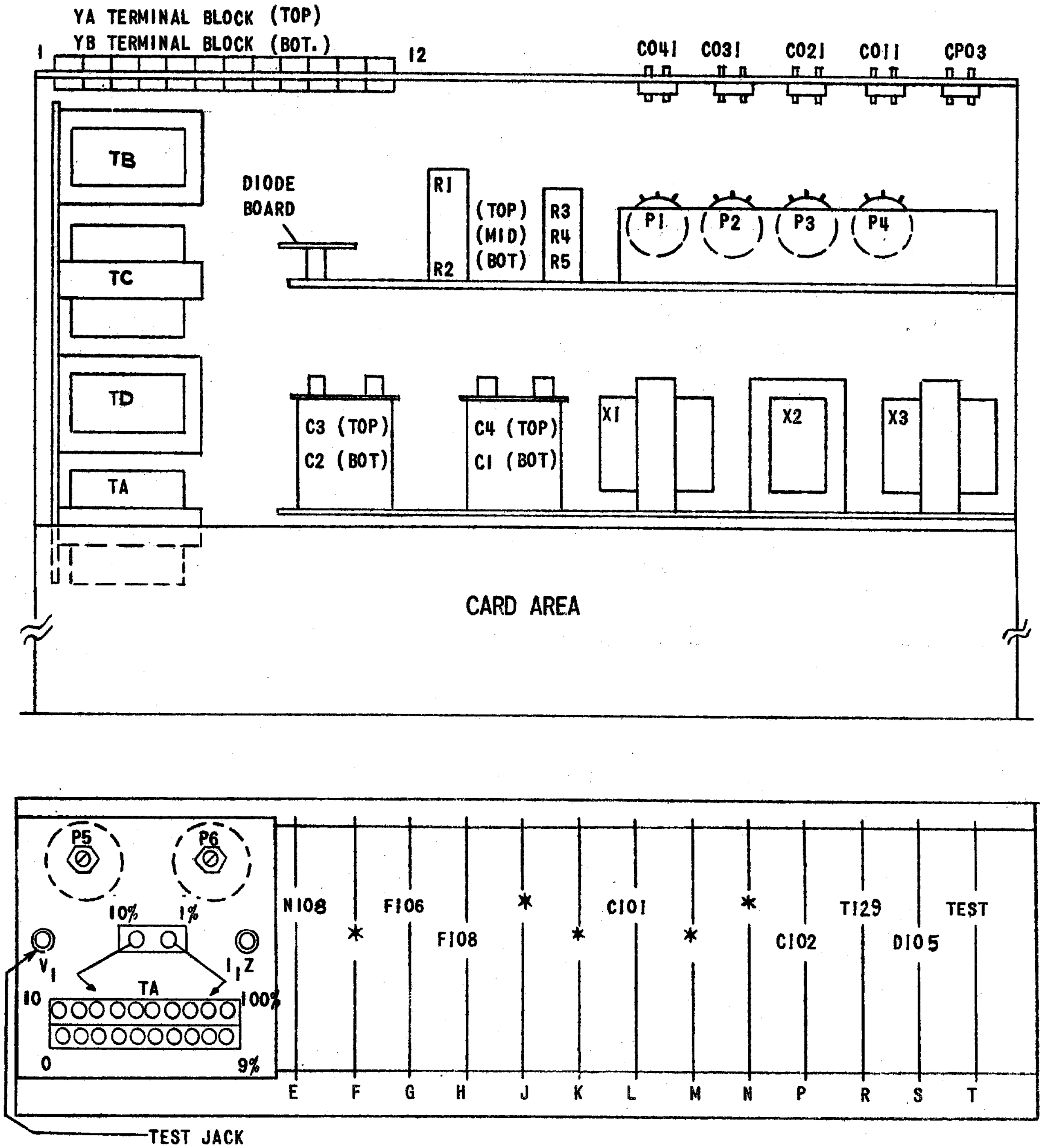


FIG. 2 (0149C7363-2) INTERNAL CONNECTIONS FOR THE TYPE SLYP51B RELAY



* SEE INTERNAL 0149C7363 FOR CARDS IN THESE POSITIONS

FIG. 3 (0227A2138-1) COMPONENT AND CARD LOCATIONS FOR THE TYPE SLYP51B RELAY

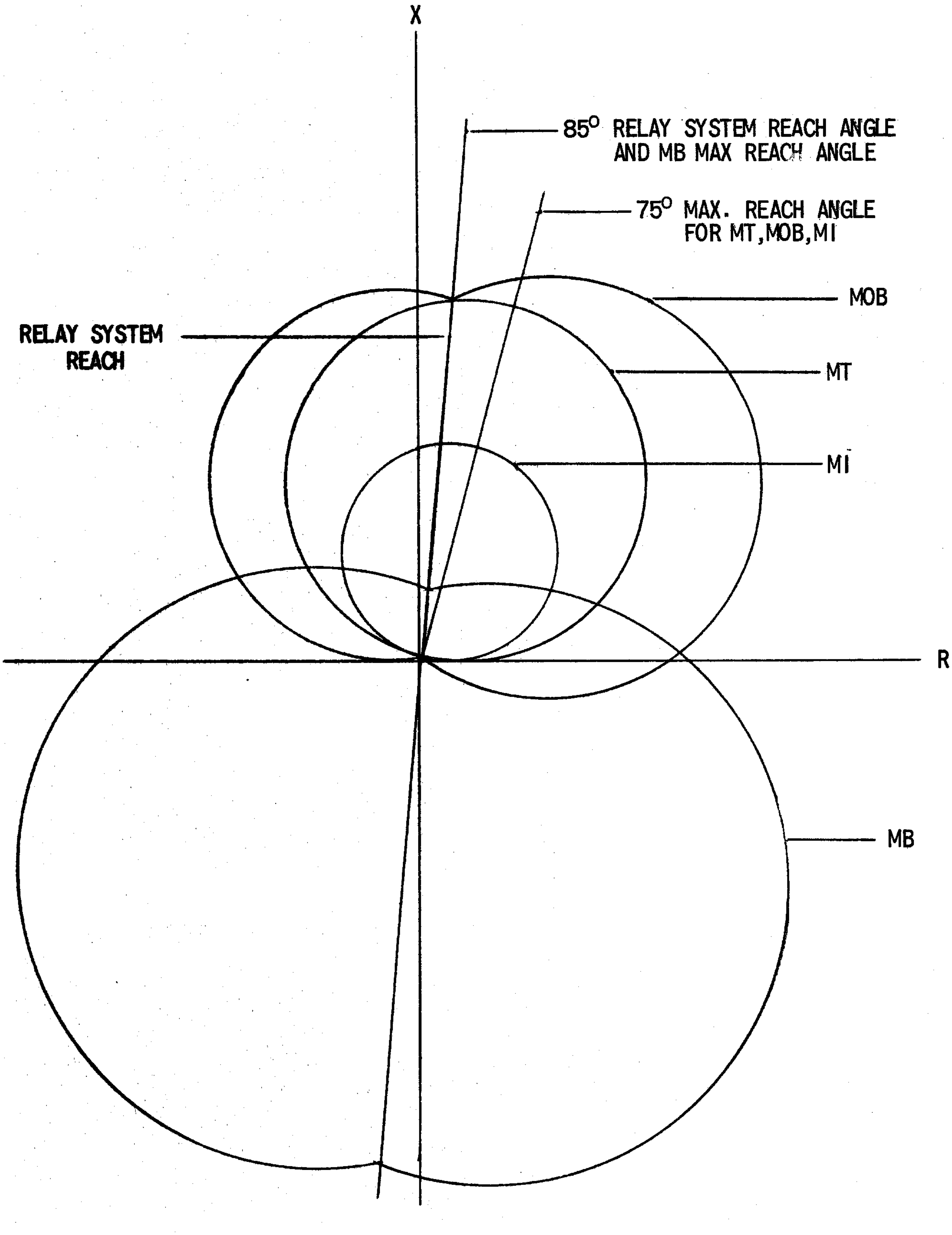


FIG. 4 (0257A6200-0) STANDARD MHO FUNCTION CHARACTERISTICS OF TYPE SLYP51B RELAY USED ON UNCOMPENSATED LINES SHORTER THAN 100 MILES

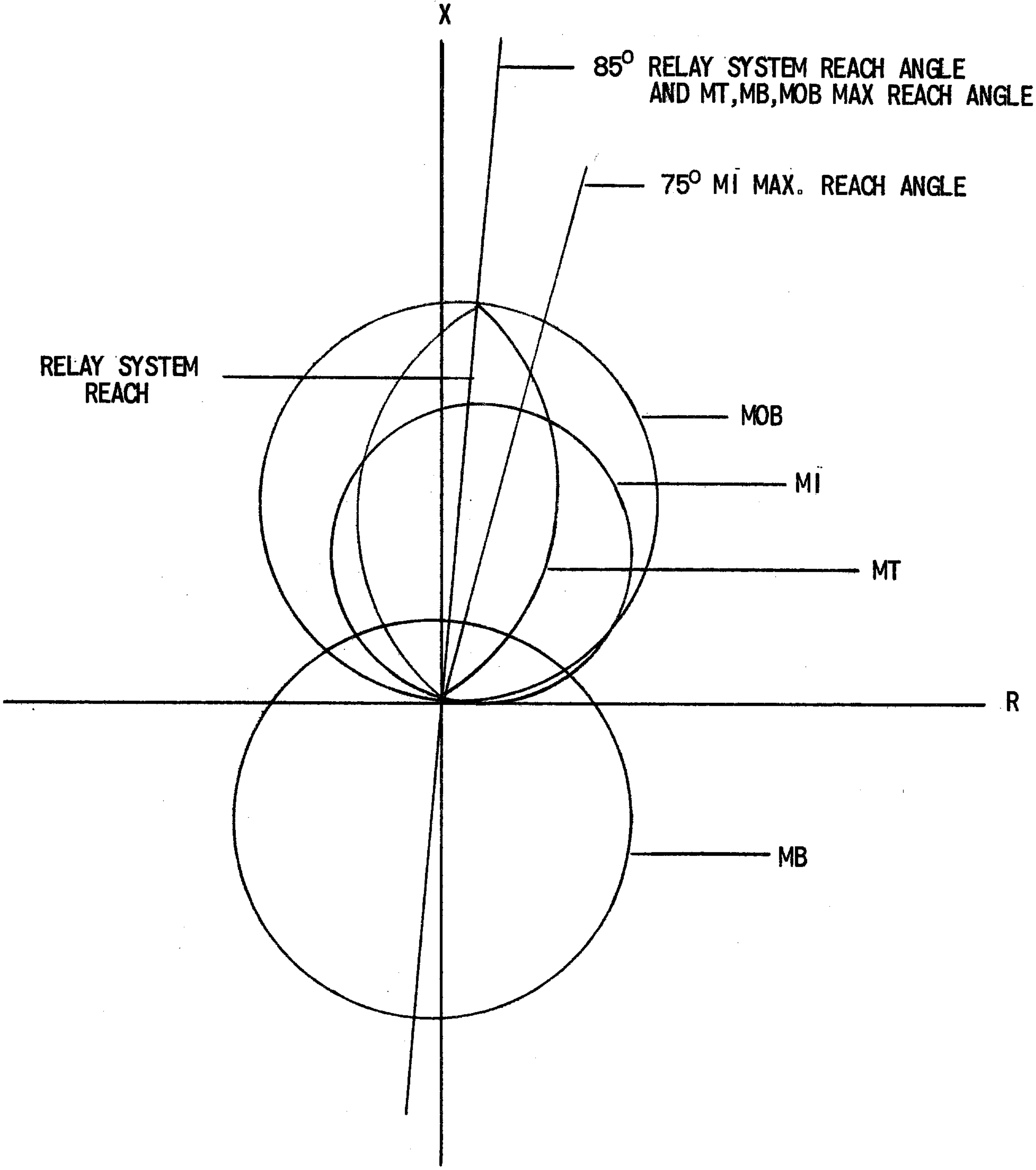


FIG. 5 (0257A6201-0) STANDARD MHO FUNCTION CHARACTERISTICS OF TYPE SLYP51B RELAY USED ON UNCOMPENSATED LINES LONGER THAN 100 MILES

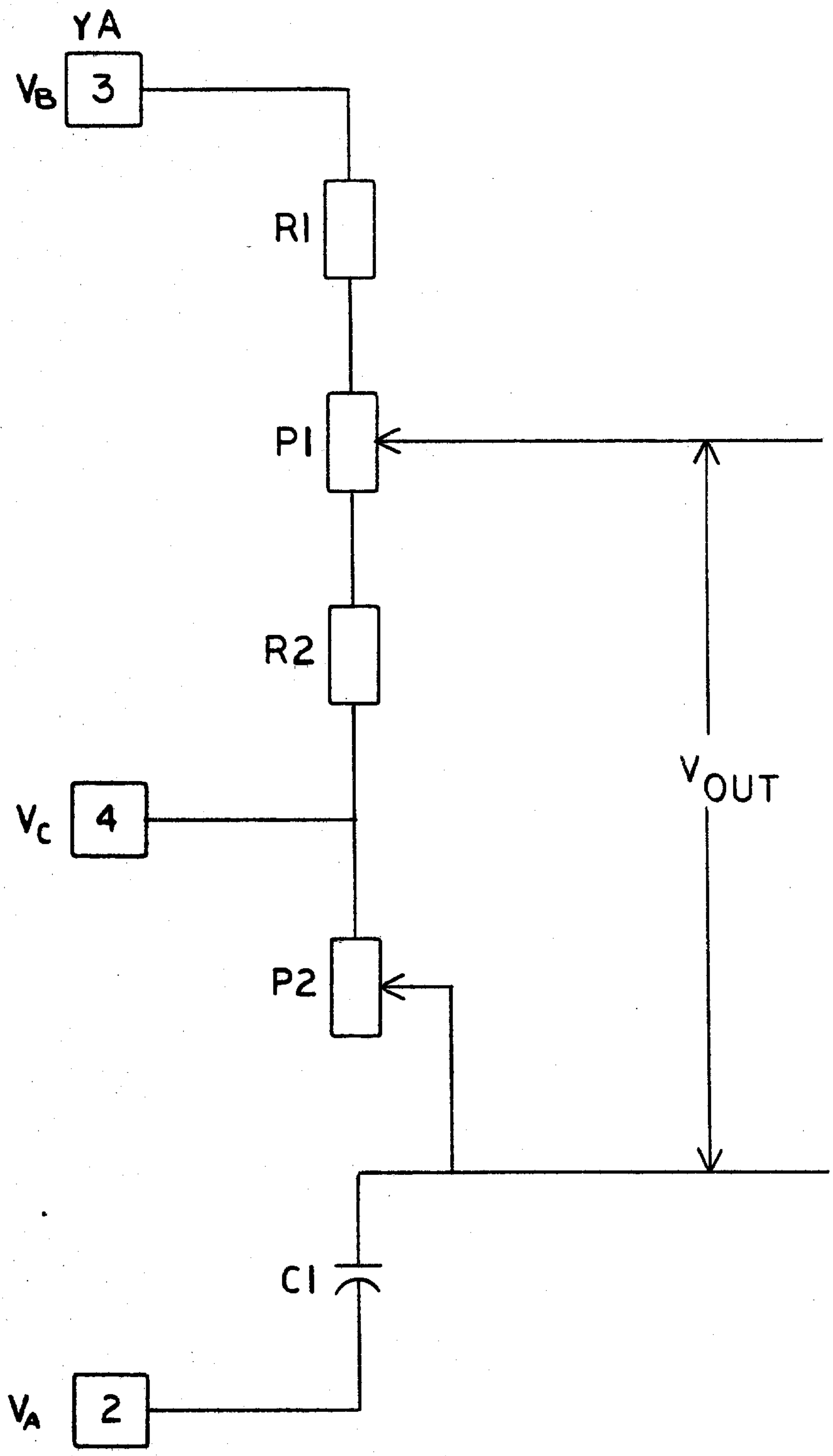


FIG. 6 (0246A6887-0) SLYP POSITIVE SEQUENCE VOLTAGE NETWORK

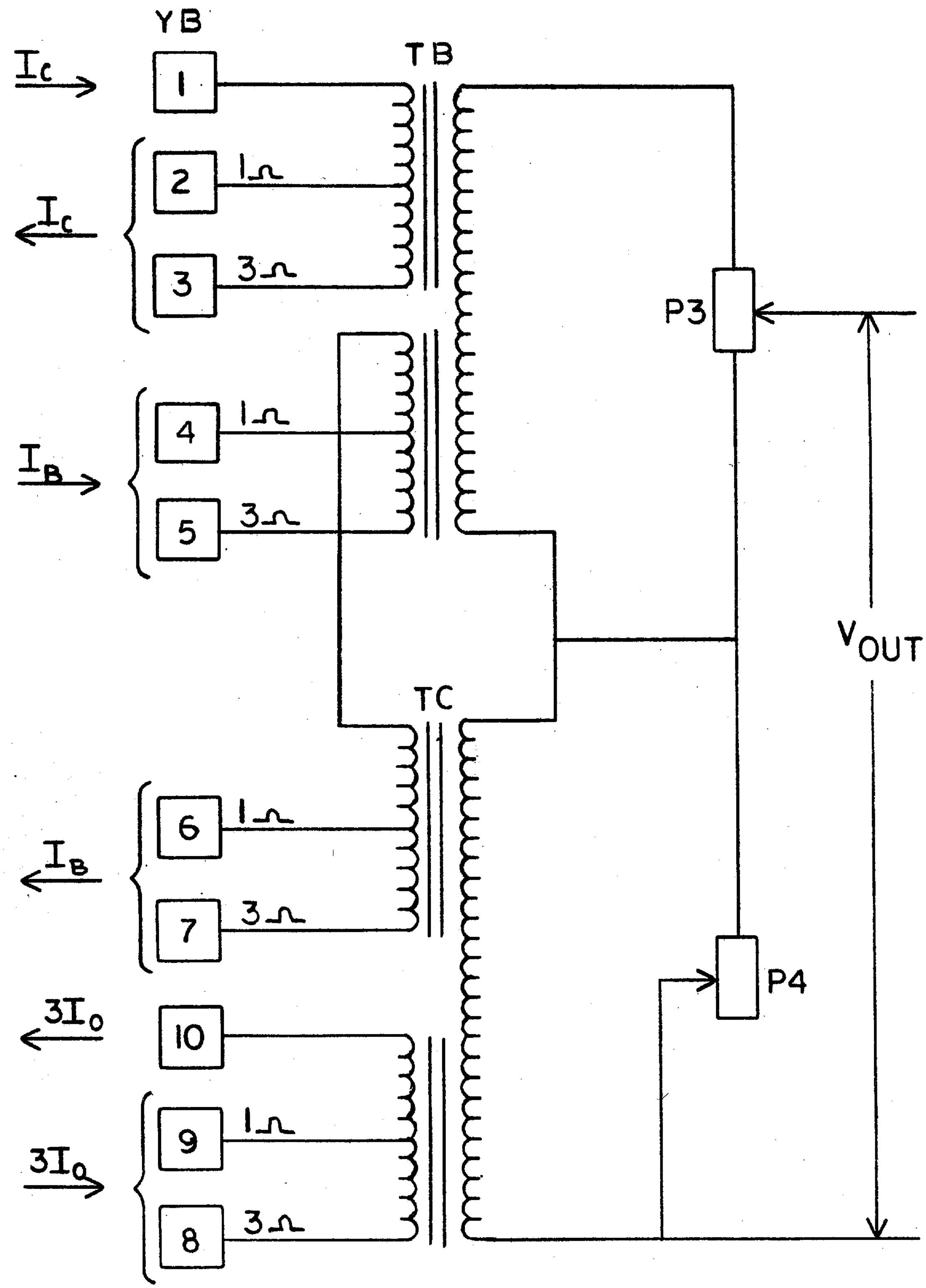


FIG. 7 (0246A6886-0) SLYP POSITIVE SEQUENCE CURRENT NETWORK

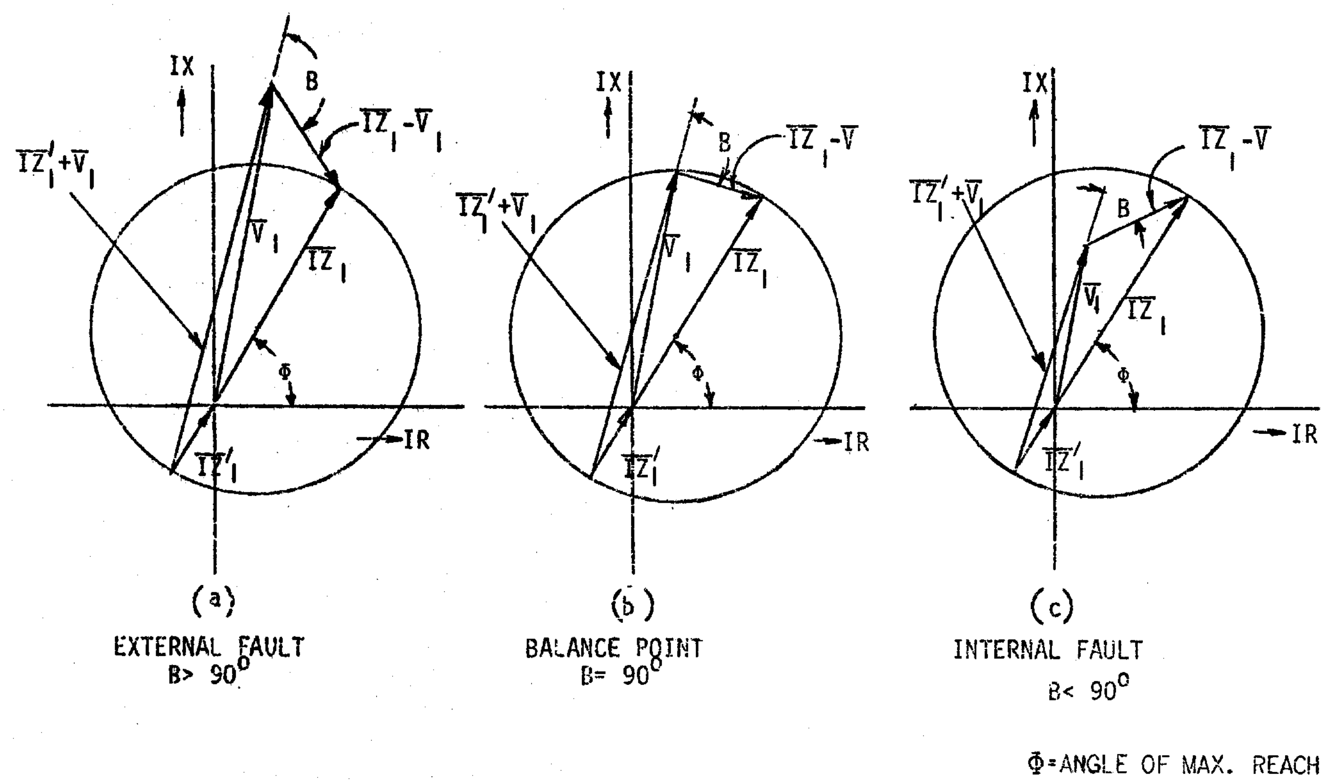


FIG. 8 (0246A7984-0) OFFSET MHO CHARACTERISTIC BY PHASE ANGLE MEASUREMENT

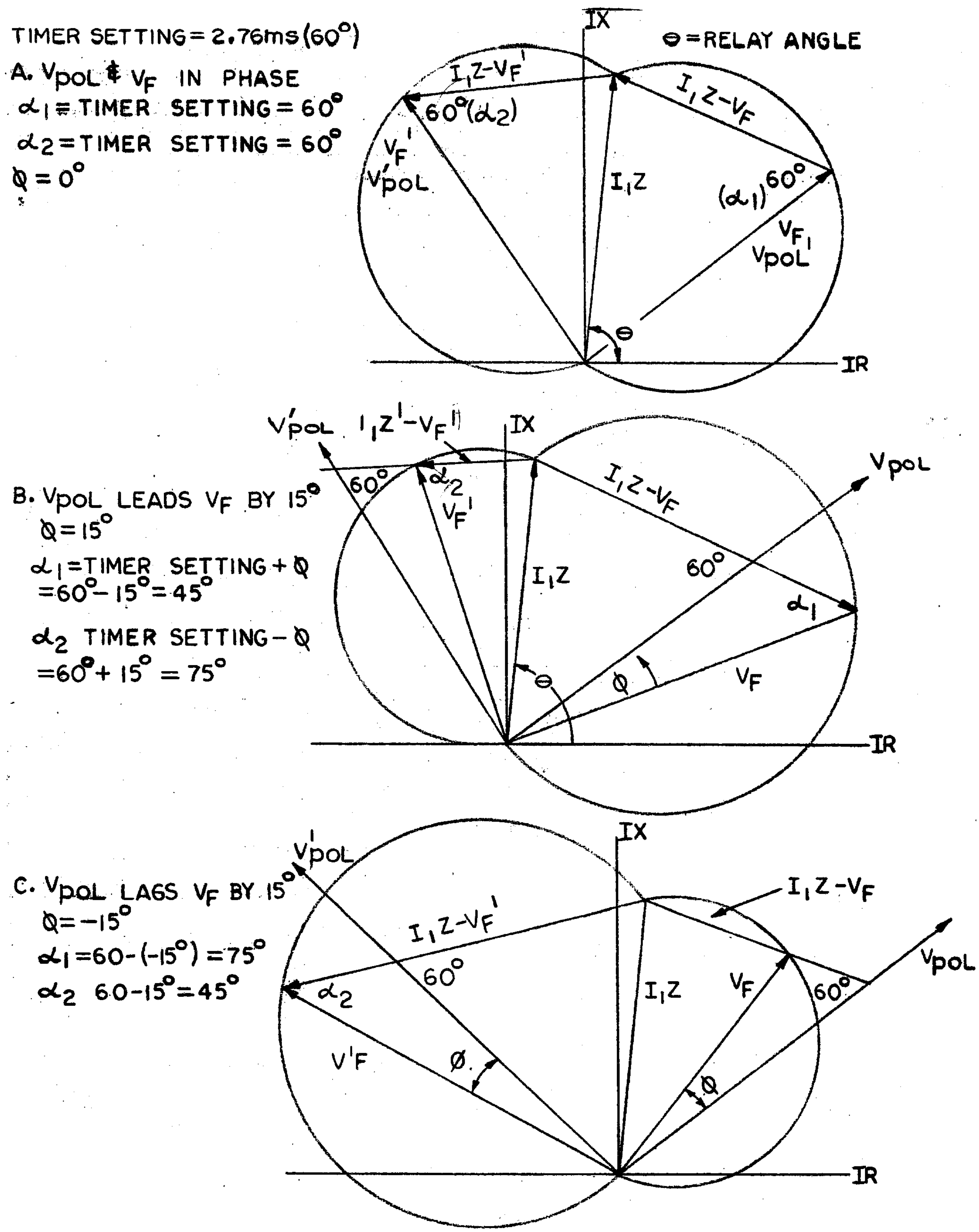


FIG. 9 (0246A6866-1) EFFECT OF POLARIZING QUANTITY PHASE SHIFT TO MHO CHARACTERISTIC

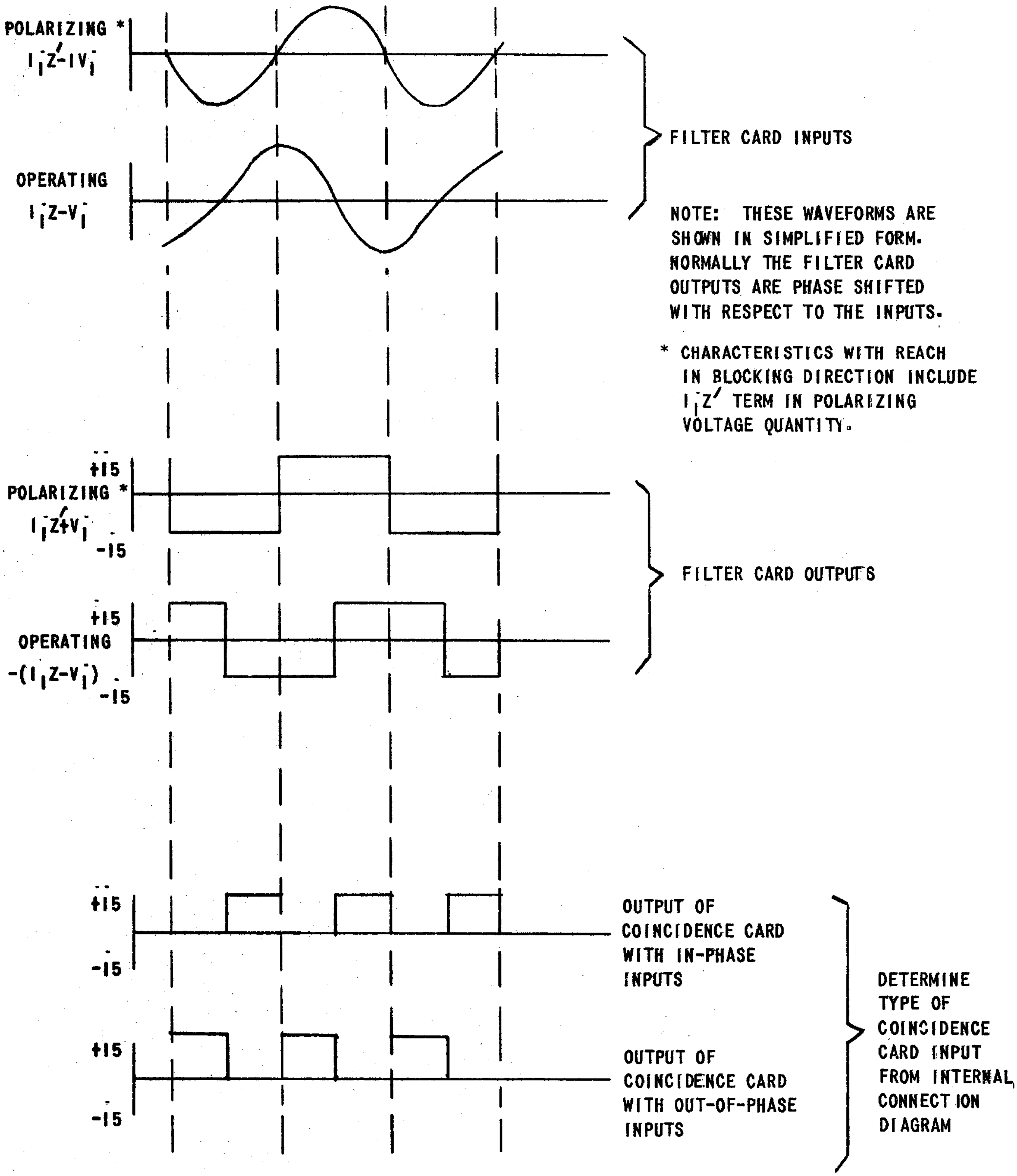


FIG. 10 (0257A6209-0) SLYP OPERATING QUANTITY WAVEFORMS

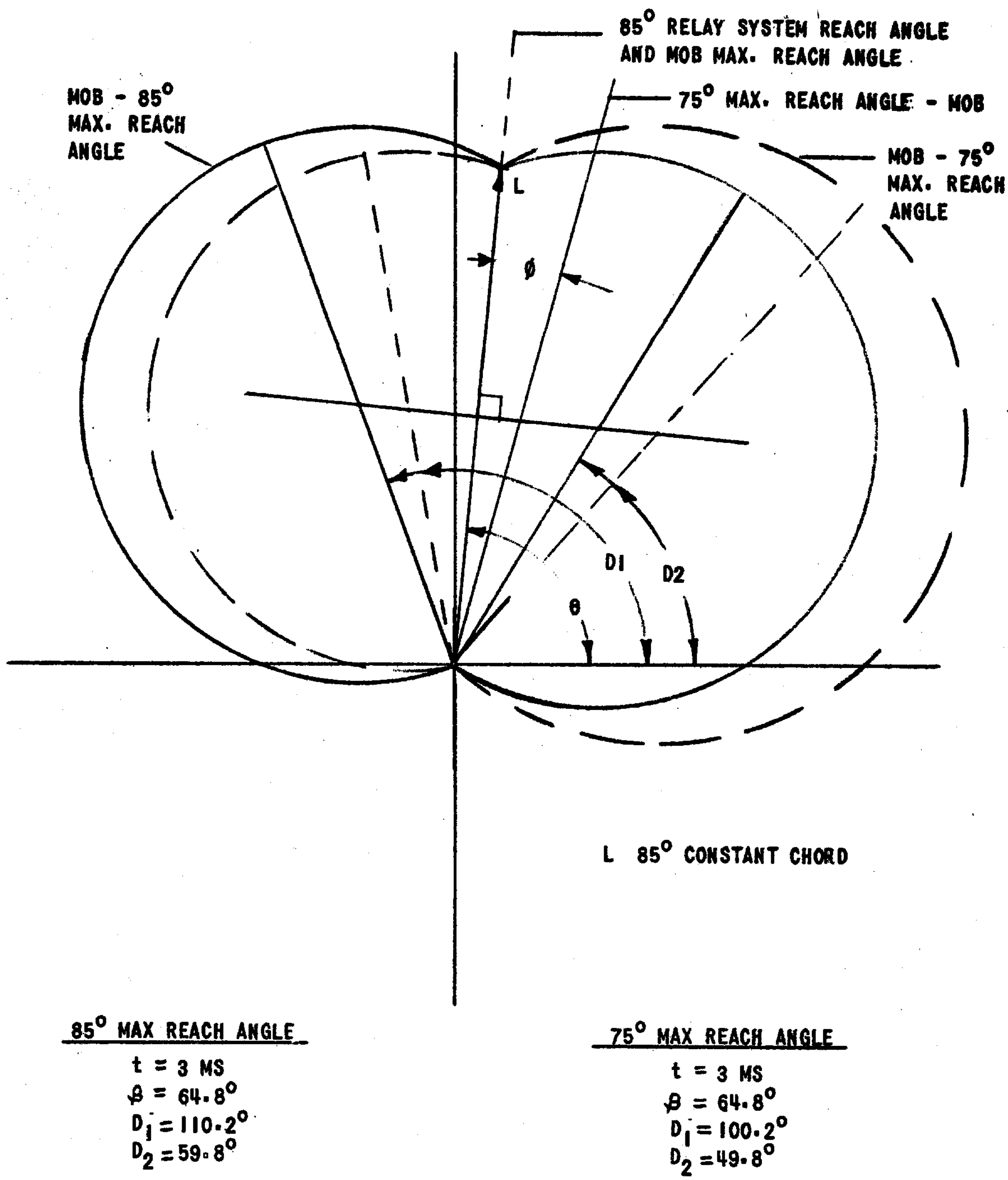


FIG. 11 (0227A2199-0) MOB CHARACTERISTIC AT 85° and 75° ANGLES OF MAXIMUM REACH

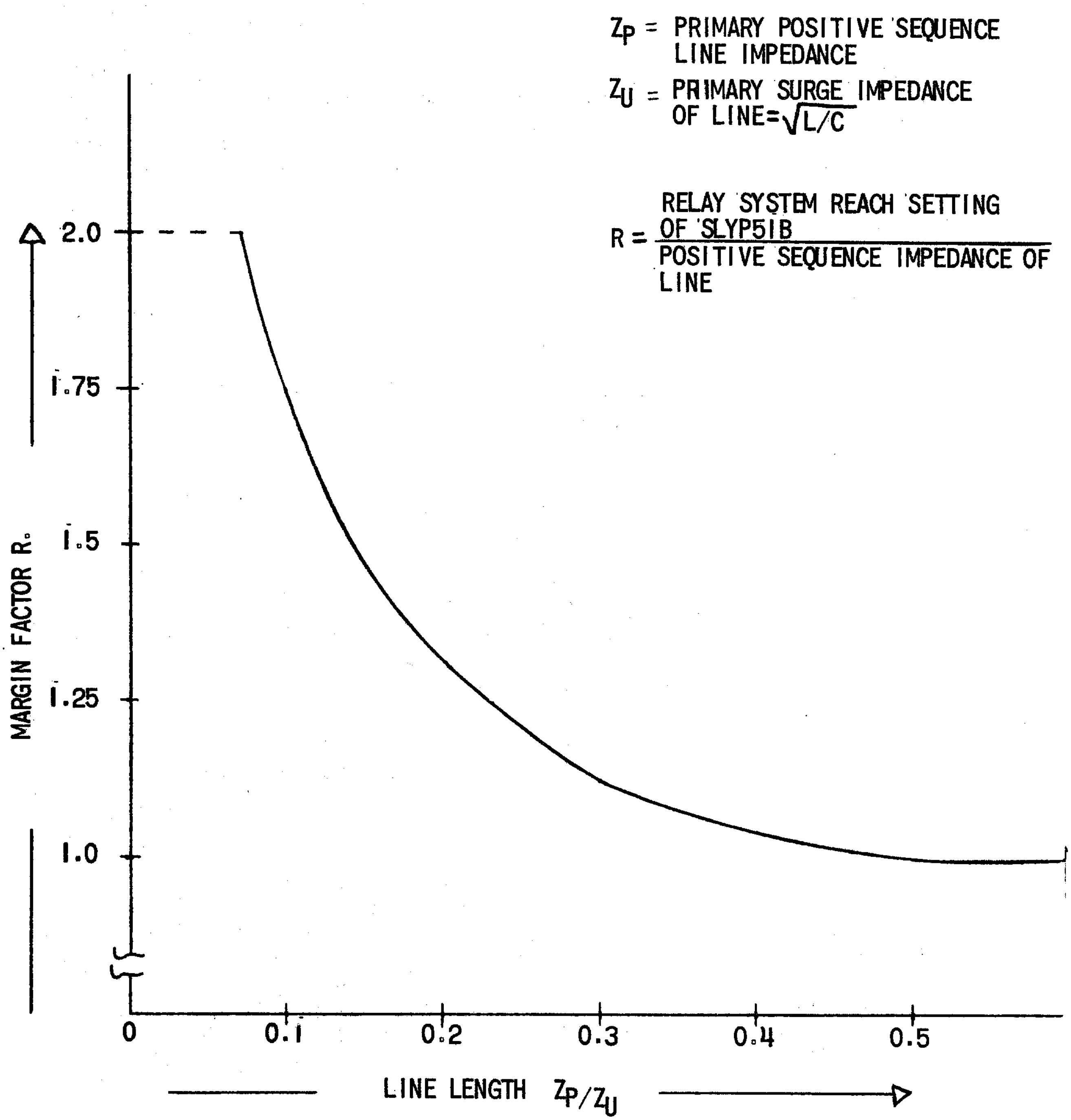


FIG. 12 (0257A6202-0) RELAY SYSTEM REACH MARGIN FACTOR

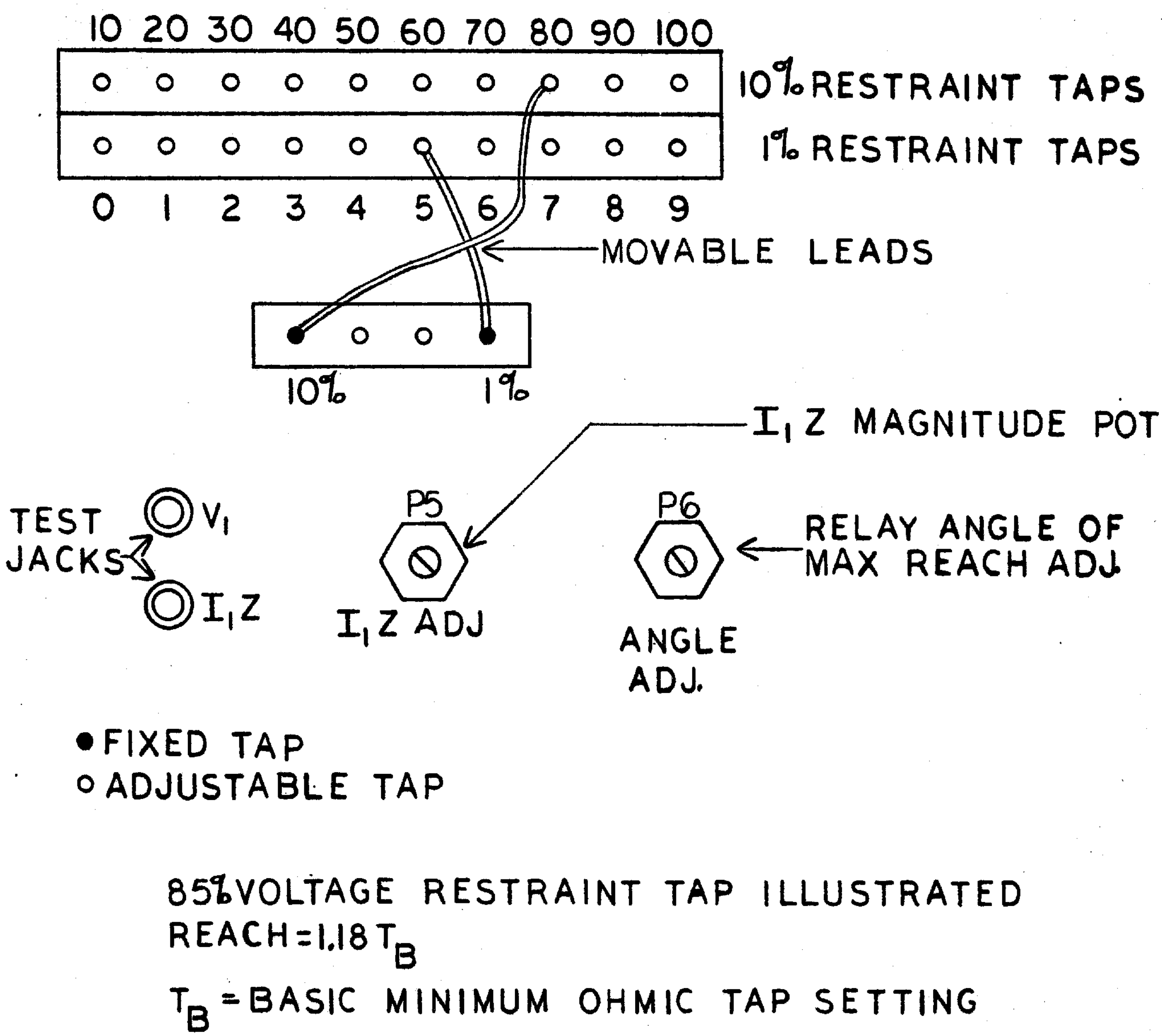
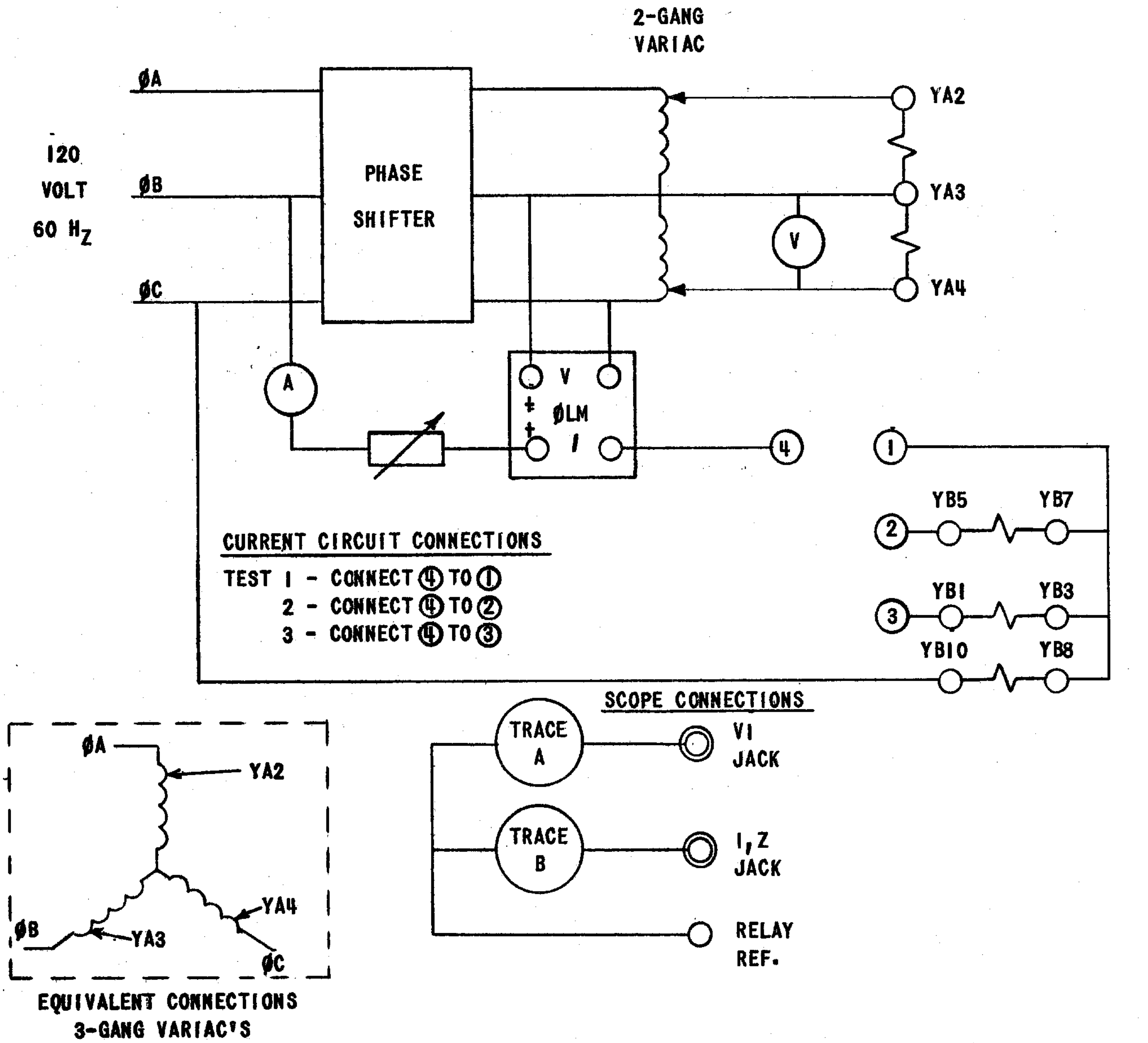


FIG. 13 (0246A6885-1) TYPICAL SLYP51B VOLTAGE RESTRAINT TAP SETTINGS

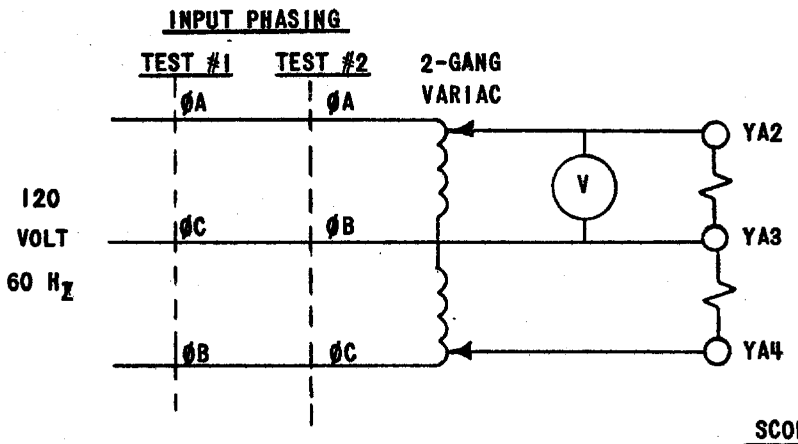


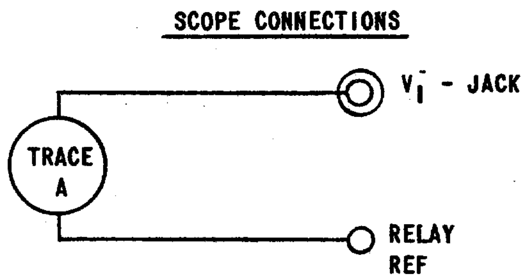
	BALANCED 3Ø RELAY INPUT VOLTS	INPUT AMPS	PHASE ANGLE *	OUTPUT INDICATION	REMARKS **
TEST 1	8.66 VOLT RMS	5 AMP	TEST ANGLE	CHECK $V_1 = I_1 Z$ (±.05V)	AØ TO GRD. NETWORK CHECK
TEST 2	8.66 VOLT RMS	5 AMP	TEST ANGLE +120°	$V_1 \cong 1.2$ VOLTS P-P	BØ TO GRD. NETWORK CHECK
TEST 3	8.66 VOLT RMS	5 AMP	TEST ANGLE +240°	V_1 & $I_1 Z$ IN PHASE (± 0.2MS)	CØ TO GRD. NETWORK CHECK

* TEST ANGLE = RELAY ANGLE PLUS (+) 30°

** RELAY VOLTAGE RESTRAINT TAP SETTING = 100% FOR ALL TESTS

FIG. 14 (0257A6205-0) TYPE SLYP51B RELAY SEQUENCE NETWORK CHECK USING SINGLE PHASE CURRENT

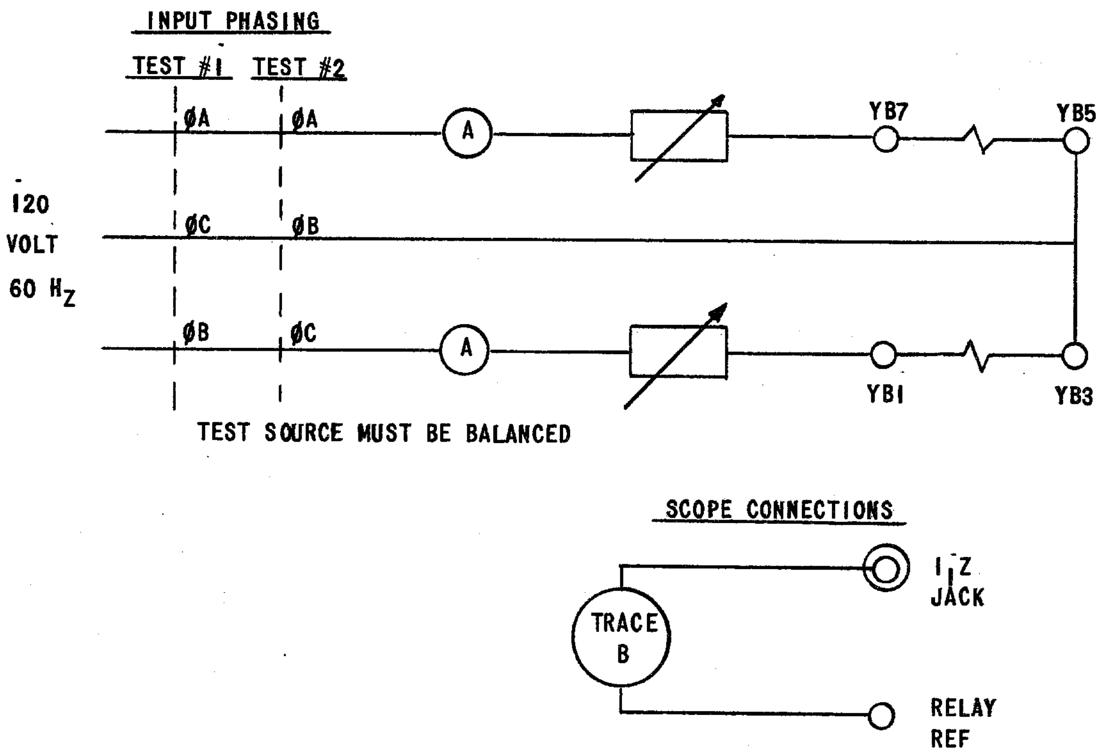




TEST	BALANCED 3Ø RELAY INPUT VOLTS	OUTPUT INDICATION	ADJUST	REMARKS *
#1 V1 - NULL	120 VOLTS R.M.S.	LESS THAN 0.2 VOLT P-P RIPPLE	P2 & P1 ALTERNATELY FOR MINIMUM FUNDAMENTAL OUTPUT	VOLTAGE RESTRAINT TAP SETTING ≈ 100% START P2 & P1 ADJUSTMENT FROM MIDPOINT OF POTS
#2 V1 OUTPUT	26 VOLTS R.M.S.	APPROX. 3.4 VOLTS P-P	NONE	VOLTAGE RESTRAINT TAP SETTING = 100% RECORD VOLTAGE VALUE FOR I_1Z CALIBRATION

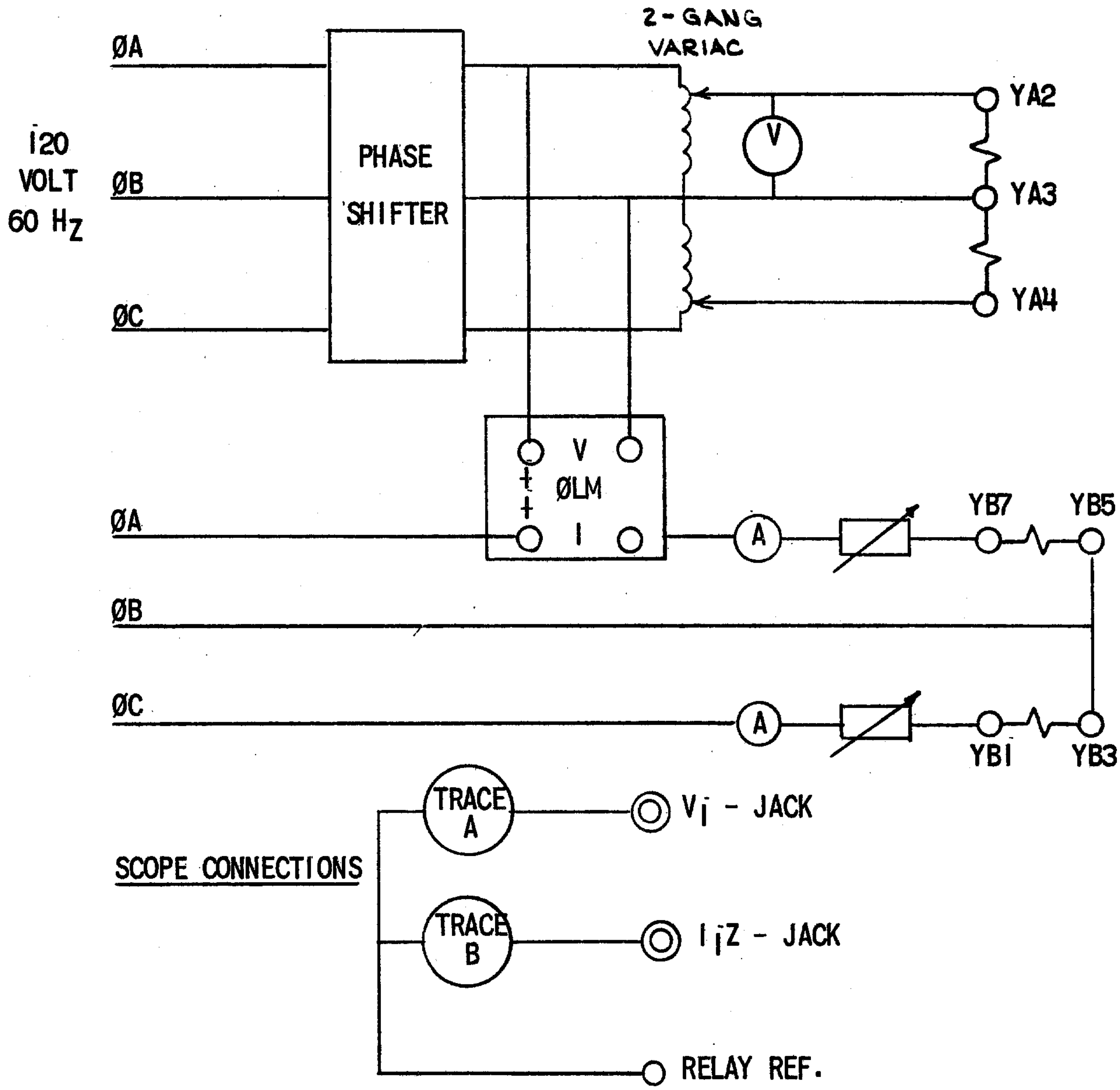
* OBSERVE INPUT PHASING

FIG. 15 (0257A6206-0) TYPE SLYP51B RELAY VOLTAGE SEQUENCE NETWORK V_1 NULL AND AUTPUT TESTS



	INPUT AMPS	OUTPUT INDICATION	ADJUST	REMARKS
TEST #1 I_1Z NULL	5 AMPS PER PHASE	LESS THAN 0.2 VOLT P-P RIPPLE	P4 & P3 ALTERNATELY FOR MINIMUM FUNDAMENTAL OUTPUT	OBSERVE INPUT PHASING, START P4 & P3 ADJUSTMENT FROM MIDPOINT OF POTS
TEST #2 I_1Z OUTPUT	5 AMPS PER PHASE	APPROXIMATELY 3.4 VOLTS P-P	P5 TO OBTAIN VALUE EQUAL TO V_1 OUTPUT	OBSERVE INPUT PHASING

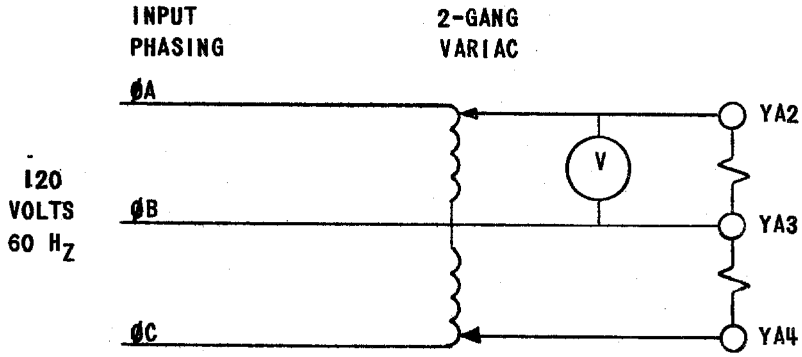
FIG. 16 (0257A6203-0) TYPE SLYP51B RELAY CURRENT SEQUENCE NETWORK I_1Z NULL AND OUTPUT TESTS



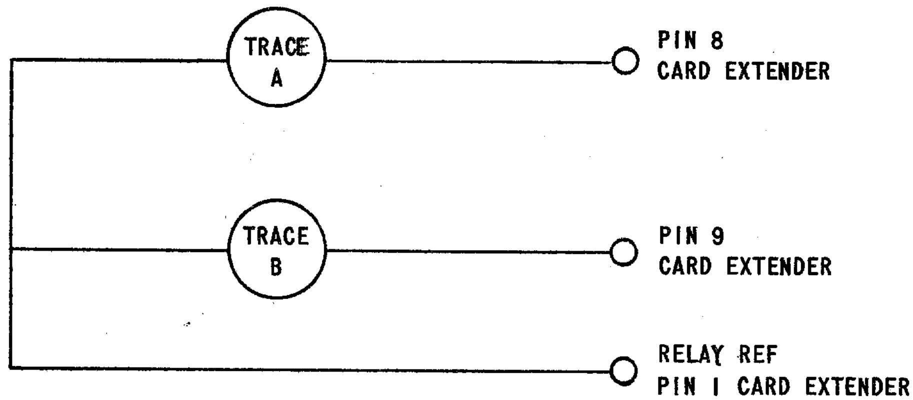
BALANCED 3Ø RELAY INPUT VOLTS	INPUT AMPS	PHASE ANGLE *	OUTPUT INDICATION	ADJUST	REMARKS
26 VOLTS RMS	5 AMPS PER PHASE	TEST ANGLE	V_I & $I_I Z$ EQUAL MAGNITUDE AND IN PHASE (TRACES A & B)	ADJUST P6 TO BRING $I_I Z$ IN PHASE WITH V_I READJUST P5 TO MAINTAIN MAGNITUDE EQUAL TO V_I	OBSERVE INPUT PHASING RELAY VOLTAGE RESTRAINT TAP SETTING = 100%

* TEST ANGLE = RELAY ANGLE MINUS (-) 30°

FIG. 17 (0257A6211-0) TYPE SLYP51B RELAY ANGLE OF MAXIMUM REACH TEST

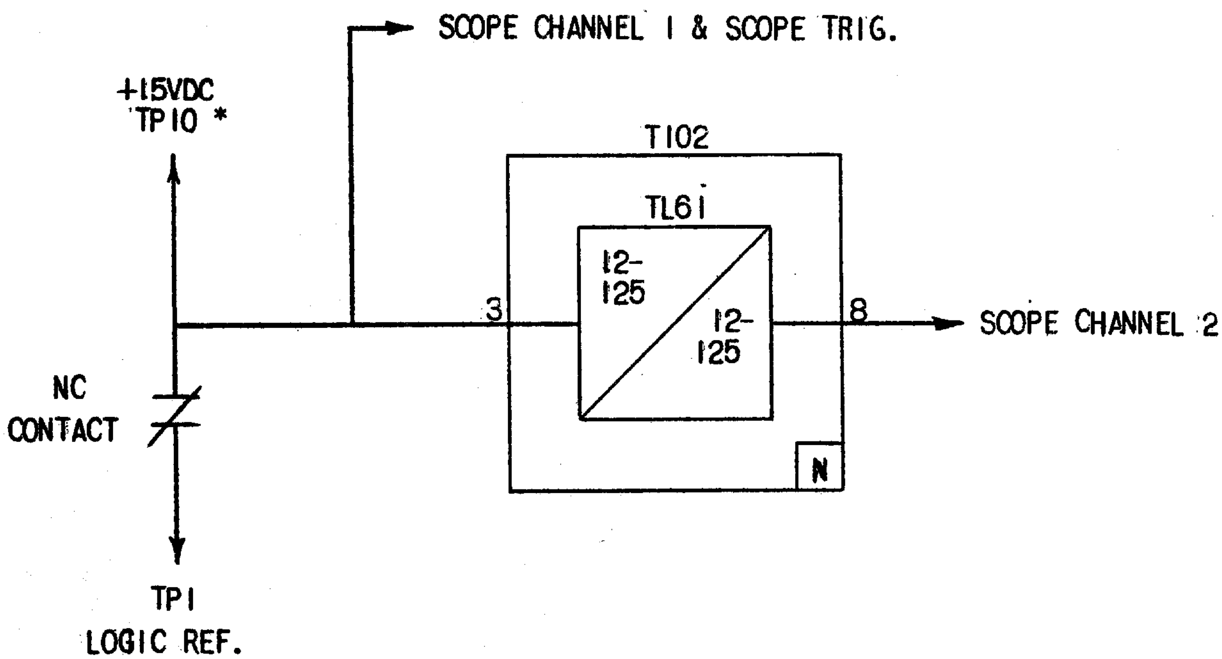


SCOPE CONNECTIONS



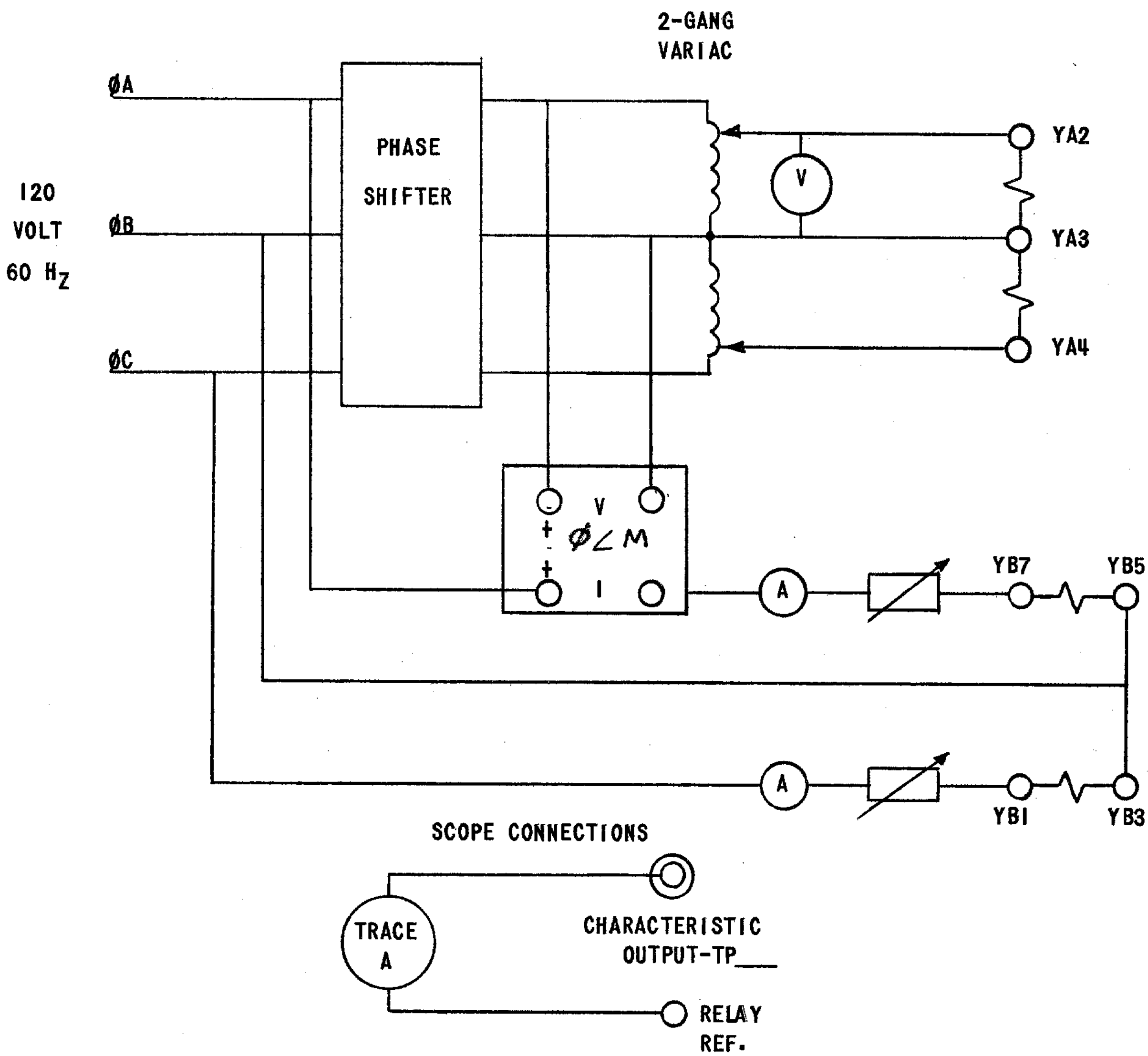
FUNCTION	CARD LOCATION	BALANCED 3-4 RELAY INPUT VOLTS	SCOPE CONN	OUTPUT INDICATION	ADJUSTMENT	REMARKS
MI	F	120 VOLTS RMS	TRACE A-PIN 8 TRACE B-PIN 9 OF CARD TESTED USE CARD EXTENDER	TRACE B LEADS TRACE A BY 10°(.47MS)	TRIM P71 POT ON BOTTOM OF CARD UNDER TEST	CONNECT I1Z JACK TO RELAY REF (TP1)
MT, MOB	G			TRACE B LEADS TRACE A BY 10°(.47MS)		
MB	H			TRACE B & TRACE A IN PHASE		

FIG. 18 (0257A6207-0) TYPE SLYP51B FILTER CARD POLARIZING VOLTAGE PHASE SHIFT TEST



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

FIG. 19 (0246A7987-0) TYPICAL TIMER TEST CIRCUIT



FUNCTION	BALANCED 3-Ø RELAY INPUT VOLTS	INPUT AMPS	PHASE ANGLE	ADJUSTMENTS	OUTPUT
MI	REDUCE FROM 100 VOLTS UNTIL REQUIRED OUTPUT NOTED & RECORD VALUE	CONSTANT 5 AMPS	ADJUST TO OBTAIN REQUIRED NUMBER OF POINTS TO PLOT SPECIFIC CHARACTERISTIC	SET BASE REACH AND VOLTAGE TAPS AS DETERMINED FROM "CALCULATIONS OF SETTINGS"	TP6
MT					TP7
MOB					TP8
MB					TP9

* TEST ANGLE = RELAY ANGLE MINUS 30°

FIG. 20 (0257A6204-0) TYPE SLYP51B THREE PHASE CHARACTERISTIC TESTS.