INSTRUCTIONS

GEK-65589A
Supersedes GEK-65589

STATIC POSITIVE SEQUENCE DISTANCE RELAY

TYPE SLYP51D (FORMS 21 AND ABOVE)

GENERAL ELECTRIC

CONTENTS

STATIC POSITIVE SEQUENCE DISTANCE RELAY

TYPE SLYP51D (FORMS 21 AND ABOVE)

DESCRIPTION

The Type SLYP51D relay is a distance relay utilizing positive sequence current and voltage quantities in the distance measuring functions. The SLYP51D relay, in conjunction with the other relays required to form a complete relay system, provides protection for transmission lines either with or without series capacitors.

The SLYP51D relay has provision for an overreaching tripping distance function, M_1T, an underreaching tripping distance function, $(M_1)_1$, a blocking distance function, M_1B, a positive sequence overvoltage function, V1, and a characteristic timer for the out-of-step blocking function, MOB. Any or all of these functions will be included depending on which model number of the relay is provided.

The SLYP51D distance functions measure distance correctly on three phase faults, and will underreach on unbalanced faults. The greatest underreach will be on single line-to-ground faults, and the least underreach will occur on double line-to-ground faults.

APPLICATION

The application of the SLYP51D relay is similar in most respects to the application of other types of distance relays. However, the application consideration will vary depending on whether or not series capacitors are used. Refer to the logic description for the application considerations for the specific application.

RANGES

The SLYP51D has an adjustable system reach of 1-30 ohms (five amperes) or 5-150 ohms (one ampere) in the trip direction, with one and three ohm (five amperes) or 5 and 15 ohm (one ampere) base reach taps in the current circuits and one percent restraint taps in the voltage circuits. With the exception of the $(M_1)_1$ function, the reach of each measuring function in the SLYP51D is fixed at a specific percentage of the relay system reach. For example, if the relay system reach has been set at 20 ohms and the unit nameplate indicates that the M_1T reach is 125 percent, the reach of the M_1T function at the relay system angle is 25 ohms (1.25 x 20). The reach of the $(M_1)_1$ function is adjustable from 20 percent to 90 percent of the relay system reach. The backward reach of the M_1B function is settable at either 125 percent or 175 percent of the relay system reach.

The relay system angle is adjustable from 60 degrees to 90 degrees. The standard factory setting is 85 degrees. The angle of maximum reach of the various mho functions is individually adjustable by the polarizing phase shift on its associated filter card (F108, F146 or F147 (60 hertz) or F133, F132 or F131 (50 hertz). The ranges of polarizing phase shifts relative to the operating quantity are:

M_1T and MOB	0 degree or 20 degrees lead
(M_1)	15 degrees lag to 30 degrees lead
M_1B	5 degree lag to 30 degrees lead

The pickup range of the V_1 function is adjustable over the range of 50 percent to 100 percent of rated system positive sequence voltage.

In those applications where the M_1 function is used with its optional V-I_1Z level detector feature, the V-I_1Z pickup range is 15 to 90 volts.

RATINGS

The Type SLYP51D relay is designed for use in an environment where the air temperature outside the relay case is between minus 20°C and plus 65°C.

The Type SLYP51D relay requires a plus or minus 15 volt DC power source which can be obtained from Type SSA50 and up power supplies.

The current circuits of the Type SLYP51D relay are rated at five or one ampere, 60 or 50 hertz for continuous duty and have a one second rating of 300 amperes. The potential circuits are rated 120 volts, 60 or 50 hertz.

OPERATING PRINCIPLES

INTRODUCTION

The Type SLYP51D relay employs positive sequence voltage and current networks to obtain the V_1 and I_1Z signals that are used to derive the various mho characteristics included in the SLYP51D relay. The voltage at the V_1 test jack is given by the expression:

$$V_1 \text{ test jack voltage} = (0.0866) \left(\frac{T}{100}\right) (V_{1sys}) \angle 240^\circ$$

where V_1 system is the magnitude of positive sequence voltage applied to the relay, and T is the restraint tap setting in percent.

The voltage at the I_1Z test jack is given by the expression:

$$I_1Z \text{ test jack voltage} = 0.0866 \text{ TB } I_1 \angle(300^\circ - 330^\circ)$$

where I_1 is the magnitude of positive sequence current applied to the relay and TB is the basic ohmic tap setting. The angle is factory set to 325 degrees, which is a relay system angle of 85 degrees.

POSITIVE SEQUENCE MHO CHARACTERISTICS

General Operating Principles

The principle used to derive the mho characteristics is illustrated in Fig. 4. The I_1Z quantity is a voltage proportional 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 $({}_1Z - V_1)$ is the vector 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 degrees for an impedance point internal to the relay characteristic, equal to 90 degrees at the balance point, and greater than 90 degrees for an external 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 degrees apart are coincident for 4.17 milliseconds (60 hertz)/5.0 milliseconds (50 hertz). Blocks which are less than 90 degrees apart are coincident for more than 4.17 milliseconds (60 hertz)/5.0 milliseconds (50 hertz). Blocks which are more than 90 degrees apart are coincident for less than 4.17 milliseconds (60 hertz)/5.0 milliseconds (50 hertz). 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 Fig. 2. If the characteristic has no reverse reach, the operating principle remains the same as just described except I_1Z' is zero.

M_1T Function

The resistor R_B, which is mounted on the N118 card in position E (Fig. 2), determines the relationship between the reach of the M_1T function and the relay system reach. The M_1T reach at the relay system reach angle may be calculated from the expression:

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

where:

T = Voltage restraint tap setting expressed in percent

T_B = Basic ohmic tap setting

$K = \dfrac{20{,}000}{R_B + 10{,}000}$ = percentage reach of $M_1T/100$

The F147 (60 hertz)/F132 (50 hertz) filter card (position G) is supplied with three inputs: I_1Z, $+V_1$, $-V_1$.

The outputs of the filter card are 30 volt DC square waves (minus 15 volts DC to plus 15 volts DC). 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 $(I_1Z - V1)$.

In addition to filtering, the position G card provides an adjustment of the phase relationship between the output quantities by shifting the polarizing quantity relative to the operating quantity. M_1T 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 Fig. 5. The reach at the relay system angle is a chord of all the characteristics. Adjust the polarizing phase shift in the leading direction shifts the mho characteristic in the counterclockwise direction. The angles $\alpha 1$ and $\alpha 2$ are determined by the characteristic timer setting (TS) and the polarizing phase shift ϕ.

$$\alpha 1 = TS - \phi$$

$$\alpha 2 = TS + \phi$$

The C104 coincidence measurement card (position L) compares the positive half of one square wave with the positive 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 Fig. 6.

The output blocks from the C104 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.

MOB Function

The MOB characteristic is derived from the M_1T 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. Fig. 7 shows the relationship between the MOB characteristics at both 85 degree and 75 degree 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 milliseconds (60 hertz)/5.0 milliseconds (50 hertz) 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 on the M_1T function.

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

$$B = (21.6)(t) \text{ (for 60 hertz)/ or } (18.0)(t) \text{ (for 50 hertz)}$$

where:

B = The pickup time expressed in degrees
t = The pickup time in milliseconds

Step 3: Determine the diameter angles of the two lobes

$$D_1 = 85^o - \emptyset + (90^o - B)$$

$$D_2 = 85^o - \emptyset - (90^o - B)$$

where:

D_1 and D_2	= The angles of the diameters in degrees
85^o	= Relay system reach angle (typical)
$\emptyset$	= Angle between the maximum reach angle and 85 degrees. ($\emptyset$ is also the polarizing phase shift).
B	= 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.

$(M_1)_1$ Function

The operating principle for the $(M_1)_1$ function is the same as that described for the M_1T function, except that a variable resistor is used at the input of the filter card to enable the user to set the $(M_1)_1$ reach independently of the other mho characteristics. The $(M_1)_1$ reach at the relay system angle may be calculated from the expression:

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

where:

T =	Voltage restraint tap setting expressed in percent
T_B =	Basic ohmic tap setting
K =	$\frac{20,000}{P_A + R_A + 10,000}$ = percentage reach of $M_1/100$
R_A =	Value of resistor R_A on the N118 card in position E
P_A =	Ohmic setting used on variable resistor P_A on the N118 card in position E.

If the desired reach for M_1 is known, the corresponding value of P_A can be determined from the following expression:

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

An option is available to incorporate a level detector function in the $(M_1)1$ function. This is acomplished by setting the option C jumper on the F146 (60 hertz)/F131 (50 hertz) card to the B position. The level detector setting is made by adjusting the P12 potentiometer on the same card. This option insures that the $(M_1)_1$ function will not operate until the $(I_1Z - V_1)$ operating quantity is greater than a predetermined level.

The option plug on the N118 card should be in the A position for all applications unless otherwise noted in the associated logic description.

M_1B Function

The operating principle for the M_1B is the same as that described for the M_1T function, except that an additional input (I_1Z') is provided to the filter card to give a reverse reach. The reach in the blocking direction may be calculated from the expression:

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

where:

T = Voltage restraint tap setting expressed in percent

T_B = Basic ohmic tap setting

$K = \dfrac{20{,}000}{R_C + 10{,}000}$ = percentage reach of $M_1B/100$

R_C = Value of resistor R on the N118 in position E. (RC can be picked for either 125 percent or 175 percent back reach.)

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

POSITIVE SEQUENCE VOLTAGE DETECTOR

The V_1 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 V_1 drops below the preset level. The level is adjusted using P1 on the detector card in position S.

OPERATING CHARACTERISTICS

The operate and reset times of each mho function are 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 (five ampere relay) or 0.2 ampere (one ampere relay) on a three phase fault will cause the SLYP51D relay to pull back to no less than 90 percent of the nominal reach, with the basic ohmic tap setting (T_B) of three ohms (five amperes) or 15 ohms (one ampere).

BURDENS

AC

Potential	5A, 60 Hz Relay	1A, 50 Hz Relay
ØA-ØB	1.9K ohms $\angle 41^o$	1.9K ohms $\angle 41^o$
ØB-ØC	1.4K ohms $\angle 3^o$	1.4K ohms $\angle 3^o$
ØC-ØA	1.3K ohms $\angle -89^o$	1.3K ohms $\angle -89^o$
Current		
ØB (three ohms)	0.035 ohm $\angle 8^o$	0.66 ohm $\angle 9^o$
ØC (three ohms)	0.014 ohm $\angle 14^o$	0.19 ohm $\angle 21^o$
$3I_0$ (three ohms)	0.014 ohm $\angle 1^o$	0.16 ohm $\angle 2^o$
ØB (one ohm)	0.020 ohm $\angle 2^o$	0.20 ohm $\angle 3^o$
ØC (one ohm)	0.010 ohm $\angle 3^o$	0.06 ohm $\angle 7^o$
$3I_0$ (one ohm)	0.011 ohm $\angle 0^o$	0.06 ohm $\angle 0^o$

DC

The Type SLYP51D relay presents a burden to the Type SSA power supply of

200 milliamperes from the +15 VDC supply
100 milliamperes from the -15 VDC supply

RECEIVING, HANDLING AND STORAGE

These relays will normally be supplied as part of a static relay equipment, mounted in a rack of cabinets 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 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 eight 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 EQUIPMENT IS ISOLATED FROM GROUND. IT IS A DESIGN CHARACTERISTIC OF MOST ELECTRONIC INSTRUMENTS THAT ONE OF THE SIGNAL INPUT TERMINALS IS CONNECTED TO THE 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 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.

CONSTRUCTION

The SLYP51D 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 Fig. 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 Fig. 8. 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 SLYP51D 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 one ohm/five ohm and three ohm/fifteen ohm taps are shown in Table I.

TABLE I

	I_C		I_B		$3I_0$	
	IN	OUT	IN	OUT	IN	OUT
1 OHM OR 5 OHM BASE REACH	YB1	YB2	YB4	YB6	YB9	YB10
3 OHM OR 15 OHM 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 and P4) are located inside the relay case as shown in Fig. 3.

The independent reach adjustment pot P_A for the $(M_1)_1$ function is located on the N118 card in position E.

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

The SLYP51D relay also contains printed circuit cards identified by a code number such as F146, C104 D101, T133, N112, 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 tests points (TP1, TP2, etc.) shown on the internal connection diagram, are connected to instrument test jacks on a test card position T with TP1 at the top of the card. The internal connections of the printed circuit cards may be found 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 minus 15 volt DC and pin number 10 to plus 15 volt DC. Output signals are measured with respect to the reference bus on the test card (TP1). Logic signals are approximately plus 15 volt DC for the ON or LOGIC ONE condition, and less than one volt DC for the OFF or LOGIC ZERO condition. Filter card outputs are either plus 15 volt DC or minus 15 volt DC 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.

TESTS AND ADJUSTMENTS REQUIRED

The SLYP51D 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 (user setting).

5. Individual mho characteristic timer setting (user check).

6. $(M_1)_1$ and $M_1(B)$ reach setting (user setting).

7. Mho characteristic plotting on R-X diagram (user check).

8. Voltage level detector, V_1, pickup setting (user setting).

DETAILED TESTING INSTRUCTIONS

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 a separate write-up, the overall logic description. The reach at the relay system angle is given by the following relationship:

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

where:

T = Voltage restraint tap setting expressed in percent

T_B = Basic minimum ohmic tap setting

Voltage Restraint Tap Setting

The arrangement of the voltage restraint tap blocks is described under CONSTRUCTION, and the choice of tap setting is discussed in the section on CALCULATIONS OF SETTINGS and the overall logic description. The pickup voltage at the relay system angle is given by the following relationship:

$$V_1 = \frac{I_1 \times T_B \times 100}{T}$$

where:

T = Voltage restraint tap setting expressed in percent

T_B = Basic minimum ohmic tap setting

I_1 = Positive sequence current

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 Fig. 9. If the required outputs cannot 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 disturbed.

1. Voltage Sequence Network Balance

   This test, described in Fig. 10, consists of two parts, V_1 null and V_1 output checks. It should be noted that this test requires a three-phase test source of equal voltages (within one to two percent). Alternate readjustment of pots P1 and P2 is required to obtain the 60 or 50 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 Fig. 10. 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 Fig. 11, 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 or 50 hertz null leaving only harmonic voltage at the I_1Z test jack. Also check that the I_1Z output is approximately as shown in Fig. 11. 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 Fig. 12 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 Fig. 12 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 for the SLYN relay.

Individual Mho Characteristic Polarizing Phase Shift Setting

The filter cards (positions F, G and H) have an adjustment for the phase shift in the polarizing circuit. The setting for the phase shift of the polarizing quantity with respect to the operating quantity is discussed in the CALCULATION OF SETTINGS section of the book and in the overall logic description. Refer to the overall logic diagram associated with the equipment for the number of the specific overall logic description.

The effects of leading and lagging polarizing quantities are shown in Fig. 5. A leading phase shift rotates the characteristic clockwise. A leading phase shift is defined as the output at pin 9 leading the output at pin 8 of the filter card under test.

A 4.17 millisecond (60 hertz) or 5.0 millisecond (50 hertz) characteristic (circle) remains circular if the polarizing voltage is shifted leading or lagging. The maximum reach of the unit, however, increases.

Fig. 13 describes the test connections to check the phase shift. The adjustment of the phase shift of the M_1B function is by potentiometer P71 on the F108 (60 hertz) or F133 (50 hertz) card in Position H. For the $(M_1)_1$ functions, the adjustment is obtained by P71 and plug Y on the F146 (60 hertz) or F131 (50 hertz) card in Position F. The range obtained by adjusting P71 for each plug location is shown below.

PLUG	LOCATION	PHASE SHIFT RANGE
Y	L	0° to $+30^\circ$
Y	M	0° to -15°

The adjustment of the phase shift of the M_1T function is by the X plug (option K) on the F147 (60 hertz) or F132 (50 hertz) card in position G.

PLUG	LOCATION	PHASE SHIFT
X	(2-3) and (4-5)	0°
X	(1-2) and (3-4)	20°

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 (drop-out 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 the overall logic description.

The timers used for $(M_1)_1$, M_1B and M_1T are "integrating" characteristic timers. These timers are shown on the overall logic as T1, T2/T3, where T is the pickup on a step DC input, T2 is the pulse width which will cause the timer to pick up with one pulse applied per half-cycle, and T3 is the drop-out time. T2 is always less than T1, thus the timer integrates when a chain of pulses is applied. The two pickup modes are depicted in Fig. 14.

It should be noted that the characteristic timers have been set at the factory. The settings may be verified by the following procedure. The pickup time of a non-integrating timer, the DC pickup of an integrating timer, and the drop-out of either may be checked using a DC input and a normally closed switch as shown in Fig. 15. Opening the normally closed contact causes the timer output to step to plus 15 volts DC after the pickup delay of the timer. To increase the pickup delay, turn the upper potentiometer (P1) on the timer card clockwise. Closing the contact causes the timer output to drop out after the reset delay setting of the card. To increase the reset time, turn P2 (lower potentiometer except on T133, on which P2 is the middle potentiometer) clockwise.

To set the integration on the T133 type timer, it is necessary to supply the timer card with an input consisting of a series of pulses. This can be accomplished by adjusting the input currents, voltages or the phase angle between them to achieve the desired width pulses. Potentiometer P3 (lower potentiometer on the T133 cards) may now be adjusted to cause the timer to pick up, turning P3 clockwise increases the integration (picks up on smaller blocks).

Details of all the timer cards used in this relay are given in the printed circuit card instruction book, GEK-34158.

$(M_1)_1$ Reach Setting

The reach of the $(M_1)_1$ characteristic must be set at a specific value for the line being protected by adjusting pot PA on the N118 card in position E. Use the AC test connection in Fig. 12. The option C jumper on the F146 (60 hertz) or F131 (50 hertz) card in position F must be placed in the "T" position in order to set or check the $(M_1)_1$ reach.

1. Set the current in each branch for a constant relay rated current (five or one amp).

2. Set the voltage per the following expression for the specific $(M_1)_1$ reach setting.

$$V_{\emptyset-\emptyset} = \frac{\sqrt{3}\ I\ T_B Z\ (M_1)_1}{T}$$

where:

$V_{\emptyset-\emptyset}$ = Relay input voltage per Fig. 12
I = Branch current per Fig. 12
T_B = Basic minimum ohmic tap setting
T = Voltage restraining tap setting in percent
$Z\ (M_1)_1$ = Desired reach setting of $(M_1)_1$ in percent of relay system reach

3. Set the phase angle meter to 30 degrees less than the angle of the relay system reach. (Example: phase angle meter equals 85 degrees minus 30 degrees equals 55 degrees).

4. An oscilloscope should be connected to pin 8 of the $(M_1)_1$ filter card in position F.

5. Observe the square wave output (60 hertz) or (50 hertz) at pin 8. Adjust the pot, P_A, on the N118 card, until the square wave goes to zero. This sets the reach of the $(M_1)_1$ characteristic at the relay system reach angle.

   NOTE: Due to the loading effect, there is interaction between the adjustment of the $(M_1)_1$ reach and the relay system angle calibration (pots P5 and P6). Therefore the network calibration should be rechecked at this time per the previous procedure 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 N118 card from the relay and setting the pot, using an ohmmeter, to the value calculated from the expression in the $(M_1)_1$ part of the **OPERATING PRINCIPLES** section of this book.

6. A final check of the reach of the $(M_1)_1$ characteristic should be made by starting at 100 volts and lowering the input test voltage until an output is noted from the $(M_1)_1$ timer card at TP6. The output should occur at the value of phase-to-phase input voltage given by the expression above.

   The above procedure establishes a balance point for the operation of the $(M_1)_1$ function. This procedure assumes a zero degree polarizing phase shift setting has been used.

7. If the I_1Z-V level detector feature is not to be used, P12 (F146 (60 hertz) or F131 (50 hertz) card) should be adjusted fully counterclockwise. If the level detector feature is to be used, refer to $(M_1)_1$ Function I_1Z-V Level Detector Setting for the procedure to set P12.

$(M_1)_1$ Function I_1Z-V Level Detector Setting

The following procedure should be used to set the I_1Z-V level detector which is included in the $(M_1)_1$ function. If the level detector feature is not to be used, the option C jumper on the F146 (60 hertz) or F131 (50 hertz) card in position F must be in the "T" position; if the level detector feature is used, the jumper must be placed in the "B" position.

1. Determine the proper I_1Z-V level as discussed in the logic description associated with the particular static terminal.

2. Use the test connections of Fig. 13.

3. Set the applied voltage for

$$\text{Vtest} = \sqrt{3}\ \text{Vcal}$$

where:

Vcal is the I_1Z-V level calculated in Step 1, measured RMS

Vtest is the applied voltage of Fig. 13.

4. Adjust P12 on the F145 (60 hertz) or F131 (50 hertz) card in position F, to obtain blocks at pin 8 of the F card, the longer of which is equal in width to the shorter pickup time of the $(M_1)_1$ function. The width of the blocks should be measured at the 7.5 volt level of the square wave.

MHO Characteristic Plotting

Each of the relay characteristics may be checked over its entire range by using the test circuit of Fig. 12. By setting the current in each branch for constant relay rated current, 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 Fig. 12.

2. Set currents to relay rated current (five amperes/or one ampere 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 the overall logic description.

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

$$V_{\emptyset-\emptyset} = \frac{\sqrt{3}\ I\ T_B Z\ \text{Cos}\ (\alpha - \emptyset)}{T}$$

where:

$V\emptyset\text{-}\emptyset$ = Relay input voltage per Fig. 12.

I = Branch current per Fig. 12.

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 on the unit nameplate if the polarizing phase shift is zero.*

α = Angle of maximum reach

$\emptyset$ = Test angle.

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

$$Z = \frac{Z_O}{\text{Cos B}}$$

where:

Z_O = Function reach in percent of system reach as given on the unit nameplate

B = 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 Function. Also see Fig. 5 and 7.

V_1 Level Detector Adjustment

The positive sequence voltage pickup level is discussed in the overall logic description. Using the test circuit of Fig. 13, 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, Fig. 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 Fig. 15 and DC test method for timers as described in the section on Individual Mho Characteristic Polarizing Time Settings.

PERIODIC CHECKS AND ROUTINE MAINTENANCE

PERIODIC TESTS

All functions included in the SLYP51D relay may be checked at periodic intervals using the procedures described in the section covering DETAILED TESTING INSTRUCTIONS. Cable connections between the SLYP51D relay and the associated Type SLA relay can be checked by observing the SLYP51D 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 - General Network Calibration Check.

2. MHO Characteristic Plotting on R-X Diagram - See detailed testing instruction - MHO Characteristic Plotting

3. V_1 Level Detector Pickup Setting - See detailed testing instruction - V_1 Level Detector Adjustment.

TROUBLESHOOTING

In any troubleshooting 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 (0149C7259G2) 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 troubleshooting, 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 buses, or overheat the semiconductor components. The repaired area should be recovered with a suitable high-dielectric plastic coating to prevent possible breakdowns across the printed buses due to moisture and dust. The wiring diagrams for the cards in the SLCN51D relay are included in the card book GEK-34158; the card types are shown on the component location diagram, Fig. 3.

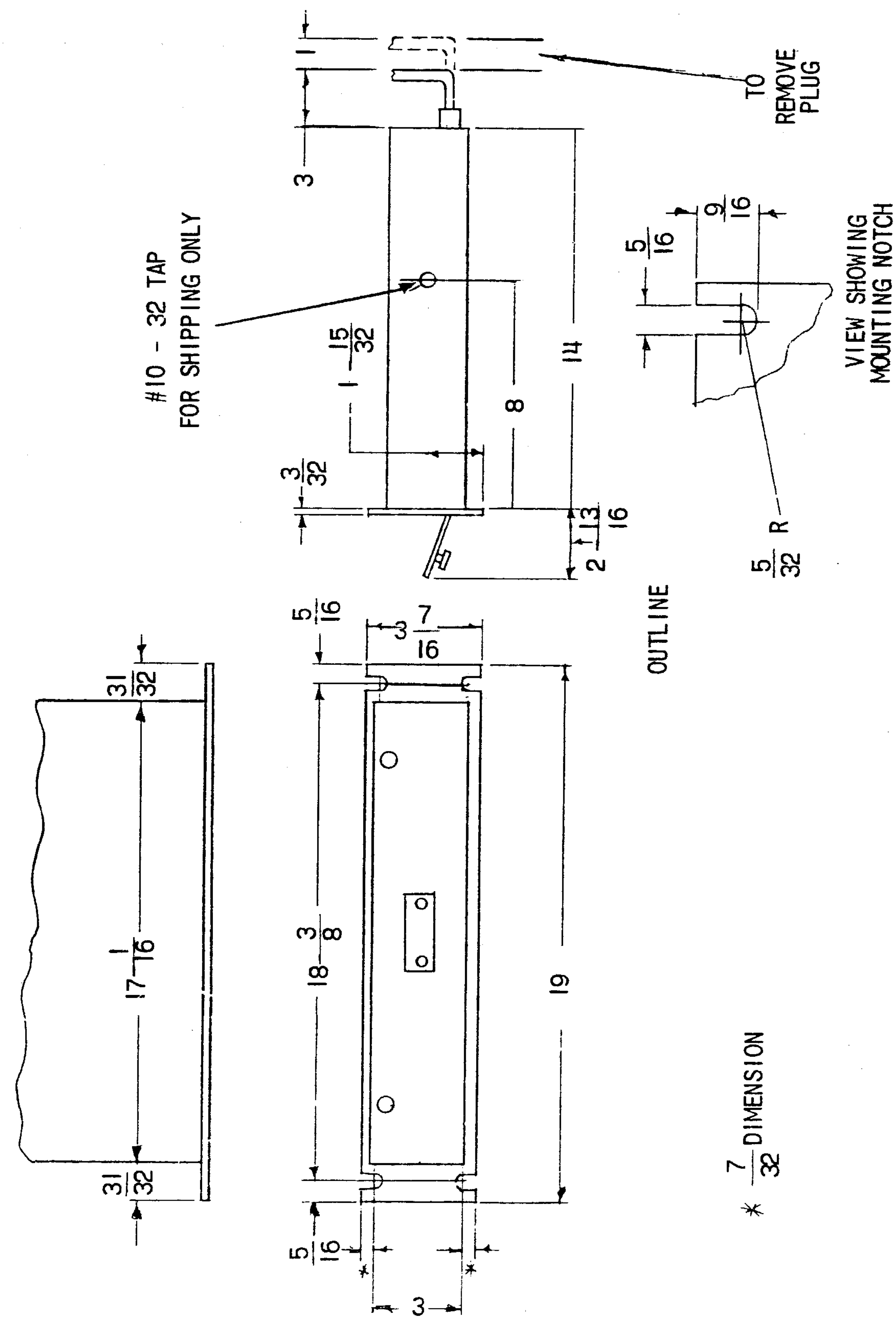


Fig. 1 (0227A2036-0) Outline and Mounting Dimensions
for the Type SLYP51D Relay

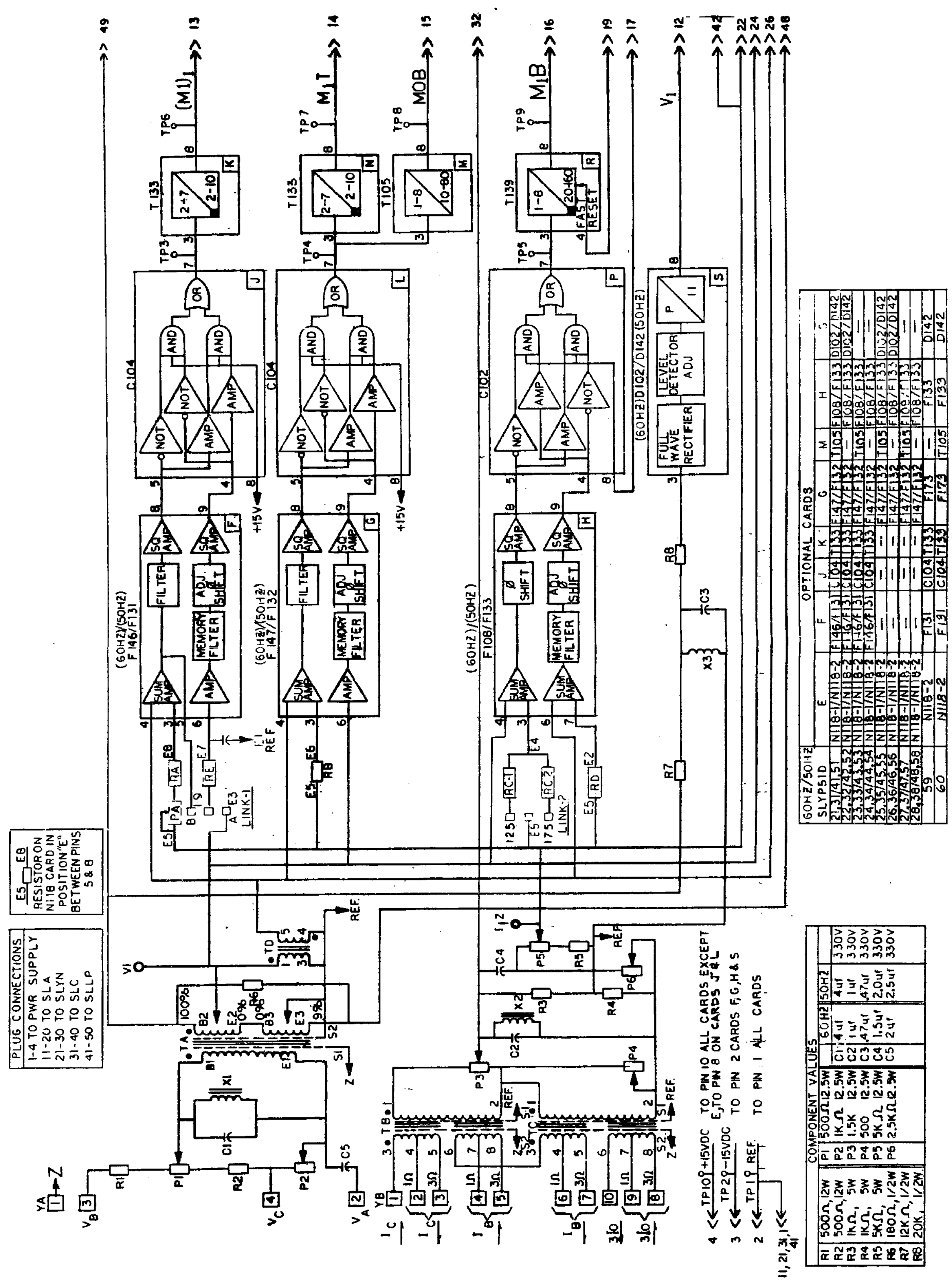
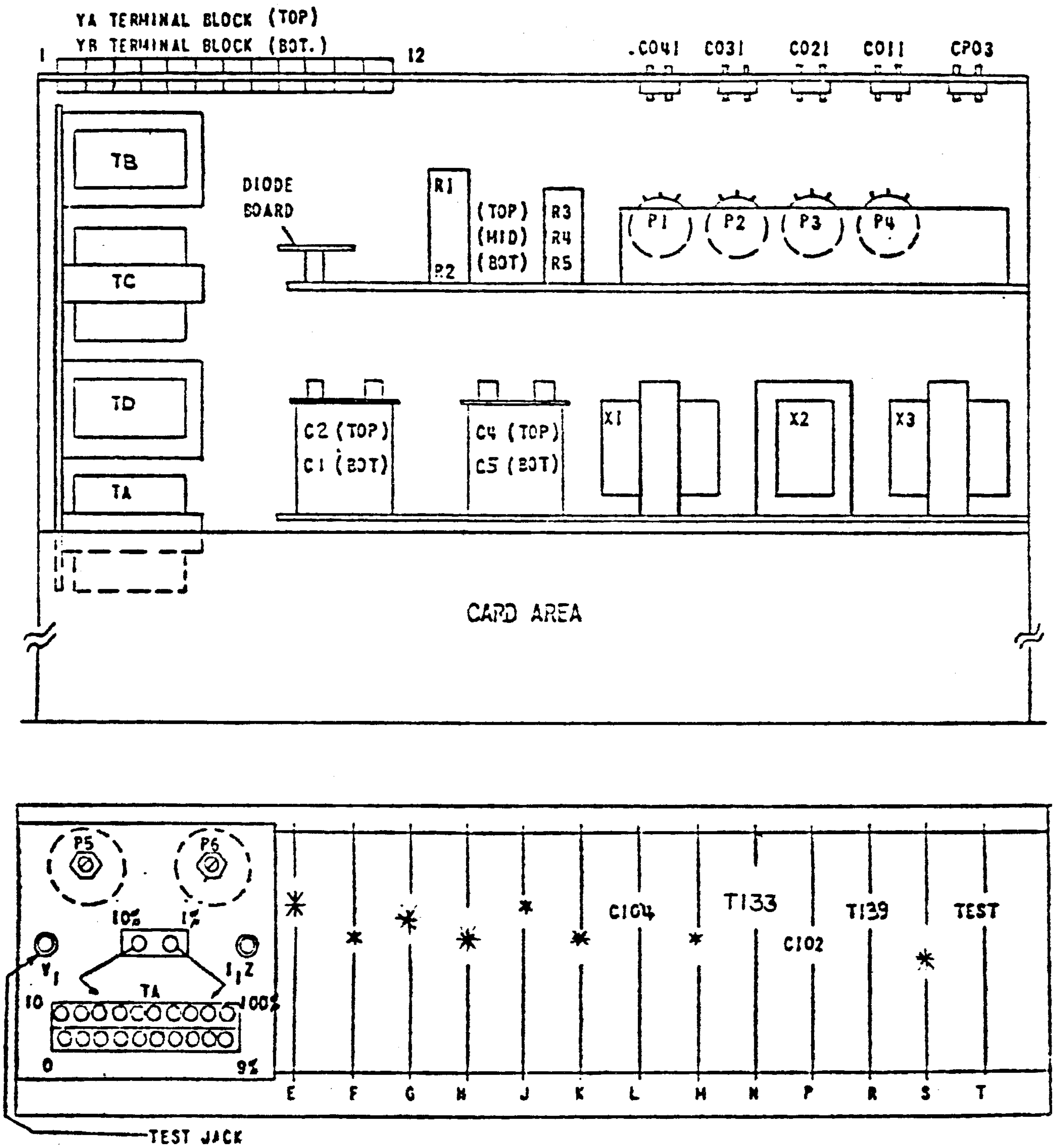


Fig. 2 (0179C6105-1) Internal Connection Diagram for the Type SLYP51D Relay (Forms 21 and Above)



*SEE INTERNAL 0179C6105 FOR CARDS IN THESE POSITIONS

Fig. 3 (0285A5618-0) Component Location Diagram for the Type SLYP51D Relay (Forms 21 and Above)

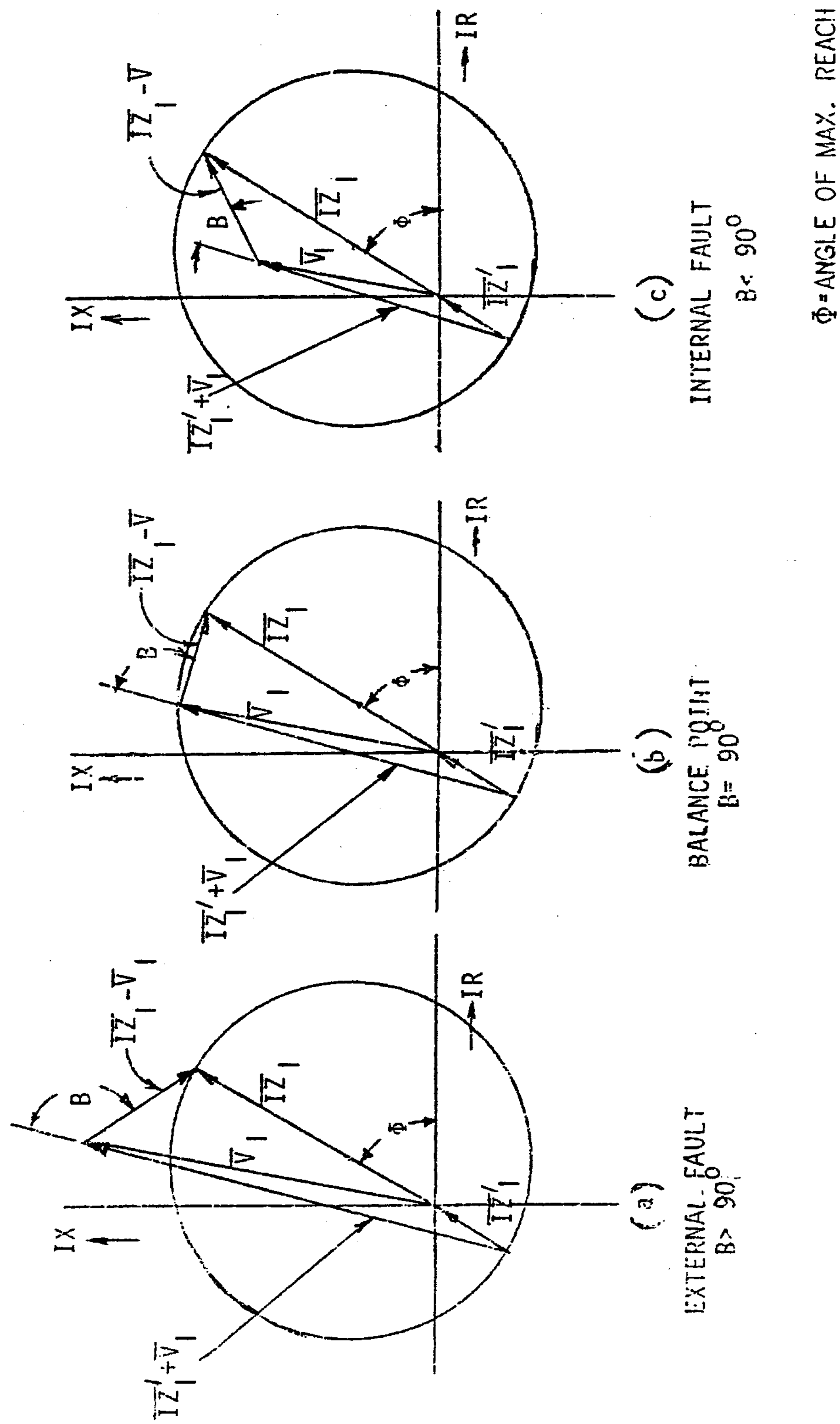


Fig. 4 (0246A7984-0) Offset Mho Characteristic by Phase Angle Measurement

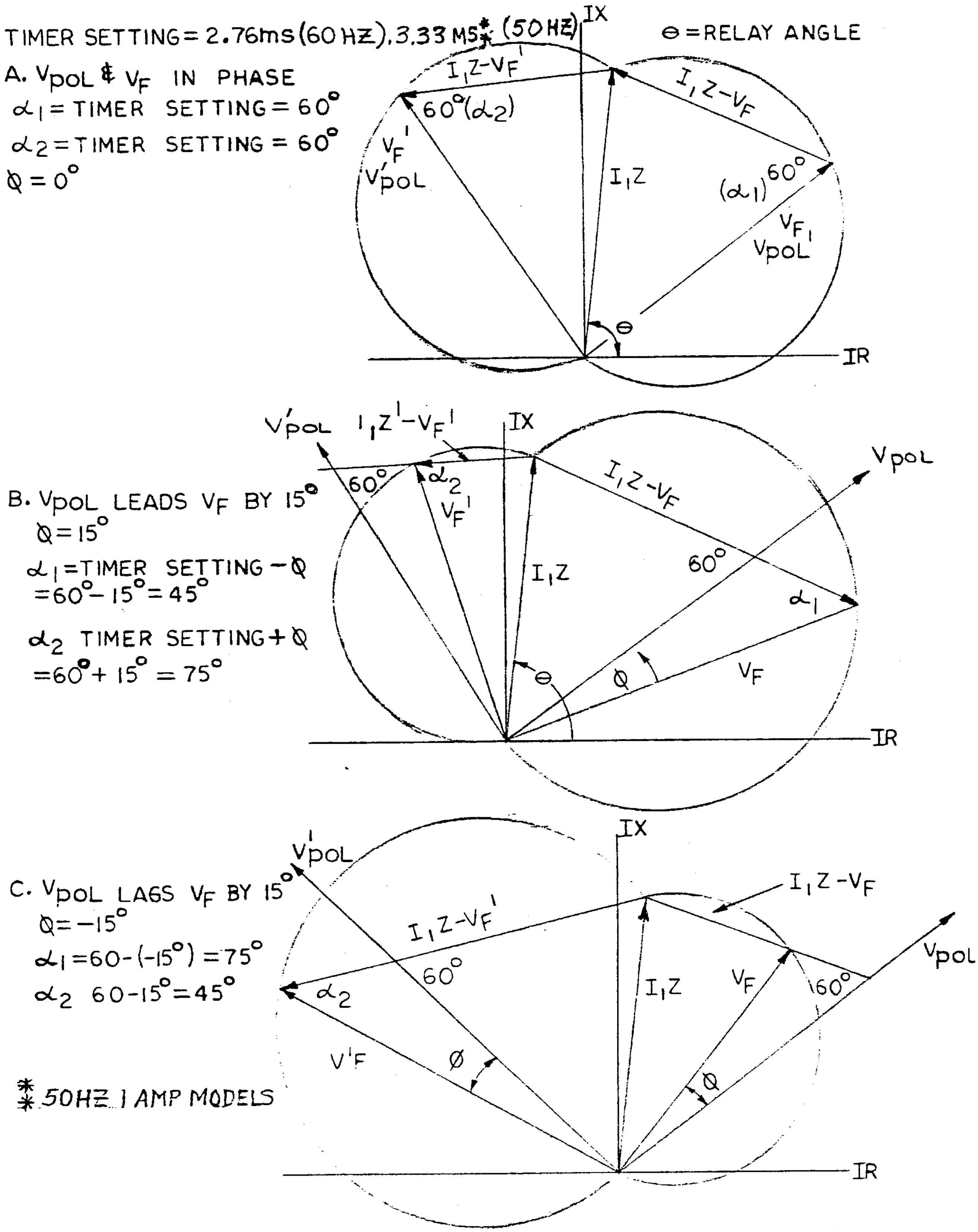


Fig. 5 (0246A6866-3) Effect of Polarizing Phase Shift on Mho Characteristic

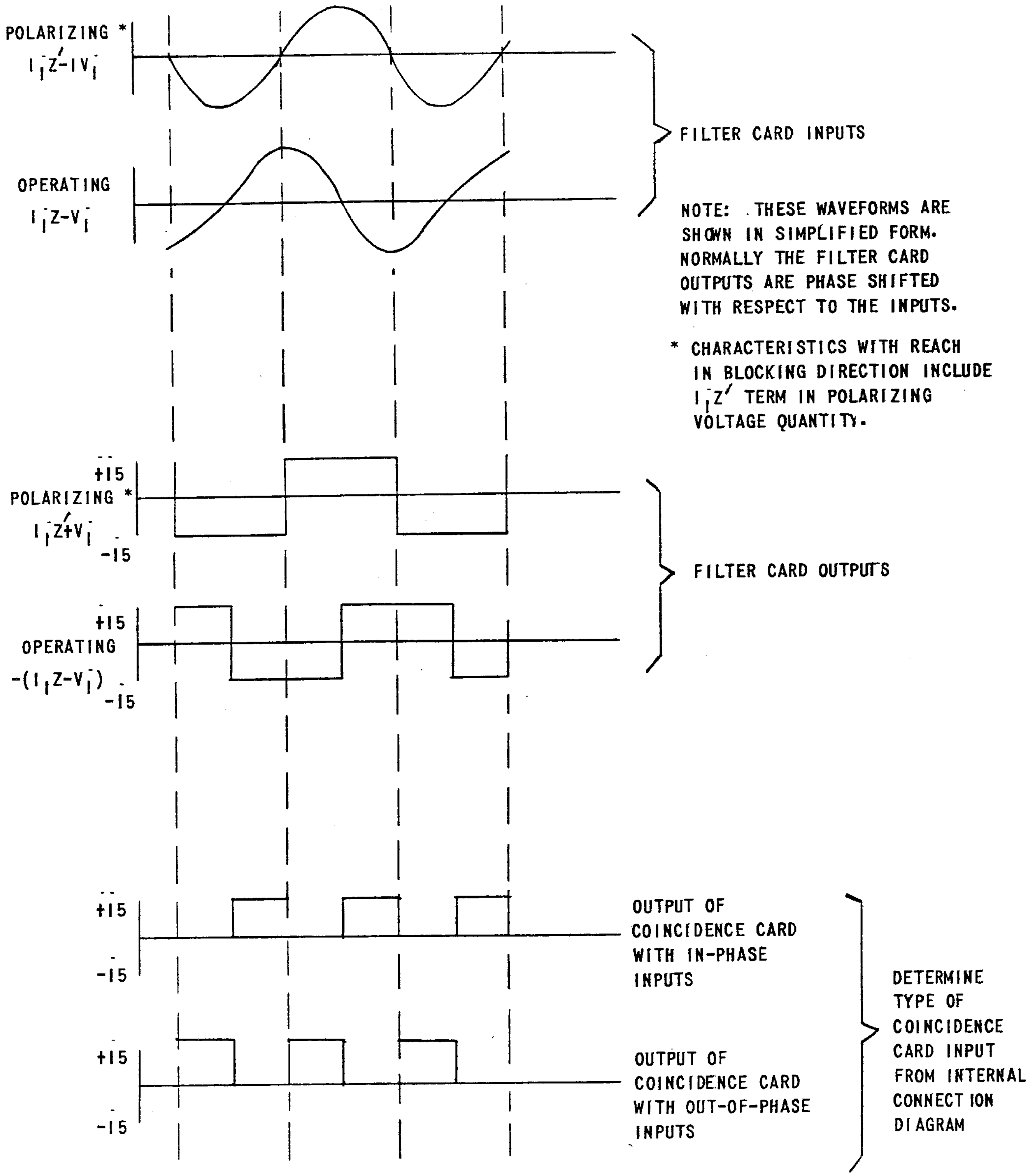
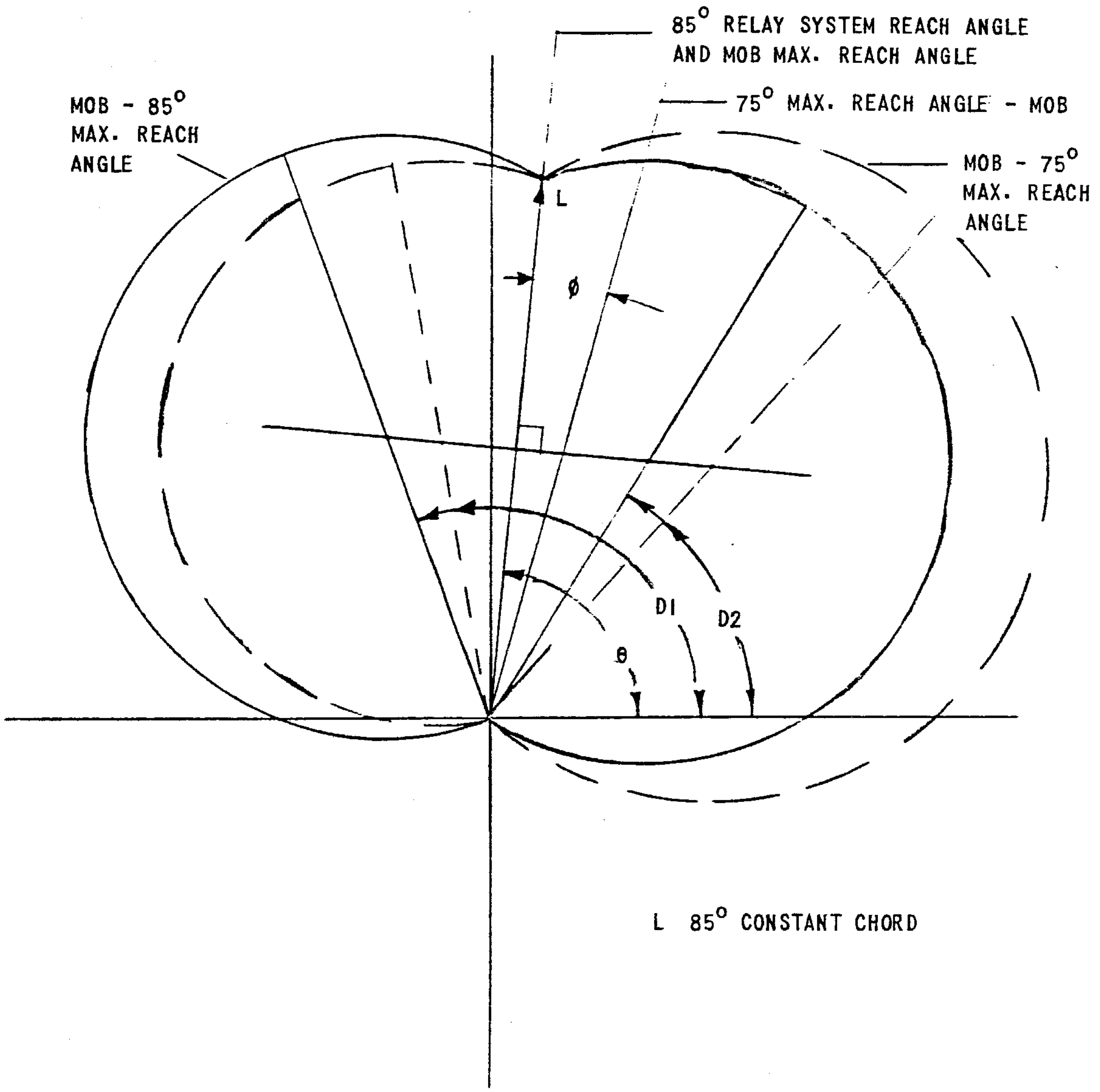


Fig. 6 (0257A6209-0) Typical SLYP Operating Quantity Waveforms



85° MAX REACH ANGLE

t = 3 MS, 60HZ; 3.6MS, 50HZ
$\theta = 64.8°$
$D_1 = 110.2°$
$D_2 = 59.8°$

75° MAX REACH ANGLE

t = 3 MS, 60HZ, MS, 50HZ
$\theta = 64.8°$
$D_1 = 100.2°$
$D_2 = 49.8°$

Fig. 7 (0227A2199-1) MOB Characteristic at 85 Degree and 75 Degree Maximum Reach Angle

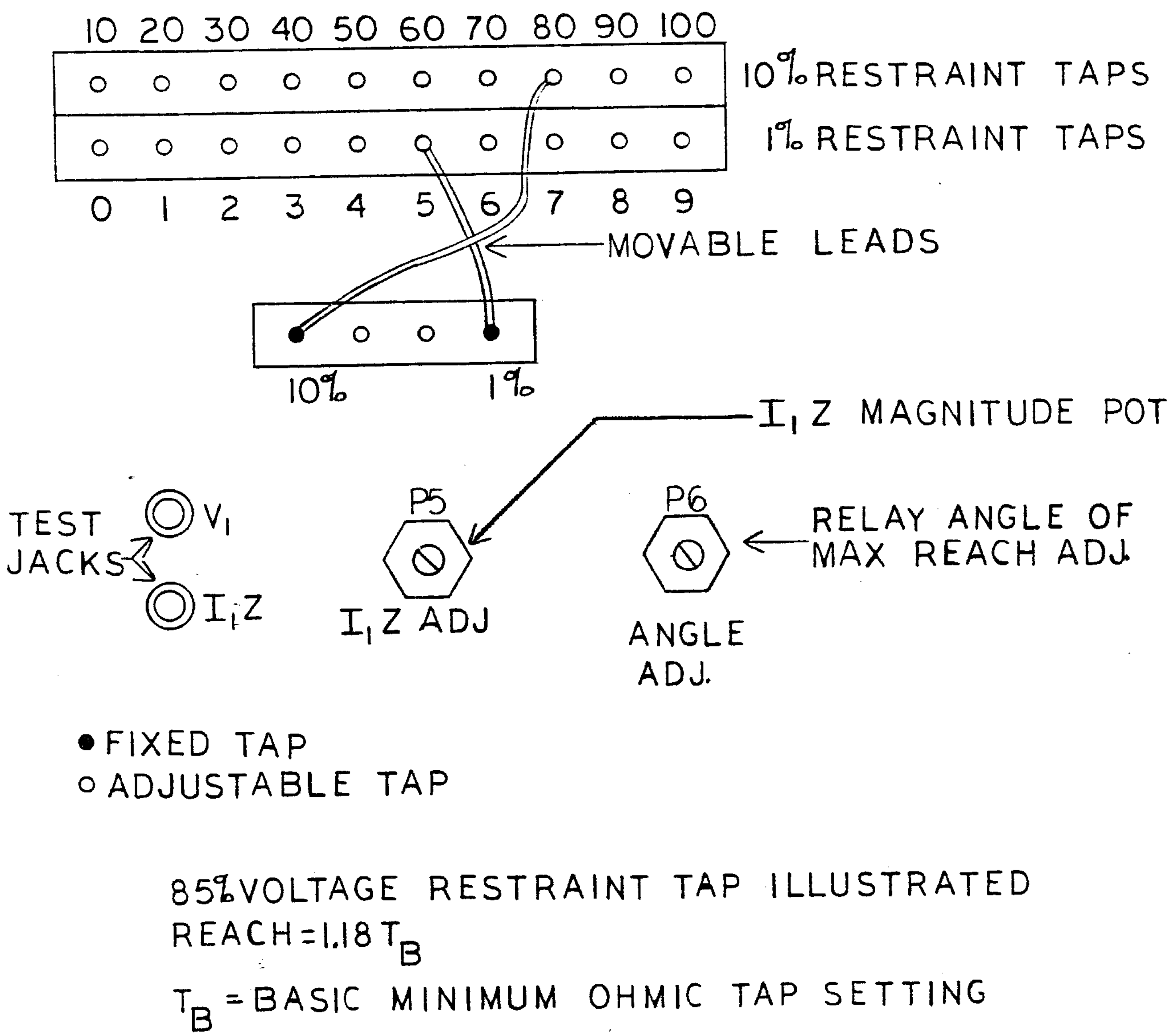
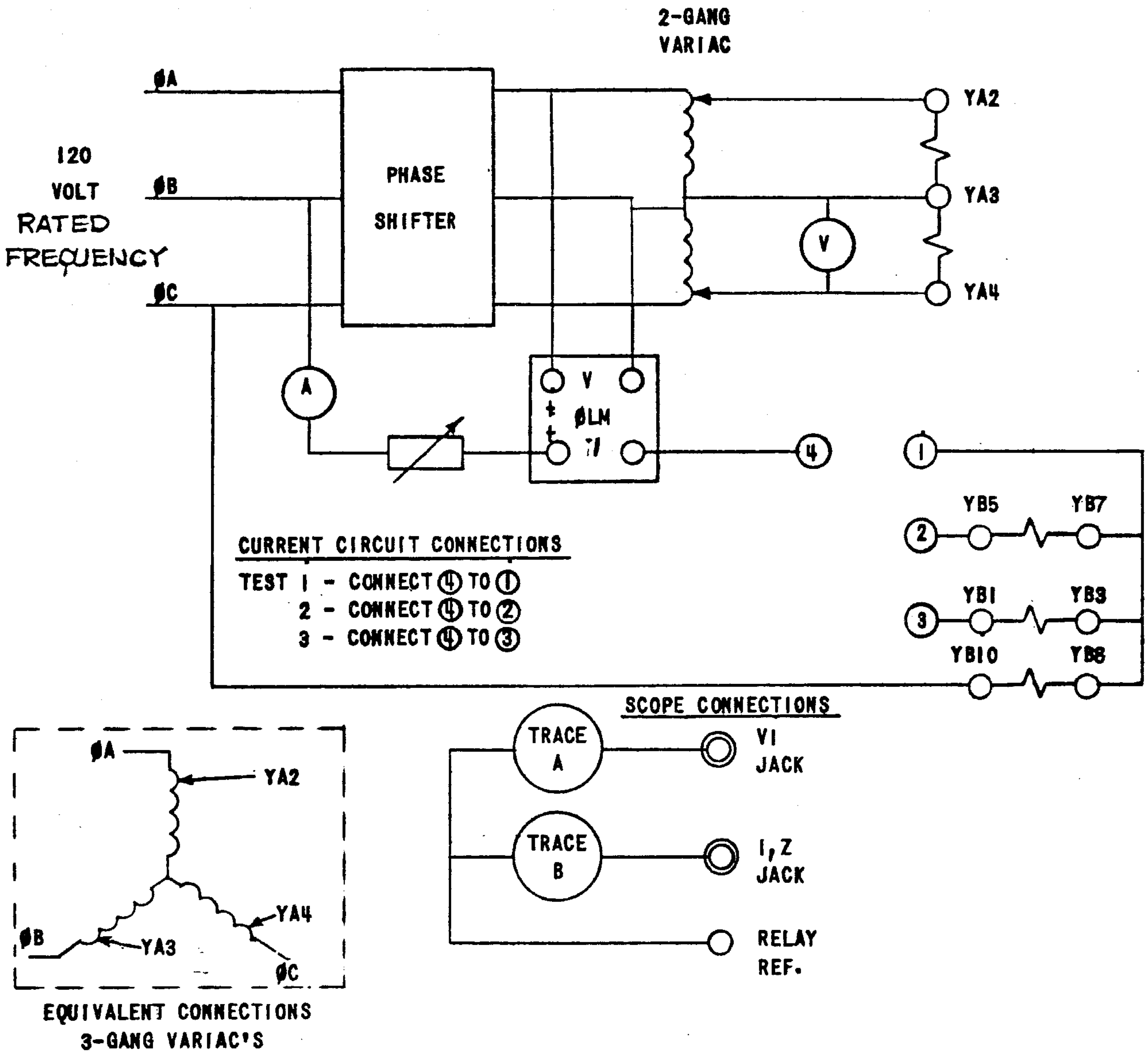


Fig. 8 (0246A6885-1) Typical SLYP Voltage Restraint Tap Settings

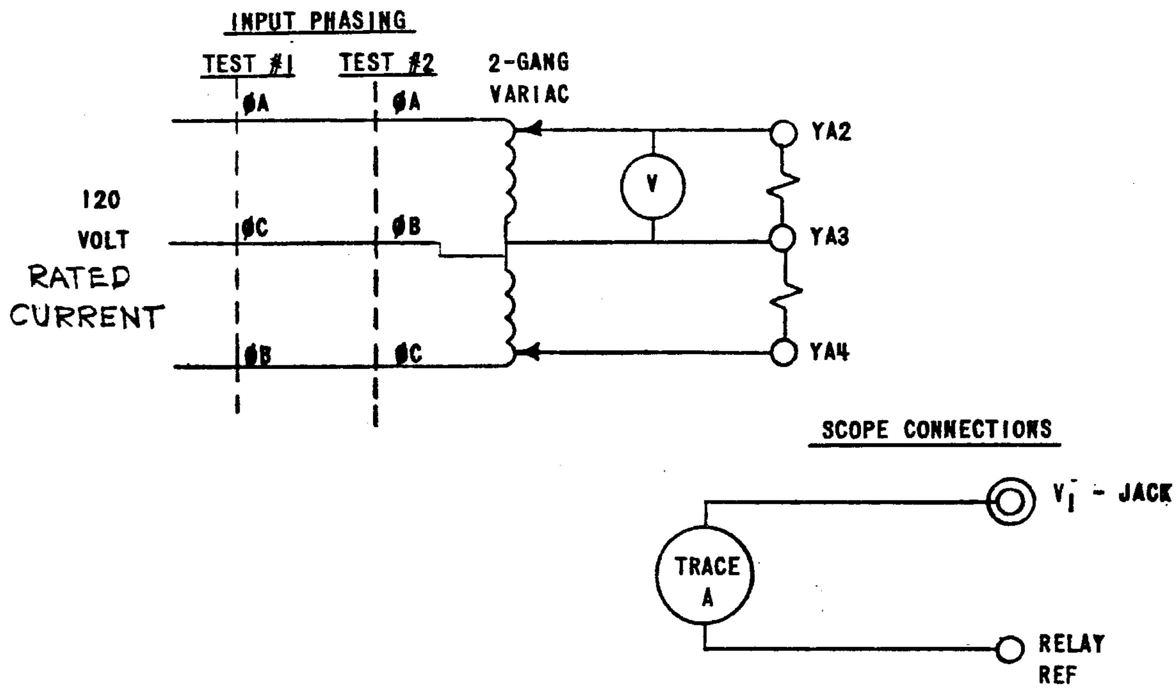


	BALANCED 3Ø RELAY INPUT VOLTS	INPUT AMPS	PHASE ANGLE *	OUTPUT INDICATION	REMARKS **
TEST 1	8.66 VOLT RMS	RATED CURRENT	TEST ANGLE	CHECK $V_I = I_I Z$ (±.05V)	AØ TO GRD. NETWORK CHECK
TEST 2	8.66 VOLT RMS	RATED CURRENT	TEST ANGLE +120°	$V_I \cong 1.2$ VOLTS P-P	BØ TO GRD. NETWORK CHECK
TEST 3	8.66 VOLT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

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

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

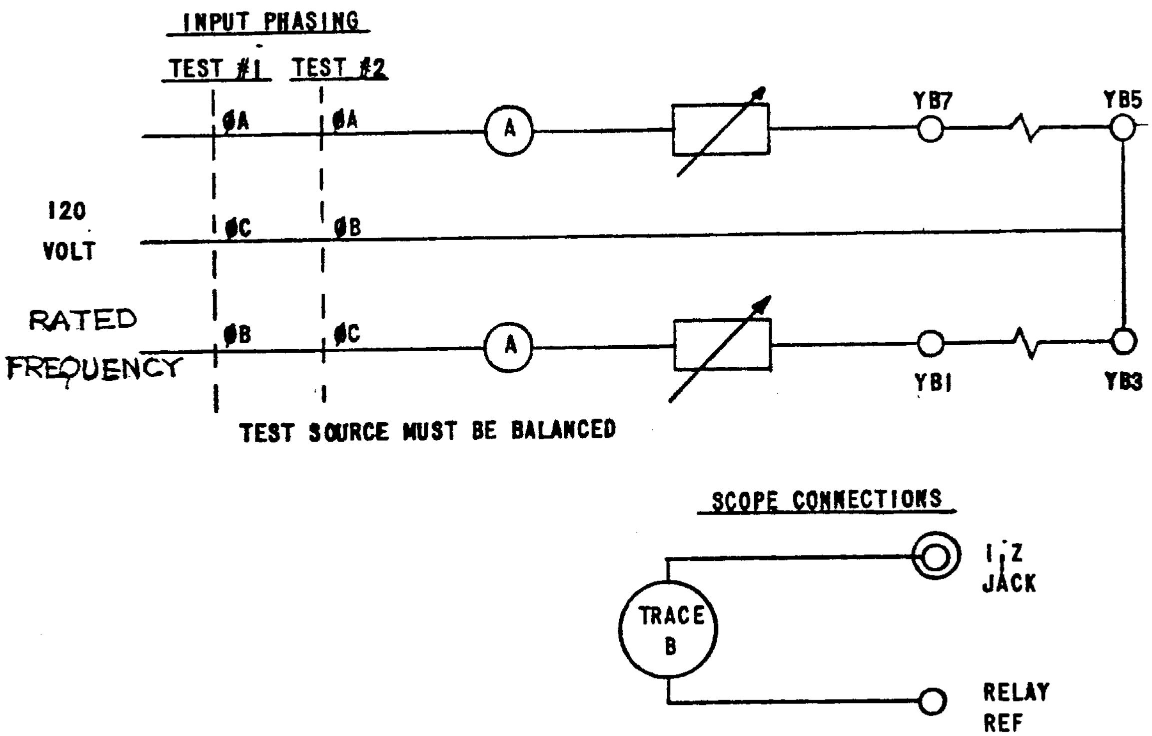
Fig. 9 (0257A6205-2) SLYP Sequence Network Check Test Circuit



TEST	BALANCED 3Ø RELAY INPUT VOLTS	OUTPUT INDICATION	ADJUST	REMARKS *
#1 VI - 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 VI 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

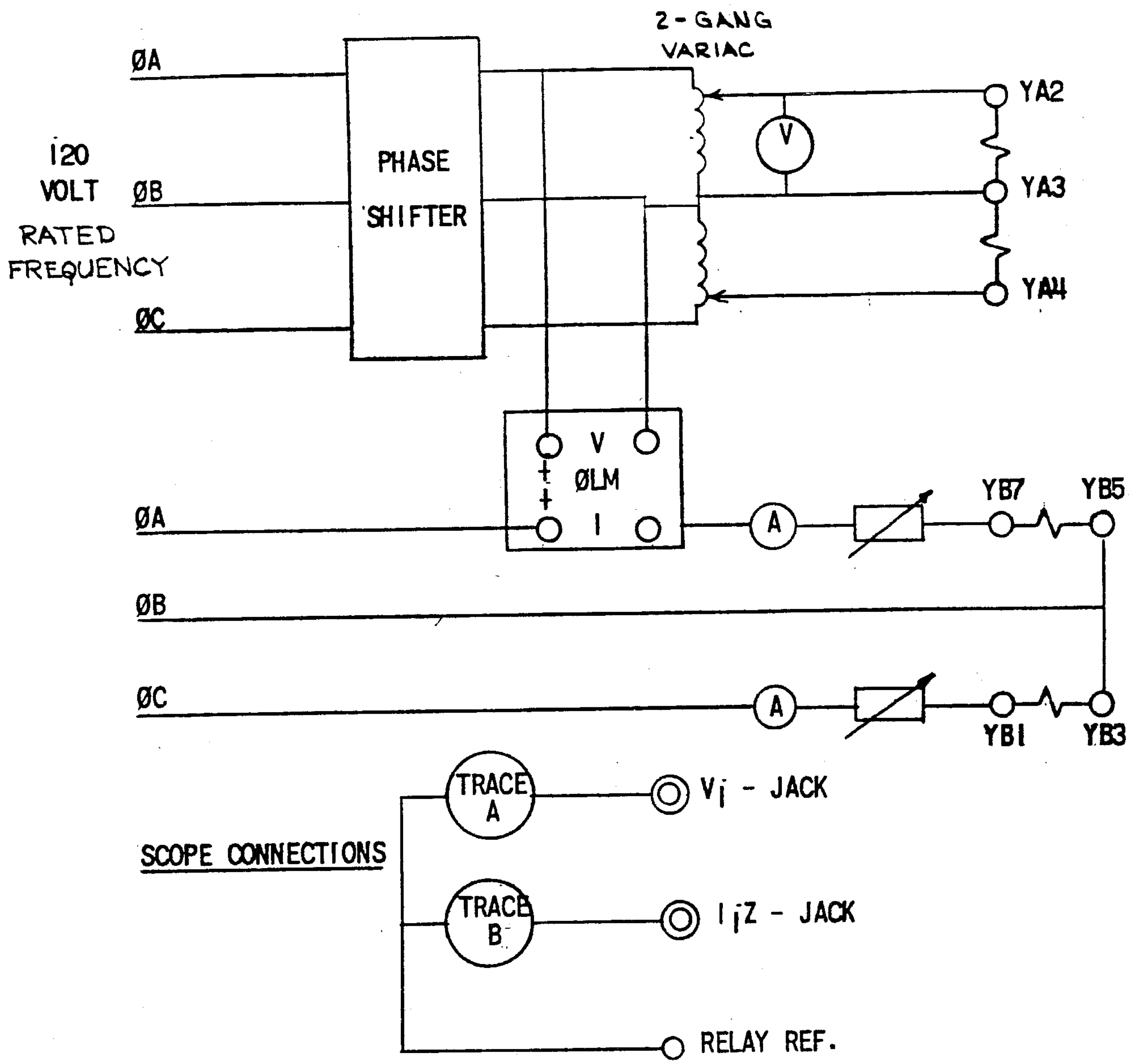
* OBSERVE INPUT PHASING

Fig. 10 (0257A6206-2) SLYP Voltage Sequence Null Test



	INPUT AMPS	OUTPUT INDICATION	ADJUST	REMARKS
TEST #1 I_1Z NULL	RATED CURRENT 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	RATED CURRENT PER PHASE	APPROXIMATELY 3.4 VOLTS P-P	P5 TO OBTAIN VALUE EQUAL TO V_1 OUTPUT	OBSERVE INPUT PHASING

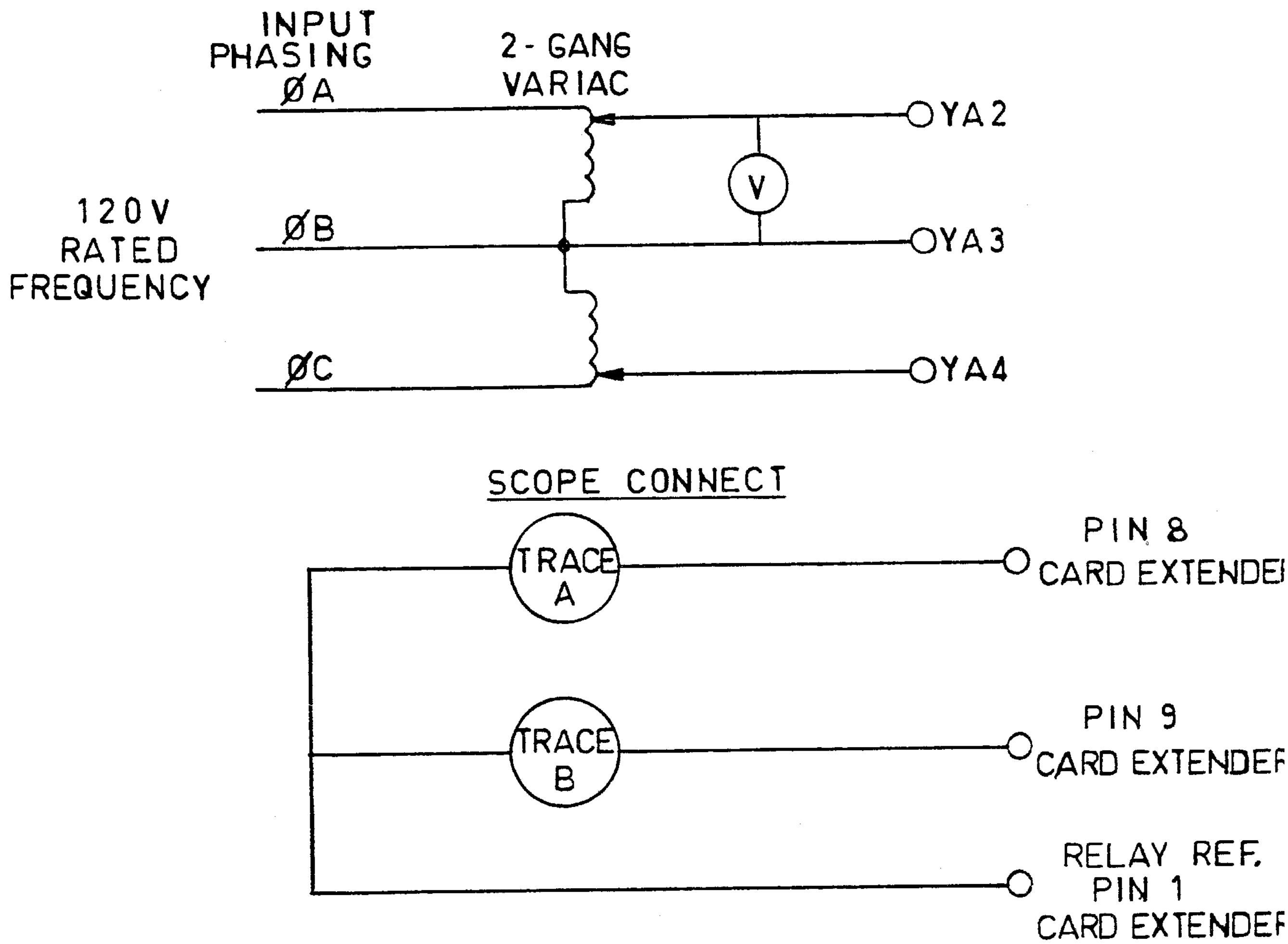
Fig. 11 (0257A6203-1) SLYP Current Sequence Null Test



BALANCED 3Ø RELAY INPUT VOLTS	INPUT AMPS	PHASE ANGLE *	OUTPUT INDICATION	ADJUST	REMARKS
26 VOLTS RMS	RATED CURRENT PER PHASE	TEST ANGLE	V_I & I_IZ EQUAL MAGNITUDE AND IN PHASE (TRACES A & B)	ADJUST P6 TO BRING I_IZ 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. 12 (0257A6211-2) SLYP Angle of Maximum Reach Setting



FUNCTION	CARD LOCATION	BALANCED 3-4 RELAY INPUT VOLTS	SCOPE	OUTPUT INDICATION	ADJ	REMARK
MI	F	120 VOLTS RMS	TRACE A-PIN 8 TRACE B-PIN 9 OF CARD TESTED USE CARD EXTENDER	ADJUST PHASE SHIFT	OPTION L/M AND P-71	CONN. I_1Z JACK TO RELAY REF. (TPI
MT, MOB	G			ADJUST PHASE SHIFT	X PLUG	
MB	H			ADJUST PHASE SHIFT	P-71	

Fig. 13 (0257A9625-1) Filter Card Phase Shift Test Circuit

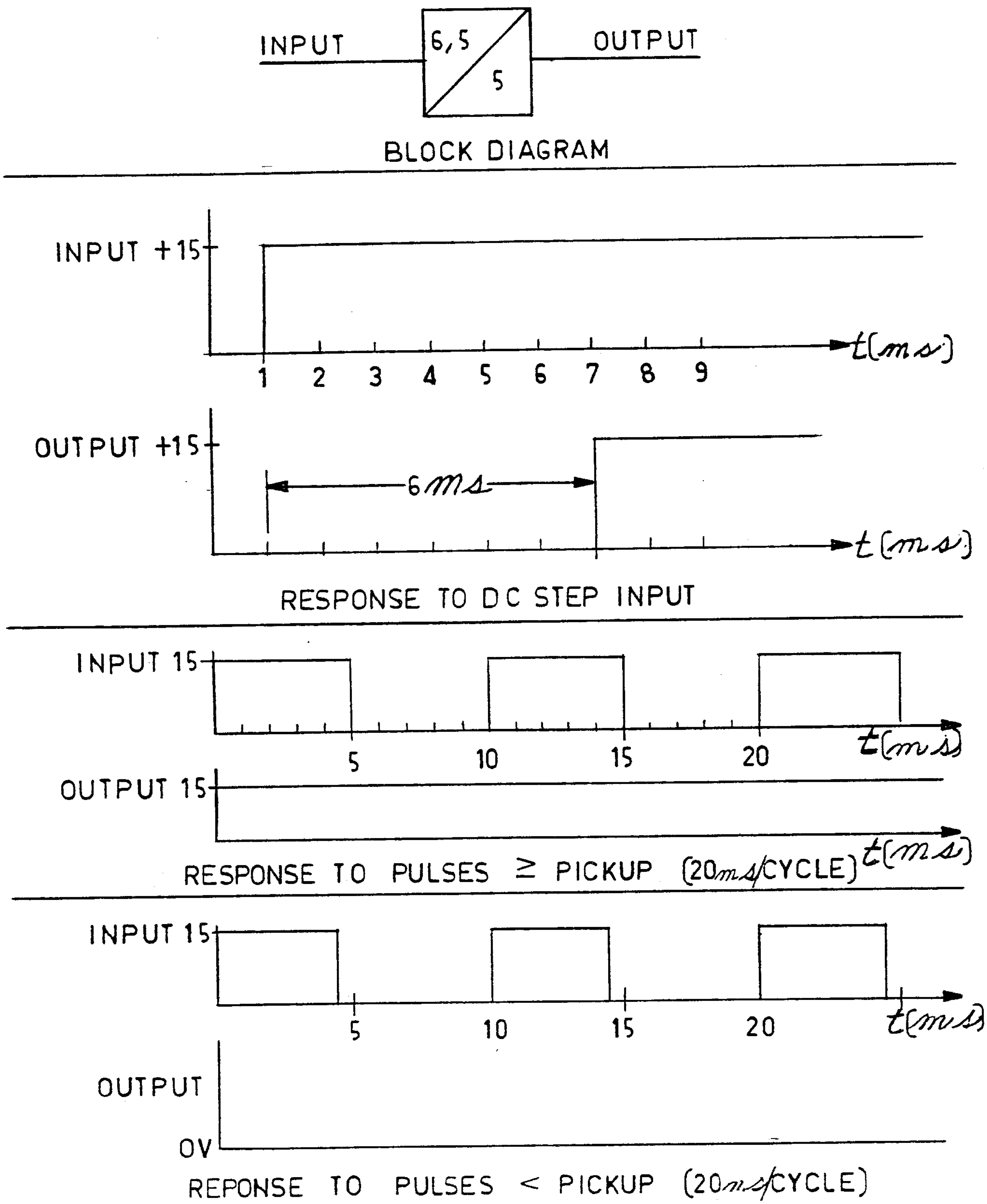
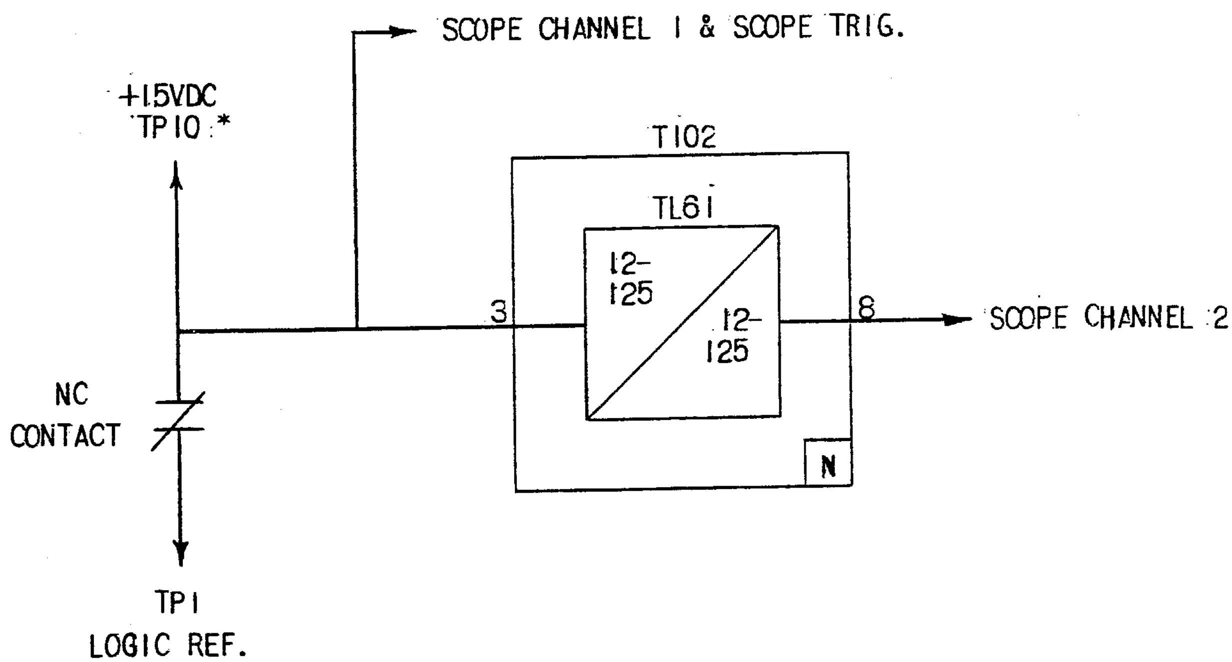


Fig. 14 (0257A9624-0) Integrating Characteristic Timer Pickup Waveforms



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

Fig. 15 (0246A7987-0) Timer Test Circuit

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