STATIC PHASE FIRST ZONE

MHO DISTANCE RELAY

TYPE SLY61A

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.

To the extent required the products described herein meet applicable ANSI, IEEE and NEMA standards; but no such assurance is given with respect to local codes and ordinances because they vary greatly.

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DESCRIPTION

The SLY61A is a first zone, three-phase, static phase-distance relay. The SLY61A is a rack-mounted unit, two rack units high. It requires other fault-detecting relays, an SSA power supply, SLA logic unit(s), SLAT output unit(s), and a test panel, to provide a complete scheme for protection of a transmission line.

APPLICATION

The SLY61A relay utilizes a two-input phase angle comparator for the phase distance measurement. The two inputs for the phase A-B measurement are:

(a) $(I_A - I_B)\ Z_{R1} - T\ V_{AB}$ Operating Quantity

(b) $V_{AB} + KV_{AB1}$ Polarizing Quantity

where: I_A and I_B are the currents in the faulted phases

Z_{R1} is the base reach impedance with a selectable impedance angle of 85^o and 75^o

$T\ V_{AB}$ is the faulted phase-to-phase voltage, multiplied by the restraint tap, T

$V_{AB} + KV_{AB1}$ is the faulted phase-to-phase voltage plus K times the positive sequence component of the faulted phase-to-phase voltage. K is a design constant equal to 0.3 per unit.

The use of the positive sequence component of voltage in the polarizing signal results in a relay characteristic of the "variable mho" type; that is, the characteristic expands as the source impedance behind the relay increases, providing an automatic accommodation of arc impedance. The positive sequence component of voltage in the polarizing signal also improves the directional integrity of the distance measurement.

The SLY61A has an adjustable characteristic, which is adjusted by means of the timer setting on the characteristic timer. For short lines, a circular characteristic is recommended, but for longer lines, lines with unusually heavy load transfer, or three-terminal lines where very large reach settings are required, a lens-shaped characteristic is recommended.

RATINGS

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

Forms of the SLY61A are available for either 50 Hz or 60 Hz applications.

Forms of this relay are available with current circuits rated for either 5 amperes or 1 ampere for continuous duty, with a 1 second rating of 300 or 60 amperes respectively.

The potential circuits are rated for 120 volts.

The relay requires a +15 VDC power source, which may be obtained from Type SSA power supplies.

Refer to the unit nameplate for the frequency and current ratings for a particular relay.

RANGES

The SLY61A relay has an adjustable reach of 0.1 to 30 ohms for the 5-ampere-rated relay or 0.5 to 150 ohms for the 1-ampere-rated relay.

Current input connections to establish the basic ohmic tap of 1 and 3 ohms line-to-neutral (5-ampere relay) or 5 and 15 ohms (1-ampere relay) are available at the current-input terminals. Restraint taps in the voltage circuit range between 10% and 100% in 1% increments. In addition to the current input taps, the relay has a selectable base reach multiplier of 1.0, 0.5, 0.2 or 0.1 per unit.

The relay has a base reach angle which can be adjusted for 85° or 75°.

The polarizing voltage has an adjustable phase shift relative to the operating quantity of 0° or 15° lead.

BURDENS

The maximum potential burden per phase, measured at 120 VRMS is:

60 Hz Relay	50 Hz Relay	
0.35	0.45	Volt-ampere
0.28	0.34	Watt
0.20	0.29	Var

The maximum phase current burden per phase is:

5 Ampere Relay 1 or 3 Ohm Tap	1 Ampere Relay 5 or 15 Ohm Tap	
Z: 0.026 $\angle$ 7.3°	Z: 0.117 $\angle$ 1.6°	Ohm
R: 0.025	R: 0.117	Ohm
X: 0.003	X: 0.003	Ohm

The maximum burdens that the logic circuits present to the power supply are:

0.215	Ampere to the +15 VDC supply
0.119	Ampere to the -15 VDC supply

SENSITIVITY

Sensitivity is defined as the steady-state rms voltage or current, measured at the relay terminals, required for a particular quantity to cause the relay to operate, if all input quantities are in the optimal phase relationship. The nominal sensitivities for the signal quantities in the SLY61A relay are as follows:

OPERATING CIRCUIT SENSITIVITY

For phase pair A-B, the current sensitivity can be determined from the relationship:

$$(I_A - I_B)\, Z_{R1} = \frac{0.20}{1-X}$$

$$\text{where } X = \frac{\text{Actual Relay Reach}}{\text{Nominal Relay Reach}}$$

For example, if Z_{R1} = 3 ohms and X = 0.9, then $(I_A - I_B)$ = 0.67 ampere

For a phase-to-phase fault, $I_A = (I_A - I_B)/2$, or 0.33 ampere. For a three-phase fault, $I_A = (I_A - I_B)/\sqrt{3}$, or 0.38 ampere.

POLARIZING CIRCUIT SENSITIVITY

Sensitivity is 1% of rated voltage.

OPERATING PRINCIPLES AND CHARACTERISTICS

GENERAL

The mho characteristic is obtained by converting relay currents into voltage signals (IZ), combining these IZ signals with signals proportional to the line voltage (V), and measuring the angle between the appropriate combinations to obtain the desired characteristic.

Currents are converted into IZ signals by means of transactors (TE, TG and TJ), which are air-gap reactors with secondary windings. The transactors are tapped on the primary to provide the basic ohmic tap selection of 1 or 3 ohms (5-ampere rating) and 5 or 15 ohms (1-ampere rating).

The Z of the IZ quantity is the transfer impedance of the transactor, and is equal to V_{OUT}/I_{IN}. The transactor secondaries have loading resistors across them. These resistors provide the desired angle between V_{OUT} and I_{IN}. This angle determines the base reach angle of the relay.

The mho distance characteristic is obtained by comparing the phase angle between the quantities (IZ-TV) and V_{pol}, where V is the phase-to-phase voltage at the relay, V_{pol} is the polarizing voltage, I is the phase current, Z is the relay base reach, and T is the voltage-restraint tap. For a circular characteristic, relay operation occurs when the angle between (IZ-TV) and V_{pol} is less than or equal to 90°.

RELAY REACH

The base reach of the relay (Z_{R1}) is determined by the Basic Ohmic Cap (BOT) and the Base Reach Multiplier Tap (BRM). The base reach is equal to the product of the basic ohmic tap and the base reach multiplier tap:

$$Z_{R1} = (BOT) \times (BRM) \qquad \text{(Equation 1)}$$

The reach of the M1 function at the base reach angle is given by the expression:

$$Z_R = \frac{Z_{R1} \times 100}{T} \qquad \text{(Equation 2)}$$

or

$$Z_R = \frac{BOT \times BRM \times 100}{T} \qquad \text{(Equation 3)}$$

where:

Z_R	is the reach at the base reach angle in line-to-neutral ohms
T	is the voltage restraint tap setting in %
BOT	is the basic ohmic tap in line-to-neutral ohms
BRM	is the base reach multiplier in per unit
Z_{R1}	is the base reach of the relay in line-to-neutral ohms, as defined in equation 1.

The reach of the relay is inversely proportional to the voltage restraint tap setting. The maximum reach of the relay (30 or 150 ohms depending upon the relay rating) is obtained with the suggested minimum restraint tap setting of 10%.

ANGLE OF MAXIMUM REACH

The relay base reach angle is adjustable by means of links on the rear of the unit. The base reach angle can be set for either 85° or 75°. The polarizing quantity used to develop the mho characteristic can be phase shifted relative to the operating quantity. The phase shift can be set for either 0° or 15° lead. The 15° setting results in a clockwise shift in the angle of maximum reach away from the base reach angle. The angle of maximum reach is equal to the base reach angle minus the polarizing phase shift. The 15° setting increases the reach at the relay angle of maximum reach by the factor (1/cos (15°), which is equal to 1.035.

PHASE ANGLE MEASUREMENT

The quantities IZ, -TV, and V_{pol} are supplied to a summing amplifier-filter card. This card sums IZ and -TV and filters extraneous frequencies from the quantities (IZ-TV) and V_{pol}. Each of the resulting signals is then amplified to produce two square wave outputs. The square waves are applied to a coincidence logic circuit, which establishes the coincidence of the same instantaneous polarity of the square waves. The output of the coincidence logic is a rectangular pulse with a duration that is proportional to the phase angle between (IZ-TV) and V_{pol}.

The coincidence logic output is applied to a timing circuit, which produces an output whenever the pulse width exceeds a preset duration. If the timer is set for 90^o (4.17 milliseconds on a 60 Hz base, 5.0 milliseconds on a 50 Hz base) a circular R-X characteristic is obtained. If the timer is set for less than 90^o, an expanded circle (tomato shaped) characteristic is obtained. If the timer is set for more than 90^o, a contracted circle (lens shaped) characteristic is obtained.

CALCULATION AND CHOICE OF SETTINGS

Assume that the line to be protected is approximately 70 miles long and has primary impedances as follows:

$$Z'_1 = 42 \angle 83^o$$

Assume that the current transformer (CT) ratio is 1000/5 and potential transformer (PT) ratio is 2000/1.

$$Z'_1 \text{ sec} = 42 \left(\frac{1000}{5}\right) \left(\frac{1}{2000}\right) = 4.2 \angle 83^o$$

For short-to-medium length lines, that is, lines less than 100 miles long, the SLY61A relay is set as follows:

a) The base reach angle is selected based on the positive sequence impedance angle of the line; for line angles above 80^o select the 85^o base reach angle tap. For line angles 80^o and below, select the 75^o base reach angle tap. For the sample line, select the 85^o tap.

b) The suggested relay reach (Z_R) for positive sequence line angles of 65^o and above is 90% of the positive sequence line impedance. For lines angles below 65^o, refer to the local General Electric Company Sales Office for suggested settings. The base reach tap (Z_{R1}) is typically selected to be as large as possible, but still less than the relay reach (Z_R). This gives the maximum current sensitivity. The base reach tap (Z_{R1}) is the product of two factors: the basic ohmic tap (BOT) and the base reach multiplier (BRM). The basic ohmic taps available are 1 ohm and 3 ohms; the base reach multiplier taps are 0.1, 0.2, 0.5 and 1.0. The available base reach settings are given in the following table.

Z_{R1}	BOT	BRM
0.1	1	0.1
0.2	1	0.2
0.3	3	0.1
0.5	1	0.5
0.6	3	0.2
1.0	1	1.0
1.5	3	0.5
3.0	3	1.0

For the sample line, the suggested relay reach setting, Z_R, is 0.90 (Z_{1L}) or 0.90(4.2) or Z_R = 3.78 ohms. The suggested base reach (Z_{R1}) is 3 ohms. This results from a BOT of 3 ohms and a BRM of 1.0.

c) After Z_{R1} has been selected, T, the restraint tap setting, can be calculated in accordance with the formula

$$Z_R = \frac{Z_{R1}}{T} \times 100, \text{ or } T = \frac{Z_{R1}}{Z_R} \times 100$$

For the sample line, $T = \frac{3}{3.78} \times 100 = 79\%$

d) The phase shift tap is typically set on the 0^o tap for normal applications involving lines less than 100 miles long.

e) For lines less than 100 miles long, the characteristic timer setting is typically the factory setting, namely 120^o, $90^o/110^o$. For 60 Hz applications, this is approximately 5.5, 4.2/5 milliseconds, and for 50 Hz, 6.6, 5/6 milliseconds.

Longer lines, such as those over 100 miles, and particularly those with heavy load transfer, may require modification of the settings for optimum performance. Refer to the nearest GE Sales Office for suggested setting modifications.

CONSTRUCTION

The type SLY61A relay is packaged in a metal enclosure designed for mounting on a 19 inch rack. The relay is two rack units high (1 ru = 1-3/4 inches). The outline and mounting dimensions are shown in Figure 1. The relay contains the magnetics and tap blocks for setting the base reach and the percent restraint. It also contains the printed circuit cards for developing three mho characteristics. The relay has a hinged front cover and a removable top cover.

The setting of the basic ohmic tap is accomplished by the connection of the input currents to the YA terminal board on the rear of the relay. The connection points for the basic ohmic taps are shown in the table on the internal connection diagram of Figure 2.

The voltage restraint tap blocks are located on the front of the unit, at the left-hand side. Refer to the component location diagrams of Figure 3. The voltage restraint tap settings are made by jumpers with taper-tip pins on the end. In the accessory kit accompanying each equipment there are two special tools supplied for use with these pins. One is an insertion tool, and the other is an extraction tool. **In order to achieve a proper connection and to prevent damage to the pins, it is essential that these tools be used.** Two tap blocks are used per phase: one is for the 10% tap and one is for the 1% tap. The voltage restraint tap setting is the sum of the 1% and the 10% settings.

The relay also contains printed circuit cards, which are located to the right of the tap blocks. The printed circuit cards are identified by a code number, such as F125, C106, T133 or P102, where F designates filter, C designates coincidence, T designates time delay, and P designates processing. 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.

RECEIVING, HANDLING AND STORAGE

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

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

Just prior to final installation, the shipping support bolt should be removed from each side of all relay units, to facilitate possible future unit removal for maintenance. These shipping support bolts are approximately 8 inches back from the relay 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 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. It is a good test procedure to connect the reference lead of a test instrument to relay reference before connecting the signal lead.

GENERAL

The test points (TP1, TP2, etc.) shown on the internal connection diagram are connected to instrument test jacks on a test card in card location T. TP1 is located at the top of the card, and is connected to relay reference. TP10 is located at the bottom of the card, and is connected to +15 VDC. Output signals are measured with respect to the relay reference (TP1). Logic signals are approximately +15 VDC for the ON or LOGIC ONE condition, and between 0 and +1 VDC for the OFF or LOGIC ZERO condition. Filter card outputs are square waves, which shift from +15V to -15V.

Any of the input/output pins on the printed circuit boards can be monitored by using the test card adapter, as described in the printed circuit card instruction book, GEK-34158. The logic signals can be monitored with an oscilloscope, a portable high-impedance voltmeter, or the voltmeter on the equipment test panel. When the test panel meter is supplied, it will normally be connected to relay reference. Placing the test lead to the proper test point 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.

The relay contains printed circuit cards with trimmer potentiometers mounted on them. Some of these potentiometers are factory set and sealed. These potentiometers should **not** be readjusted.

Before testing the relay, the trip outputs from the associated type SLAT relay should be opened, to prevent inadvertent tripping of the breakers.

Input currents and voltages may be supplied to the relay through Type XLA test plugs placed in the test receptacles on the equipment test panel. Reference to the elementary diagram for the static relay equipment will provide information concerning equipment inputs. All units of a given terminal have been calibrated together at the factory, and will have the same summary number on the unit nameplates. These units should be tested and used together.

NECESSARY ADJUSTMENTS

The following checks and adjustments should be made by the user in accordance with the procedures given under **DETAILED TESTING INSTRUCTIONS** before the relay is put into service. The necessary set points may be calculated following the procedures under **CALCULATION AND CHOICE OF SETTINGS.** The adjustments should be made in the order shown.

1. Base reach setting (Z_{R1})
   a) Basic ohmic tap selection (BOT)
   b) Base Reach multiplier selection (BRM)
2. Voltage restraint tap setting (T)
3. Angle of maximum reach setting
   a) Base reach angle
   b) Polarizing voltage phase shift
4. Characteristic timer setting
5. Overall check of the M1 function

DETAILED TESTING INSTRUCTIONS

BASE REACH SETTING

The basic ohmic tap (BOT) is determined by the terminals through which the relay input currents are connected to the unit. The correct input terminals for the various taps are given in Table I.

TABLE I

CURRENT TAP	I_A		IB		IC	
	IN	OUT	IN	OUT	IN	OUT
1 or 5 ohm	YA4	YB8	YA6	YB9	YA8	YB10
3 or 15 ohm	YA3	YB8	YA5	YB9	YA7	YB10

The base reach multiplier selector is located on the card in location E. The adjustment is accomplished by a four-position jumper block. In each position, the gain of the IZ circuit for each phase is set to the proper value of base reach multiplier. The base reach multiplier for each jumper position on the card is shown in Table II. The relay base reach is given by equation 1.

TABLE II

Jumper Position	Base Reach Multiplier (BRM)
B	1.0
C	0.5
D	0.2
E	0.1

VOLTAGE RESTRAINT TAP SETTING

The voltage restraint tap setting (T) is accomplished on tap blocks located on the front of the relay. Two separate tap blocks are provided for each phase pair. The setting consists of a 10% tap and a 1% tap. A restraint tap setting of 57% would consist of a 10% setting of 50 and a 1% setting of 7. **Only the special tools supplied with the relay should be used to change the tap setting.**

ANGLE OF MAXIMUM REACH SETTING

The base reach angle is adjusted by means of links on the rear of the relay. The angle can be set for 75^{o} or 85^{o}.

In order to set the polarizing voltage phase shift, it is necessary to adjust the X option plug on the filter cards in card locations H, J and K. The setting must be made on each of the three cards. The polarizing voltage phase shift for each position is shown in Table III.

TABLE III

Plug X Shorting Arrangement	Degrees of Leading Phase Shift
2 to 3 and 4 to 5	0
1 to 2 and 3 to 4	15

The polarizing phase shift may be checked and, if necessary, adjusted by using the test circuit of Figure 4 and the appropriate connections of Table IV. Note that only voltage is applied to the relay for this test. The following procedure is recommended:

1. Start with the phase A-B connections of Table IV. Set the voltage restraint tap for 100%. Adjust the voltage for 30 VRMS.

TABLE IV

Phase Pair	Figure 4 Connections A	Figure 4 Connections B	Figure 4 Connections Jumper Points	Filter Card Location
A-B	YB2, YB7	YB3, YB4	YB5 to YB6	H
B-C	YB4, YB3	YB5, YB6	YB2 to YB7	J
C-A	YB6, YB5	YB7, YB2	YB3 to YB4	K

2. Observe the output at pins 8 and 9 of the filter card in location H for phase A-B. The following phase angle measurements should be made, using a dual-trace oscilloscope with a calibrated sweep sufficiently fast to provide an accurate measurement, and with both traces carefully zeroed on the center line. Refer to Figure 5 for sample waveforms.

3.a) Zero Degree Polarizing Phase Shift

The square waves at pins 8 and 9 of the filter card should be exactly 180° out of phase, i.e., the zero crossings of each trace should coincide at the center line and the traces should have opposite slopes. The phase shift between pin 8 and pin 9 may be adjusted by potentiometer P71 on the filter card.

3.b) Fifteen Degree Polarizing Phase Shift

The square wave at pin 9 is now shifted 15° in the leading direction (toward the left-hand edge of the screen). The zero crossings of the square waves should now occur 15° apart. (0.694 milliseconds on a 60 Hz base, 0.833 milliseconds on a 50 Hz base). Refer to Figure 5. The phase shift between pins 8 and 9 may be adjusted by potentiometer P71 on the filter card.

4. Repeat steps 1, 2, and 3 for phase pairs B-C and C-A. Observe the outputs of the filter card associated with the phase pair under test. Use the appropriate connections from Table IV.

CHARACTERISTIC TIMER SETTINGS

The pickup settings of the characteristic timer affect the shape of the M1 characteristic as plotted on an R-X diagram. Increasing the pickup time narrows the characteristic, decreasing the pickup time widens the characteristic. The reset time delay (dropout time) provides an overlap of the next half cycle measurement. The inputs to the characteristic timers are chains of pulses (one per half cycle) from the coincidence logic cards. The outputs of the timers are DC logic signals. The timer settings are discussed in the section **CHOICE AND CALCULATION OF SETTINGS.**

The timers used for the M1 function are integrating characteristic timers. These timers are typically listed on the overall logic as T1, T2/T3, where T1 is the pickup time in milliseconds on a step DC input, T2 is the pulse width that will cause the timer to pick up with one pulse applied per half cycle, and T3 is the dropout delay. The operation of the integrating characteristic timers is dicussed in the printed circuit card intruction book, GEK-34518.

The DC pickup (T1) and the dropout (T3) of the M1 characteristic timer may be set using the test circuit of Figure 6. Before testing the timer with this circuit, the card that normally supplies the input to the timer must be removed (refer to Table V). Opening the normally-closed contact of Figure 6 causes the output to step to +15 VDC 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 to drop out (step to less than 1 VDC) after the reset delay setting of the card. To increase the reset delay, turn the second potentiometer (P2) clockwise. The pulse pickup (T2) mode of the timer may be observed while plotting the characteristic as described in **OVERALL CHECK OF THE M1 CHARACTERISTIC.** The applied voltage and current, as well as the phase angle between them, can be adjusted to vary the pulse width of the timer input. Pulse pickup (steady-state pickup) is adjusted with the third potentiometer (P3). To increase the pulse pickup delay, turn the third potentiometer (P3) clockwise.

TABLE V

Phase	Timer Under Test	Remove Card
A	P	L
B	R	M
C	S	N

OVERALL CHECK OF THE M1 FUNCTION

The test circuit of Figure 4 should be used to check the operation of the M1 function. Use the connections of Table VI for the 1 ohm or 5 ohm basic ohmic tap or Table VII for the 3 ohm or 15 ohm basic ohmic tap.

TABLE VI

Phase Pair	Figure 4 connection - 1 or 5 ohm Tap						
	A	B	C	D	E	F	Jumper Points
A-B	YB2, YB7	YB3, YB4	YA4	YB8	YB9	YA6	YB5 to YB6
B-C	YB4, YB3	YB5, YB6	YA6	YB9	YB10	YA8	YB2 to YB7
C-A	YB6, YB5	YB7, YB2	YA8	YB10	YB8	YA4	YB3 to YB4

TABLE VII

Phase Pair	Figure 4 connection - 3 or 15 ohm Tap						
	A	B	C	D	E	F	Jumper Points
A-B	YB2, YB7	YB3, YB4	YA3	YB8	YB9	YA5	YB5 to YB6
B-C	YB4, YB3	YB5, YB6	YA5	YB9	YB10	YA7	YB2 to YB7
C-A	YB6, YB5	YB7, YB2	YA7	YB10	YB8	YA3	YB3 to YB4

Relay Base Reach Angle and Reach Check

The following procedure is recommended to check the base reach angle (A) and the relay reach setting.

1) Use the test circuit of Figure 4, starting with the phase A-B connections from Table VI or VII.

Set the test current for a current equal to or greater than that specified in Table VIII.
Currents greater than twice rated should not be continuously applied to the relay.
Currents greater than four times rated should not be applied to the relay. Currents between two and four times rated should not be applied longer than 5 minutes, and should be interrupted by an off time of at least 5 minutes.

TABLE VIII

Base Reach Ohms	Recommended Minimum Test Current (Amp) for Less than 2% Pull Back	
	5 Ampere Relay	1 Ampere Relay
3.0	2	0.4
1.5	5	1.0
1.0	5	1.0
0.6	10	2.0
0.5	10	2.0
0.3	20	4.0
0.2	20**	4.0**
0.1	20**	4.0**

** Less than 5% pull back

2) Adjust the phase angle for the nominal base reach angle (75^o or 85^o)

3) Observe the output at pin 8 of the appropriate filter card (card location H for phase pair A-B, J for B-C, or K for C-A)

4) Lower the voltage to the value given by the following expression:

$$V_T = 2 \times I_T \times BOT \times BRM \times \frac{100}{T} \qquad \text{(Equation 4)}$$

where: BOT is the basic ohmic tap
BRM is the base reach multiplier
I_T is the test current
T is the voltage restraint tap setting in %
V_T is the pickup voltage at the base reach angle

5) As the voltage is lowered, observe the output of the M1 function: TP5 for phase pair A-B, TP7 for B-C, and TP9 for C-A. At the point where M1 picks up, a slight adjustment of the phase angle and voltage should cause the square wave at pin 8 of the filter card to come out of saturation. A further adjustment will cause the signal at pin 8 to be reduced to a null voltage consisting of only third and fifth harmonics. The angle on the phase angle meter is the base reach angle, and should be with 2^o of nominal setting. The voltage should be within 5% of the value given by equation 4.

6) A vernier adjustment on the reach is provided on the filter card (position H, J, and K). Turning P10 on the appropriate filter card clockwise increases the voltage required to null the M1 function, thereby increasing the relay reach.

7) Repeat Steps 1 through 6 for phase pairs B-C and C-A, using the connections from Table VI or VII.

Complete M1 Function Check

The following procedure is recommended to provide an overall check of all the adjustments included in the M1 function. It is only necessary to check the relay reach at two angles other than the base reach angle.

1) Use the test circuit of Figure 4. Start with the A-B phase pair connections from Table VI or VII. Set the current for desired current (Table VIII). Monitor the output at TP5 for phase pair A-B, TP7 for B-C, or TP9 for C-A.

2A) Pickup for angles less than or equal to the base reach angle.

a) Adjust the phase shifter to obtain a phase angle 30° less than the base reach angle.

b) Lower the applied voltage and check for an M1 output within 5% of the voltage given by the expression:

$$V_D = V_T \times \frac{\text{SIN } (D - A + B + 180 - C)}{\text{SIN } (B + 180 - C)} \qquad \text{(Equation 5)}$$

where: V_T is the pickup voltage at the base reach angle given by Equation 4
A is the base reach angle in degrees
B is the polarizing voltage phase shift setting in degrees
C is the characteristic timer setting in degrees. For 50 Hz relays, multiply the timer setting in milliseconds by 18 to obtain degrees; for 60 Hz relays multiply by 21.6
D is the phase angle meter reading (voltage leading current)

2B) Pickup for angles greater than the base reach angle.

a) Adjust the phase shifter to obtain a phase angle 30° greater than the base reach angle.

b) Lower the applied voltage and check for an M1 output within 5% of the voltage given by the expression:

$$V_D = V_T \times \frac{\text{SIN } (D - A + B + C)}{\text{SIN } (B + C)} \qquad \text{(Equation 6)}$$

PERIODIC CHECKS AND ROUTINE MAINTENANCE

The M1 functions included in the relay may be checked at periodic intervals using the procedures described under OVERALL CHECK OF THE M1 FUNCTION. By checking the reach of each unit at the base reach angle, and one angle either side of the base rech angle, all settings of the M1 function may be verified.

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 isolate the trouble quickly.

A test adapter card (0149C7259 G-3) 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 semi-conductor components. The repaired area should be re-covered 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 SLY61A relay are included in the card instruction book, GEK-34158; the card types are shown on the component location diagram, Figure 3.

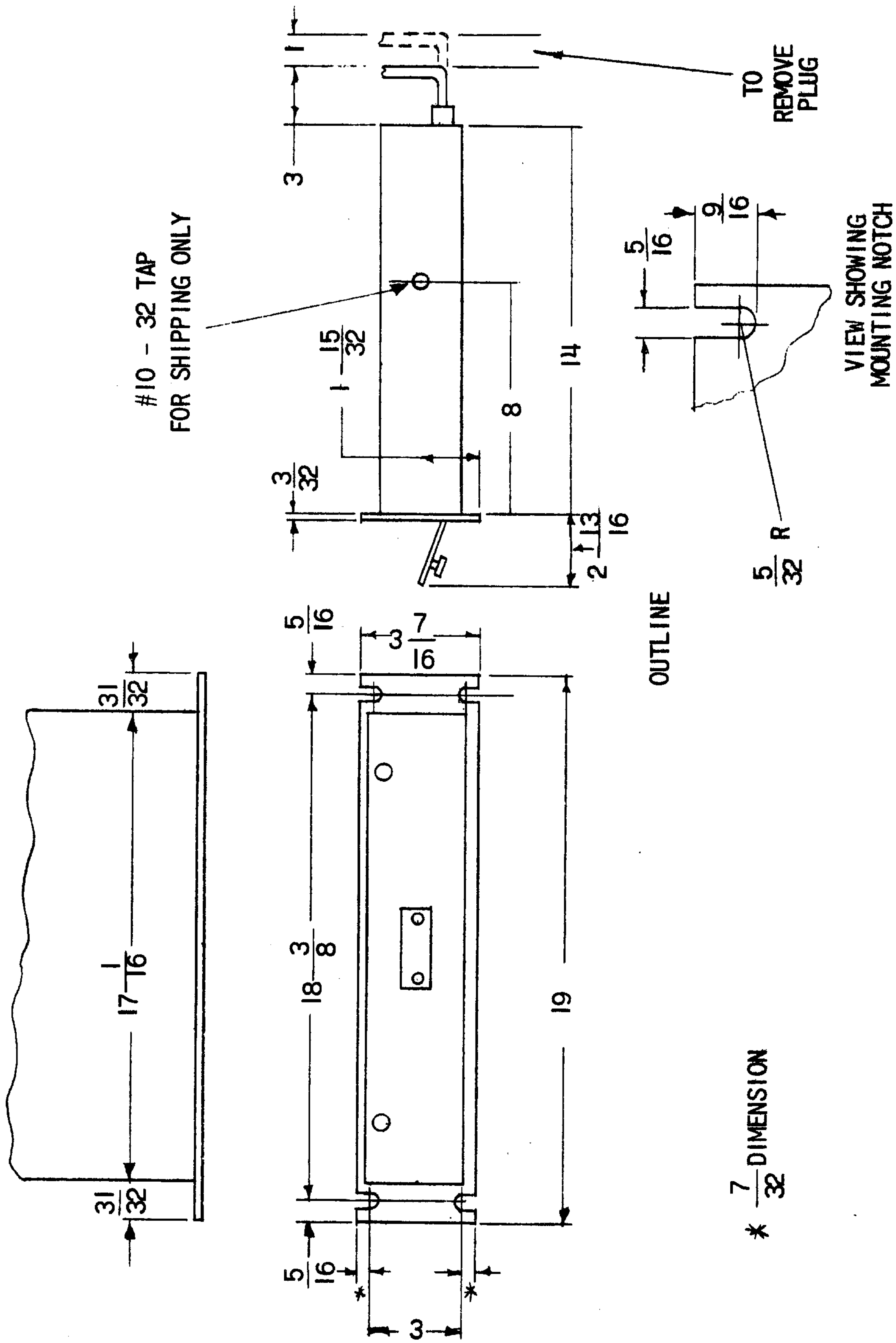


Figure 1 (0227A2036-0) Outline and Mounting Dimensions for the SLY61A Relay

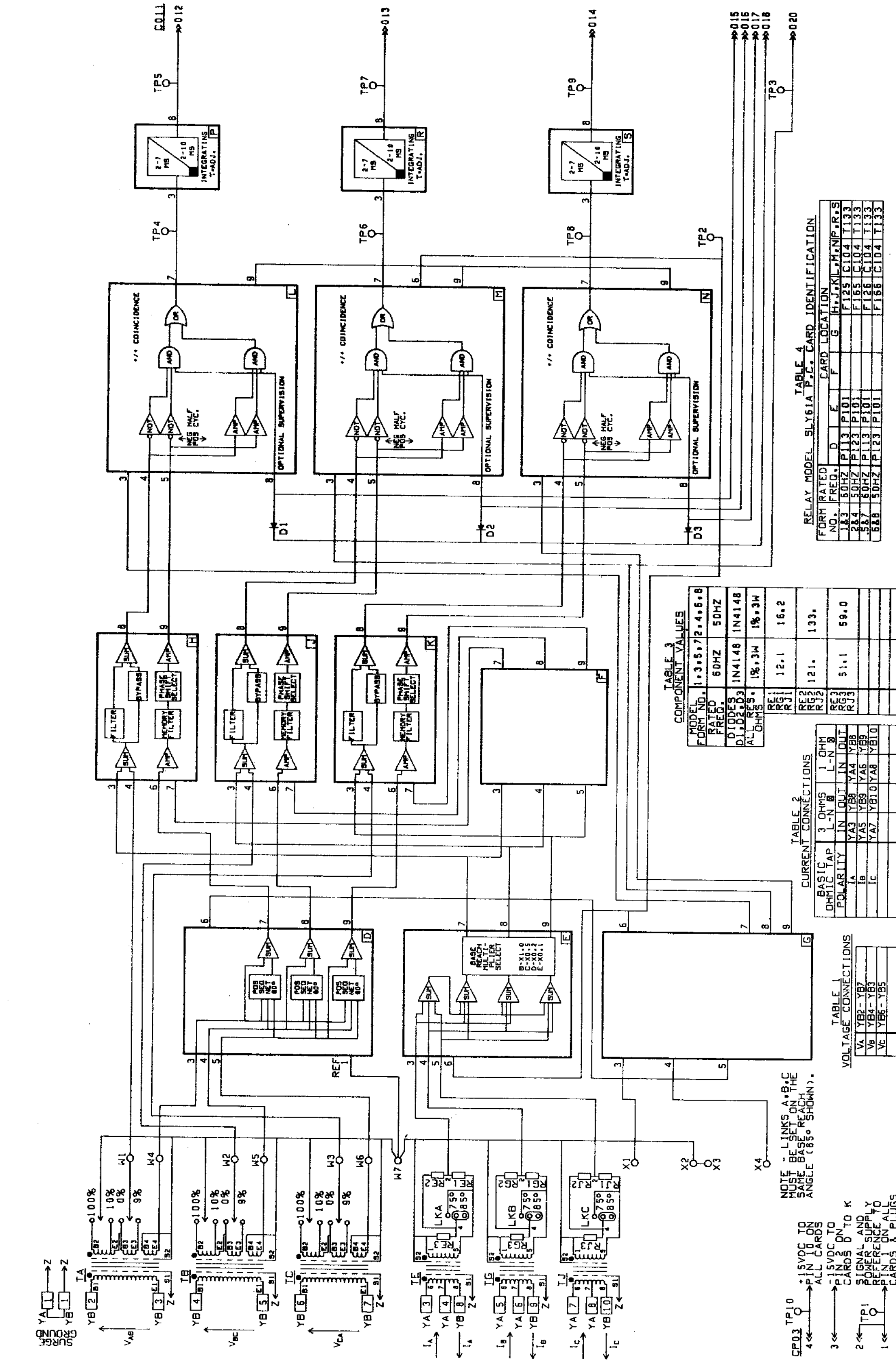


TABLE 1
VOLTAGE CONNECTIONS

V_A	YB2 - YB7
V_B	YB4 - YB3
V_C	YB6 - YB5

TABLE 2
CURRENT CONNECTIONS

BASIC OHMIC TAP	3 OHMS L-N Ø		1 OHM L-N Ø	
POLARITY	IN	OUT	IN	OUT
I_A	YA3	YB8	YA4	YB8
I_B	YA5	YB9	YA6	YB9
I_C	YA7	YB10	YA8	YB10

Ø MULT. BY (SAMP)/(RATED CURRENT)

TABLE 3
COMPONENT VALUES

MODEL FORM NO.	1,3,5,7	2,4,6,8
RATED FREQ.	60HZ	50HZ
DIODES D1,D2,D3	1N4148	1N4148
ALL RES. OHMS	1%,3W	1%,3W
RE1 RG1 RJ1	12.1	16.2
RE2 RG2 RJ2	121.	133.
RE3 RG3 RJ3	51.1	59.0

TABLE 4
RELAY MODEL SLY61A P.C. CARD IDENTIFICATION

FORM NO.	RATED FREQ.	CARD LOCATION						
		D	E	F	G	H,J,K	L,M,N	P,R,S
1&3	60HZ	P113	P101			F125	C104	T133
2&4	50HZ	P123	P101			F165	C104	T133
5&7	60HZ	P113	P101			F126	C104	T133
6&8	50HZ	P123	P101			F166	C104	T133

Figure 2 (0136D4911-0) Internal Connection Diagram for the SLY61A Relay

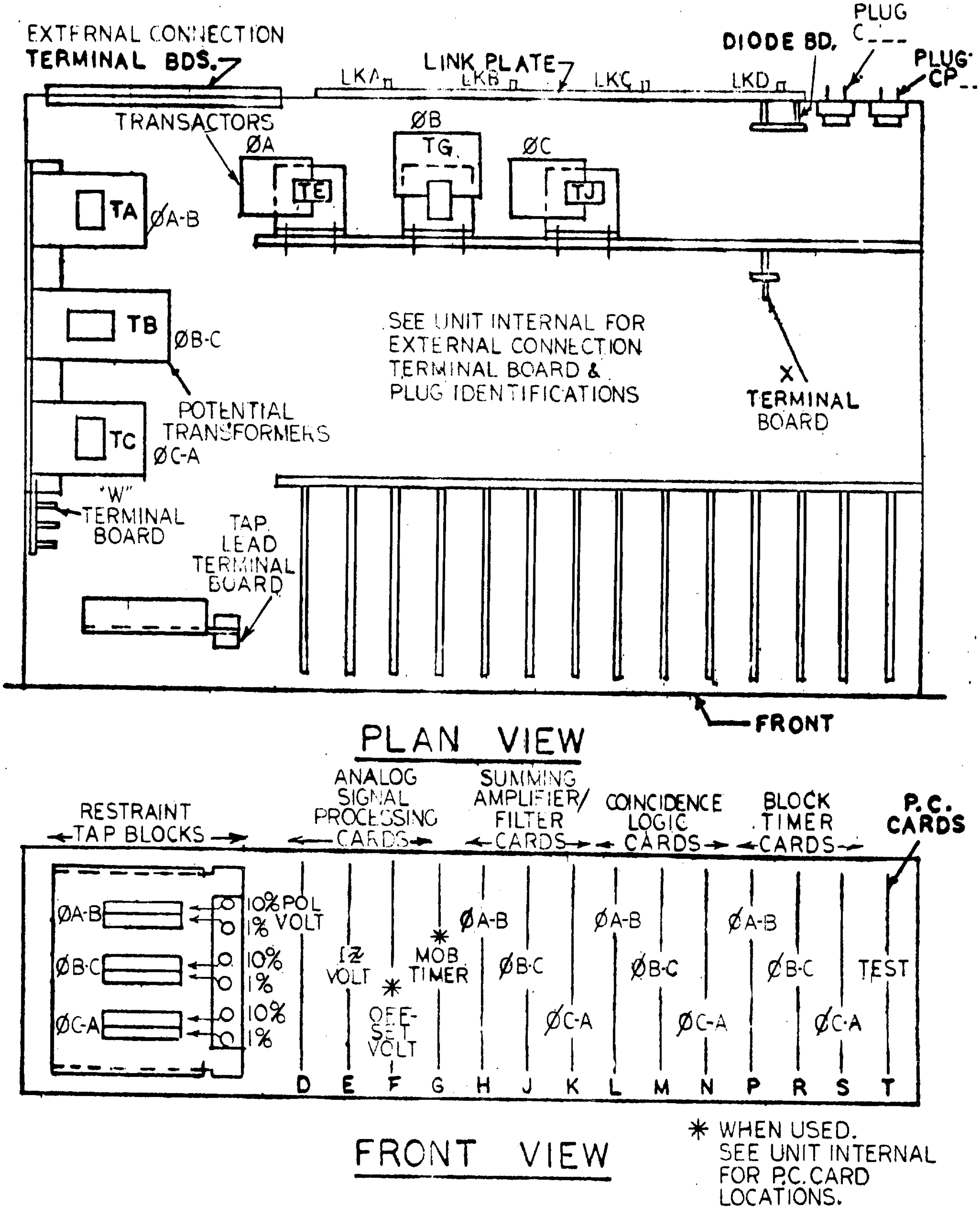


Figure 3 (0269A3157-1) Component Location Diagram for the SLY61A Relay

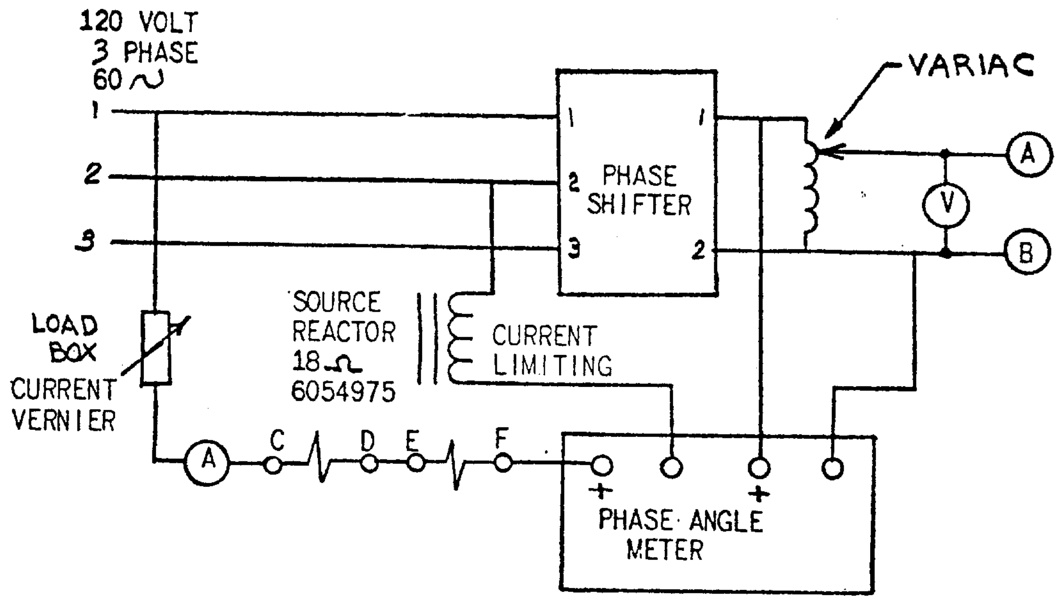
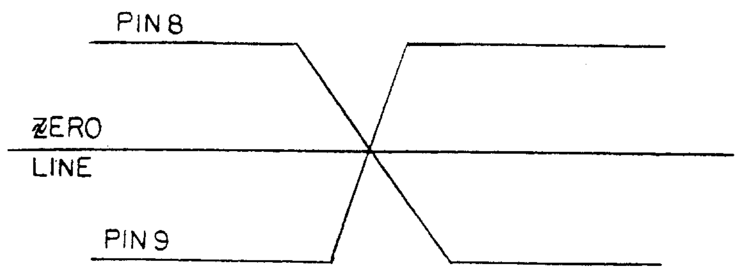
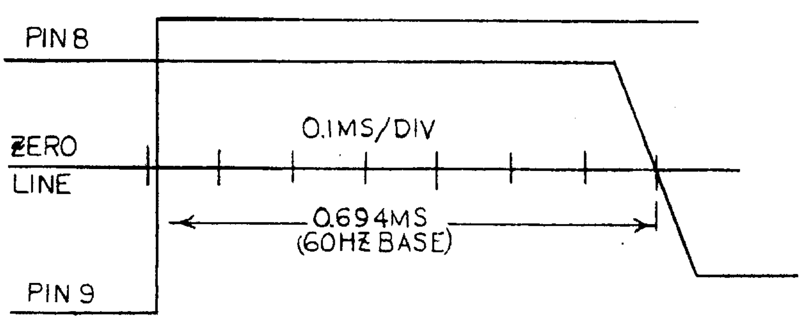


Figure 4 (0178A7029-3) M1 Function Test Circuit

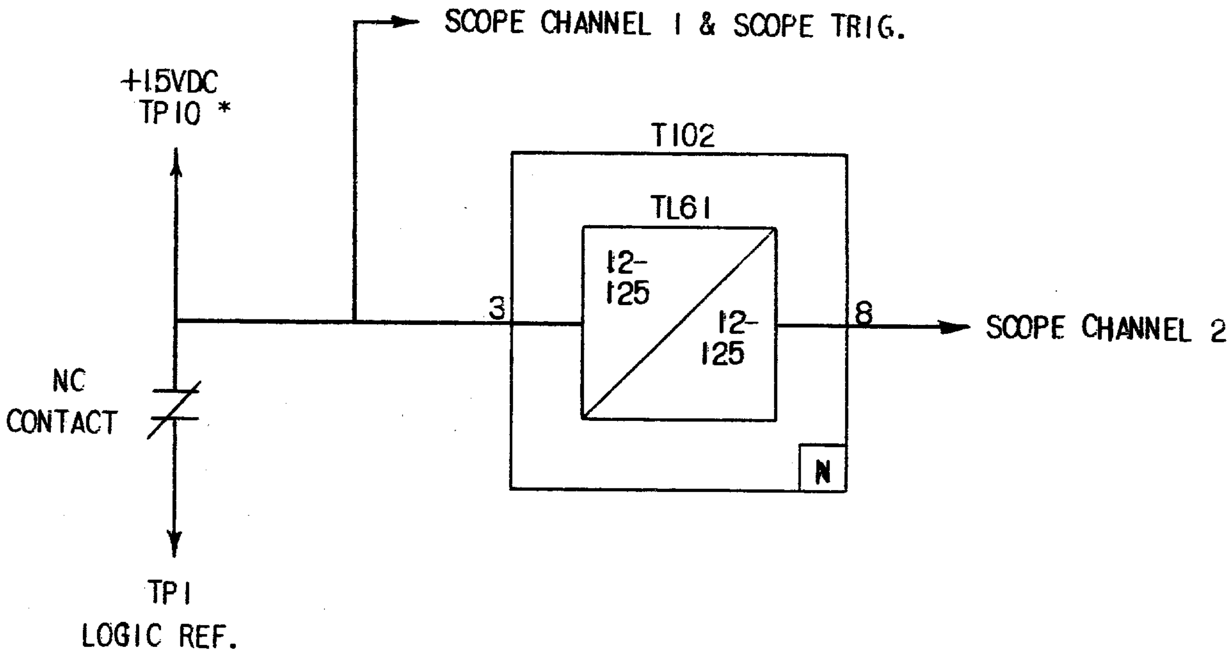


PROPERLY SET 0 DEGREE PHASE SHIFT



PROPERLY SET 15 DEGREE PHASE SHIFT

Figure 5 (0257A9696-1) Polarizing Circuit Phase Shift Waveforms



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

Figure 6 (0246A7987-0) Timer Test Circuit

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