



INSTRUCTIONS

GEK-49888A

**STATIC PHASE
MHO DISTANCE RELAY
TYPE SLY62B**

GENERAL  ELECTRIC

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STATIC PHASE
MHO DISTANCE RELAY
TYPE SLY62B

DESCRIPTION

The SLY62B is a second zone, three phase, static phase distance relay. The SLY62B 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 SLY62B relay is suitable for application in single pole tripping schemes, as well as three pole tripping schemes, for the protection of series compensated or uncompensated transmission lines.

The SLY62B relay utilizes a two-input phase-angle comparator for the phase distance measurement. The two inputs for the phase A-B measurements are:

- (a) $(I_A - I_B) Z_{R1} - T V_{AB}$ Operating Quantity
- (b) $V_{AB1} - [(I_A - I_B) Z_{R1}]^P$ 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 degrees and 75 degrees

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

V_{AB1} is the positive sequence component of the faulted phase-to-phase voltage.

P is the offset reach multiplier and may be set for 0.0, 0.75, 1.5, 2.25, or 3.0

The use of the positive sequence voltage 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 voltage polarizing signal also improves the directional integrity of the distance measurement.

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.

The SLY62B 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.

The SLY62B has the capability of a forward offset of the tripping characteristic to permit a more circular characteristic (and therefore faster operation) on long, heavily loaded lines. The forward offset also enhances the steady state directional integrity of the tripping unit in those cases where there are series capacitors between the potential source of the relay and an external fault behind the relay.

The SLY62B has the capability of reducing the sensitivity of the polarizing circuit. This feature improves the directional integrity and also allows a shorter characteristic timer pickup setting.

The SLY62B relay can be used as a standard distance relay or as a hybrid overcurrent-distance relay. When the relay is used as a hybrid overcurrent-distance relay, operation is not permitted unless the magnitude of the I_Z-V quantity is greater than a preset level.

RATINGS

This 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.

Forms of the SLY62B are available for either 50 or 60 hertz applications.

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

The potential circuits are rated for 120 volts.

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

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

RANGES

The SLY62B has an adjustable reach of 0.1 to 30 ohms for the five ampere rated relay or 0.5 to 150 ohms for the one ampere rated relay. The relay has a selectable offset in the tripping direction of 0.0, 0.75, 1.50, 2.25 or 3.00 per unit of the base reach.

Current input connections to establish the basic ohmic tap of one and three ohms line-to-neutral (five ampere relay) or 5 and 15 ohms (one ampere relay) are available at the current input terminals. Restraint taps in the voltage circuit range between 10

and 100 percent in one percent 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 degrees.

The polarizing voltage has an adjustable phase shift relative to the operating quantity of zero to twenty degrees lead.

BURDENS

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

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

The maximum phase current burden per phase is:

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

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

- 0.254 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 SLY62B relay are as follows:

OPERATING CIRCUIT SENSITIVITY

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

$$(I_A - I_B) Z_{R1} = \frac{0.16}{1-X}$$

where:

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

For example, if $Z_{R1} = 3$ ohms and $X = 0.9$, then:

$$(I_A - I_B) = 0.53 \text{ ampere}$$

For a phase-to-phase fault, $I_A = (I_A - I_B)/2$ or 0.267 ampere. For a three phase fault, $I_A = (I_A - I_B)/\sqrt{3}$ or 0.308 ampere.

POLARIZING CIRCUIT SENSITIVITY

Sensitivity is adjustable between 5 and 35 percent of rated voltage; it is factory set at 5 percent.

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 one or three ohms (five ampere rating) and five or fifteen ohms (one 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 (Vpol-IZP), where V is the phase-to-phase voltage at the relay, V_{pol} is the positive sequence voltage at the relay which is used as the polarizing voltage, I is the phase current, Z is the relay base reach, P is a percentage of 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 (Vpol-IZP) is less than or equal to 90 degrees.

RELAY REACH

The base reach of the relay (Z_{R1}) is determined by the basic ohmic tap (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.

$$Z_{R1} = (BOT) \times (BRM) \quad (\text{Eq. 1})$$

The reach of the MT/MOB function at the base reach angle is given by the expression:

$$Z_R = \frac{Z_{R1} \times 100}{T} \quad (\text{Eq. 2})$$

or

$$Z_R = \frac{BOT \times BRM \times 100}{T} \quad (\text{Eq. 3})$$

where:

Z_R is the reach at the base reach angle in line-to-neutral ohms

T is the voltage restraint tap setting in percent

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 setting of ten percent.

CHARACTERISTIC OFFSET

The relay may be adjusted by means of a movable jumper block on one of the printed circuit cards to produce a characteristic with a forward (tripping direction) offset. When the relay is adjusted in this manner, a plot of its characteristic will be a circle that does not pass through the origin of the IR-IX diagram.

The amount of characteristic offset is equal to a percentage (P) of the relay base reach.

$$\text{Offset} = (Z_{R1}) (P) \quad (\text{Eq. 4})$$

where: P = per unit offset factor.

The offset quantity, $I_{\phi-\phi} (Z_{R1}) (P)$, is clamped to a maximum value of 0.25 times the rated phase-to-phase voltage.

IZ-TV LEVEL DETECTOR SETTING

A low set level detector is incorporated in the mho operate circuitry for use in certain applications. The "D" option jumper on the F177 cards should be in the "2" position if the low set level detector is to be used. The level detector setting is made by adjusting the P20 potentiometer on the F177 cards in positions H, J and K. The level detector insures that the mho function will not produce an output until the IZ-TV operating quantity is greater than the set level.

If the "D" option jumper on the F177 cards is placed in position "1," the level detector is bypassed by a filter circuit, and operates as a standard mho distance function.

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 degrees.

The polarizing quantity used to develop the mho characteristic can be phase shifted relative to the operating quantity. The phase shift can be adjusted between zero and 20 degrees lead. The 20-degree 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 20-degree setting increases the reach at the relay angle of maximum reach by the factor $1/\cos(20 \text{ degrees})$ which is equal to 1.064.

PHASE ANGLE MEASUREMENT

The quantities (IZ-TV) and (Vpol-IZP) are supplied to a summing amplifier-filter card. This card sums IZ and -TV and Vpol and -IZP then filters extraneous frequencies from those quantities. 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 which is proportional to the phase angle between (IZ-TV) and (Vpol-IZP).

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 degrees (4.17 milliseconds on a 60 hertz base, 5.0 milliseconds on a 50 hertz base) a circular R-X characteristic is obtained. If the timer is set for less than 90 degrees, an expanded circle (tomato shaped) characteristic is obtained. If the timer is set for more than 90 degrees, a contracted circle (lens shaped) characteristic is obtained.

CALCULATION AND CHOICE OF SETTINGS

The following discussion is limited to the use of the SLY62B relay as a standard distance relay. The forward offset, IZ-V level detector, and the polarizing voltage phase shift and sensitivity are left at the factory settings. A discussion of these settings will be found in the logic description for the scheme in which the unit is used.

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

$$Z_1^i = 42 \angle 83^\circ,$$

Assume CT ratio is 1000/5 and PT ratio is 2000/1.

$$Z_1^i \text{ sec} = 42 \left(\frac{1000}{5}\right) \left(\frac{1}{2000}\right) = 4.2 \angle 83^\circ$$

For short to medium length lines, that is, lines less than 100 miles long, the SLY62B 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 degrees, select the 85-degree base reach angle tap. For line angles 80 degrees and below, select the 75-degree base reach angle tap. For the sample line, select the 85-degree tap.
- (b) A typical relay reach (Z_R) for positive sequence line angles of 65 degrees and above is 175 percent of the positive sequence line impedance. For line angles below 65 degrees, 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 base ohmic tap (BOT) and the base reach multiplier (BRM). The basic ohmic taps available are one ohm and three 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 1.75 (Z_{1L}) or 1.75 (4.2) or $Z_R = 7.35$ ohms. The suggested base reach (Z_{R1}) is three ohms. This results from a BOT of three ohms and BRM of 1.0.

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

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

For the sample line $T = \frac{3 \times 100}{7.35} = 40.8$ or 41 percent

- (d) The polarizing phase shift is typically set at zero degrees 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, 97 degrees, 90 degrees/110 degrees. For 60 hertz applications, this is approximately 4.5, 4.2/5 milliseconds, and for 50 hertz, 5.3, 5/6 milliseconds.

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

MOB TIMER SETTING

The MOB characteristic timer setting should be set in conjunction with the out-of-step blocking timer in the SLA. The MOB characteristic should be sufficiently larger than the tripping relay characteristics it is blocking, to permit the OSB timer to time out during the period that the fastest swing impedance is inside the MOB characteristic but outside the tripping characteristic. Refer to the appropriate logic description for further discussion.

CONSTRUCTION

The Type SLY62B relay is packaged in a metal enclosure designed for mounting on a 19-inch rack. The relay is two rack units high (one rack unit is 1-3/4 inches). The outline and mounting dimensions are shown in Fig. 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-phase 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 YC 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 Fig. 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 Fig. 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 ten percent tap and one is for the one percent tap. The voltage restraint tap setting is the sum of the one and ten percent 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 F177, C106, T133 or P101, 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

These relays 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, the static relay equipment 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, 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 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 TEST INSTRUMENT WITH A GROUNDED CHASSIS WILL NOT AFFECT THE TESTING OF THE EQUIPMENT. HOWEVER, 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 the instrument test jacks on a test card in 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 plus 15 volt DC. Output signals are measured with respect to the relay reference (TP1). Logic signals are approximately plus 15

volt DC for the ON or LOGIC ONE condition, and between zero and plus one volt DC for the OFF or LOGIC ZERO condition. Filter card outputs are square waves which shift from plus 15 volt DC to minus 15 volt DC.

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)
 - (c) Per unit offset reach selection (P)
2. Voltage restraint tap setting (T)
3. Angle of maximum reach setting
 - (a) Base reach angle
 - (b) Polarizing voltage phase shift
4. Polarizing sensitivity setting
5. Characteristic timer setting

6. Level detector setting
7. IZ-V cancellation magnitude selection
8. Severe Fault Detection Option
9. Overall check of the MT/MOB function

DETAILED TESTING INSTRUCTIONS

BASE REACH SETTING

The basic ohmic tap (BOT) is determined by the terminals to 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	IA		IB		IC	
	IN	OUT	IN	OUT	IN	OUT
1 OR 5 OHM	YC4	YD8	YC6	YD9	YC8	YD10
3 OR 15 OHM	YC3	YD8	YC5	YD9	YC7	YD10

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

The per unit characteristic offset selector is located on the card in location F. The adjustment is accomplished by a five-position jumper block. In each position the gain of the IZ circuit for each phase is set to the proper value of the per unit offset reach multiplier. The per unit offset reach for each jumper position on the card is shown in Table III. The relay characteristic offset is given by Equation 4.

TABLE III

JUMPER POSITION	PER UNIT OFFSET REACH (P)
A	0.00
B	0.75
C	1.50
D	2.25
E	3.00

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 ten percent tap and a one percent tap. A restraint tap setting of 57 percent would consist of a ten percent setting of 50 and a one percent 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 or 85 degrees.

In order to set the polarizing voltage phase shift, it is necessary to adjust the P80 potentiometer on the filter cards in locations H, J and K. The setting must be made on each of the three cards.

The polarizing phase shift is adjusted by using the test circuit of Fig. 5 and 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 percent. Adjust the voltage for 30 volts RMS.

TABLE IV

PHASE PAIR	FIG. 5 CONNECTIONS			FILTER CARD LOCATION
	A	B	JUMPER POINTS	
A-B	YD2, YD7	YD3, YD4	YD5 TO YD6	H
B-C	YD4, YD3	YD5, YD6	YD2 TO YD7	J
C-A	YD6, YD5	YD7, YD2	YD3 TO YD4	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.

3. (a) Zero Degree Polarizing Phase Shift

The square waves at pins 8 and 9 of the filter card should be exactly 180 degrees out of phase, i.e., the zero crossings of each trace should coincide at the center line and the traces should have opposite slopes. The phase shift between pin 8 and pin 9 may be adjusted by potentiometer P80 on the filter card.

(b) Twenty Degree Polarizing Phase Shift

The square wave at pin 9 can be made to lead the square wave at pin 8 by up to 20 degrees. At 20 degrees the zero crossing of the square waves should occur 20 degrees apart (0.926 milliseconds on a 60 hertz base, 1.11 milliseconds on a 50 hertz base). The square wave at pin 9 will be toward the left-hand edge of the screen. The phase shift between pins 8 and 9 may be adjusted by potentiometer P80 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.

POLARIZING SENSITIVITY SETTING

The polarizing sensitivity is adjusted by means of the P90 potentiometer on the filter card (positions J, K and L). The following procedure is recommended:

1. Use the test circuit of Fig. 6, adjust the test voltage to the desired level.
2. Monitor the signal at pin 9 of the filter card (position H for phase A-B).
3. Adjust the P90 potentiometer on the filter card to the point that causes the wave form monitor at pin 9 to become a sine wave with magnitude of 7.5 volts RMS.
4. Repeat Steps 2 and 3 for the other two filter cards (position J and K).

CHARACTERISTIC TIMERS SETTINGS

The pickup settings of the characteristic timer determines the shape of the MT 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 (drop-out 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. Timer settings are discussed in the section **CHOICE AND CALCULATION OF SETTINGS**.

The timers used for the MT 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 which will

cause the timer to pick up with one pulse applied per half-cycle, and T3 is the drop-out delay. The operation of the integrating characteristic timers is discussed in the printed circuit card instruction book, GEK-34158.

The DC pickup (T1) and the dropout (T3) of the MT characteristic timer may be set using the test circuit of Fig. 4. Before testing the timer with this circuit, the card which normally supplies the input to the timer must be removed (refer to Table V). Opening the normally closed contact of Fig. 4 causes the 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 (step to less than one volt DC) after the reset delay setting of the card. To increase the reset delay, turn the second potentiometer (P2) clockwise. The pulse pickup mode of the timer may be observed while plotting the characteristic as described in OVERALL CHECK OF THE MT FUNCTION. 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.

TABLE V

PHASE	TIMER UNDER TEST	REMOVE CARD
A-B B-C C-A	P R S	L M N
MOB	G	L, M and N

LEVEL DETECTOR SETTING

The IZ-TV level detector setting is made by means of P20 on the filter cards (positions H, J and K). The following procedure should be used to make the setting:

1. Move the "D" option jumper block to position 2 and remove the "C" option jumper block.
2. Determine the proper IZ-TV level as discussed in the section **CALCULATION OF SETTINGS**.
3. Use the test connections of Fig. 5.
4. Set the applied voltage for the proper level per calculations in 2 (above).
5. Adjust P20 on the filter cards in positions H, J and K to obtain blocks at pin 8 of the card, the longer of which is 4.2 milliseconds (5.0 milliseconds for 50 hertz). The width of the blocks should be measured at the 7.5 volt level of the square wave.

The "B" option jumper block on the filter card is the level detector range selector; changing the position of this block will extend the range of adjustment of the level detector. The upper position (1 and 3) is normally used for Zone 1 applications and the lower position (2 and 4) is normally used for Zone 2 applications.

Moving the "D" option jumper block on the filter card to position 2 removes the filtered component from the operate circuit of the filter card and makes it act as a level detector only. If it is not intended that the circuit act as a level detector only, move the "D" option jumper block to position 1.

IZ-V CANCELLATION MAGNITUDE SELECTION

The "C" option jumper block on the filter card is used to select the desired magnitude of IZ-V cancellation. Check the logic description supplied with the equipment for the proper method of determining the required magnitude of IZ-V cancellation. The upper position (1 and 3) is used for 0.7 or 0.8 cancellation and the lower position (2) is used for 0.4 cancellation.

SEVERE FAULT DETECTION OPTION

The severe fault detection circuit is an optional non-directional overcurrent/distance function. If this function is to be used, the "G" option jumper block on the filter card must be moved from position 2 to position 1.

OVERALL CHECK OF THE MT FUNCTION

The test circuit of Fig. 7 should be used to check the operation of the MT function. Use the connections of Table VI for the one or five-ohm basic ohmic tap or Table VII for the three or fifteen-ohm basic ohmic tap.

TABLE VI

PHASE PAIR	FIG. 7 CONNECTIONS - 1 or 5 OHM TAP						
	A	B	C	D	E	F	G
A-B	YD2 & YD7	YD3 & YD4	YD5 & YD6	YC4	YD8	YD9	YC6
B-C	YD4 & YD3	YD5 & YD6	YD2 & YD7	YC6	YD9	YD10	YC8
C-A	YD6 & YD5	YD7 & YD2	YD3 & YD4	YC8	YD10	YD8	YC4

TABLE VII

PHASE PAIR	FIG. 7 CONNECTIONS - 3 or 15 OHM TAP						
	A	B	C	D	E	F	G
A-B	YD2 & YD7	YD3 & YD4	YD5 & YD6	YC3	YD8	YD9	YC5
B-C	YD4 & YD3	YD5 & YD6	YD2 & YD7	YC5	YD9	YD10	YC7
C-A	YD6 & YD5	YD7 & YD2	YD3 & YD4	YC7	YD10	YD8	YC3

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 Fig. 7, 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 five minutes with an off time of at least five minutes.

TABLE VIII

BASE REACH OHMS	RECOMMENDED MINIMUM TEST CURRENT (AMP) FOR LESS THAN 2 PERCENT PULL BACK	
	FIVE AMPERE RELAY	ONE AMPERE RELAY
3.0	3.5	0.7
1.5	7.0	1.4
1.0	10	2.0
0.6	17	3.4
0.5	20	4.0
0.3	20**	4.0**
0.2	20**	4.0**
0.1	20**	4.0**

**Less than 5 percent pull back.

2. Adjust the phase angle for the nominal base reach angle (75 or 85 degrees)
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:

$$V_T = 2 \times I_T \times BOT \times BRM \times \frac{100}{T} \quad (\text{Eq. 5})$$

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 percent
- V_T is the pickup voltage at the base reach angle

5. As the voltage is lowered, observe the output of the MT function: TP5 for phase pair A-B, TP7 for B-C and TP9 for C-A. At the point where MT 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 within two degrees of the nominal setting. The voltage should be within five percent of the value given by Equation 5.
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 MT function, thereby increasing the relay reach.
7. If an offset characteristic is being used, it can be checked using the circuit shown in Fig. 7 and the connections shown on Table VI or Table VII.

The voltage should be lowered to the value given by the following expression:

$$V_{OS} = 2 \times I_T \times BOT \times BRM \times P$$

where:

P is per unit offset setting (percent of base reach setting)

V_{OS} is the offset (dropout) voltage at the base reach angle.

NOTE: Because the maximum value of the offset quantity, V_{OS} , is limited to 0.25 rated phase-to-phase voltage, the applied current must be in accordance with equation 6 when checking characteristic offset.

$$I_T \leq \frac{0.25 \times \text{nominal } \emptyset-\emptyset \text{ voltage}}{BOT \times BRM \times \text{Offset Tap (PU)} \times 2} \quad (\text{Eq. 6})$$

where:

BOT is the basic ohmic tap

BRM is the base reach multiplier

I_T is the test current

A per unit offset tap must be picked such that the reach of the relay is greater (typically 2X) than the offset. For example, if a base reach tap of 1.5 ohms is used with a voltage restraint tap of 100 percent, then the relay reach, per equation 2, is

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

$$Z_R = 1.5 \times \frac{100}{100} = 1.5 \text{ ohms}$$

For Z_R to be greater than twice the offset

$$P \leq \frac{2Z_R}{Z_{R1}}$$

or

$$P \leq Z \times \frac{100}{T}$$

For the example, P must be less than or equal to 2.

8. Lower the voltage as indicated in Step 5 to the point where the MT function picks up. Because this test takes place at low currents, there will be some pull-back of the MT pickup. Continue to lower the voltage and observe that the MT function drops out at the point indicated by the expression given in Step 7. Note that when the test voltage is at the point indicated in Step 7, the signal at pin 9 of the filter card is reduced to a null voltage consisting of only third and fifth harmonics.
9. A vernier adjustment of the characteristic offset is provided by the P60 potentiometer on the filter card (positions H, J and K).
10. Repeat Steps 1 through 9 for phase pairs B-C and C-A using the connections from Table VI or VII.

MT FUNCTION CHECK

The following procedure is recommended to provide an overall check of the adjustments included in the MT 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 Fig. 7. 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.

NOTE: The following equations apply with 0.0 characteristic offset only.

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

- (a) Adjust the phase shifter to obtain a phase angle 30 degrees less than the base reach angle.
- (b) Lower the applied voltage and check for an MT output within five percent of the voltage given by the expression:

$$V_D = V_T \times \frac{\text{SIN}(D - A + B + 180 - C)}{\text{SIN}(B + 180 - C)} \quad (\text{Eq. 7})$$

where:

V_T is the pickup voltage at the base reach angle given by Equation 5

A is the base reach angle in degrees

- B is the polarizing voltage phase shift setting in degrees (0 to 20)
- C is the characteristic timer setting in degrees. For 50 hertz relays, multiply the timer setting in milliseconds by 18 to obtain degrees; for 60 hertz 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 degrees greater than the base reach angle.
- (b) Lower the applied voltage and check for an MT output within five percent of the voltage given by the expression:

$$V_D = V_T \times \frac{\text{SIN } (D - A + B + C)}{\text{SIN } (B + C)} \quad (\text{Eq. 8})$$

COMPLETE MOB FUNCTION CHECK

The following procedure is recommended to provide an overall check of the MOB function. Note that the MT and MOB functions have common circuits and adjustments for all settings except the characteristic timer settings. The same procedure is used for the MOB check as for the MT check outlined in COMPLETE MT FUNCTION CHECK, with the following exceptions. The output of the MOB function should be monitored at TP3. Pin 8 on the coincidence logic cards for the phase pairs not under test should be jumpered to reference; refer to Table IX for the cards involved.

TABLE IX

PHASE PAIR UNDER TEST	JUMPER PIN 8 TO REFERENCE ON CARDS
A-B	M and N
B-C	L and N
C-A	L and M

PERIODIC CHECKS AND ROUTINE MAINTENANCE

PERIODIC CHECKS

The MT functions included in the relay may be checked at periodic intervals using the procedures described under OVERALL CHECK OF THE MT FUNCTION. By checking the reach of each unit at the base reach angle and one angle either side of the base reach angle, all settings of the MT functions 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 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 printed circuit 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 relay are included in the card book, GEK-34158; the card types are shown on the component location diagram, Fig. 3.

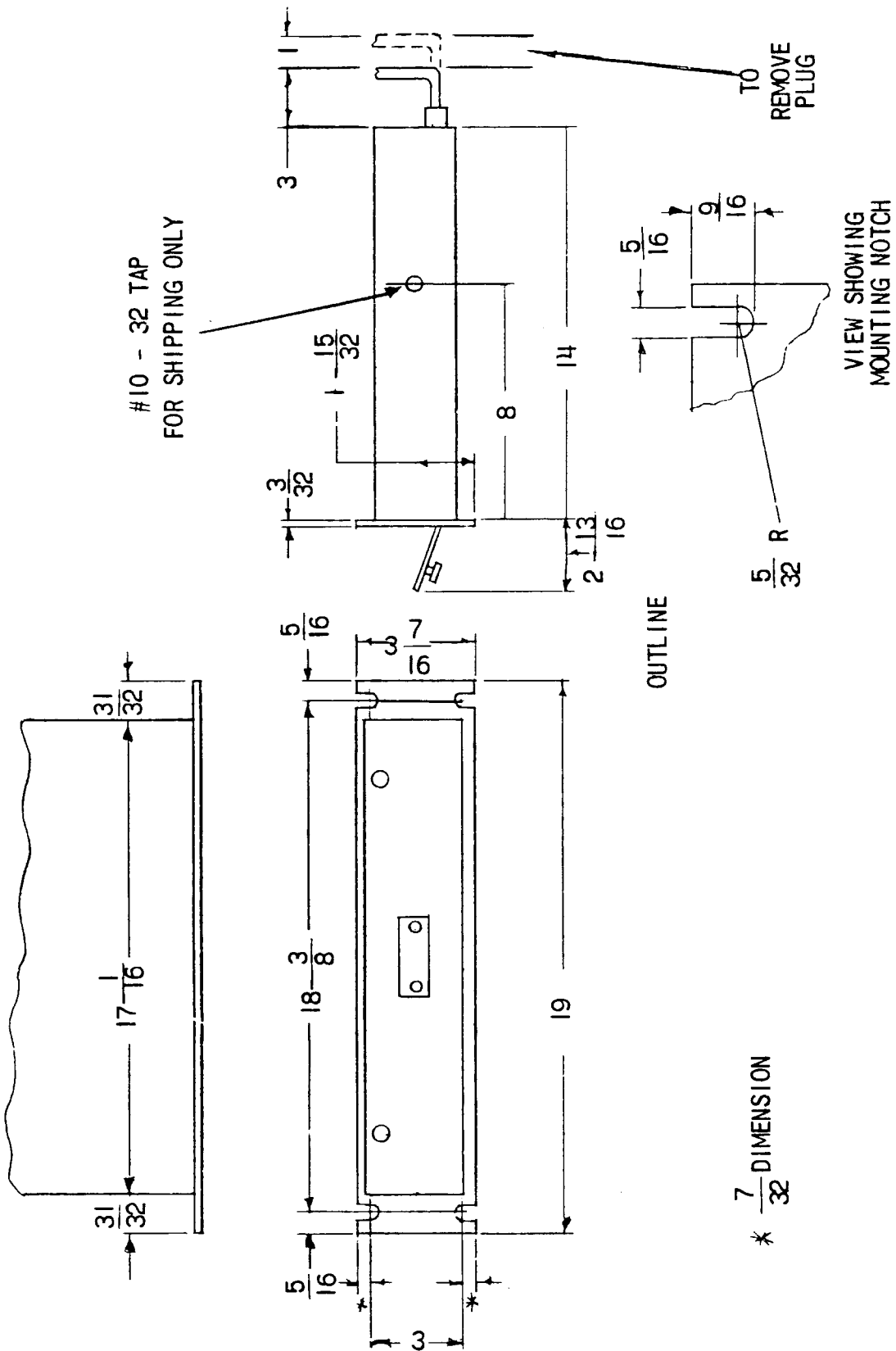


Fig. 1 (O227A2036-0) Outline and Mounting Dimensions for the SLY62B Relay

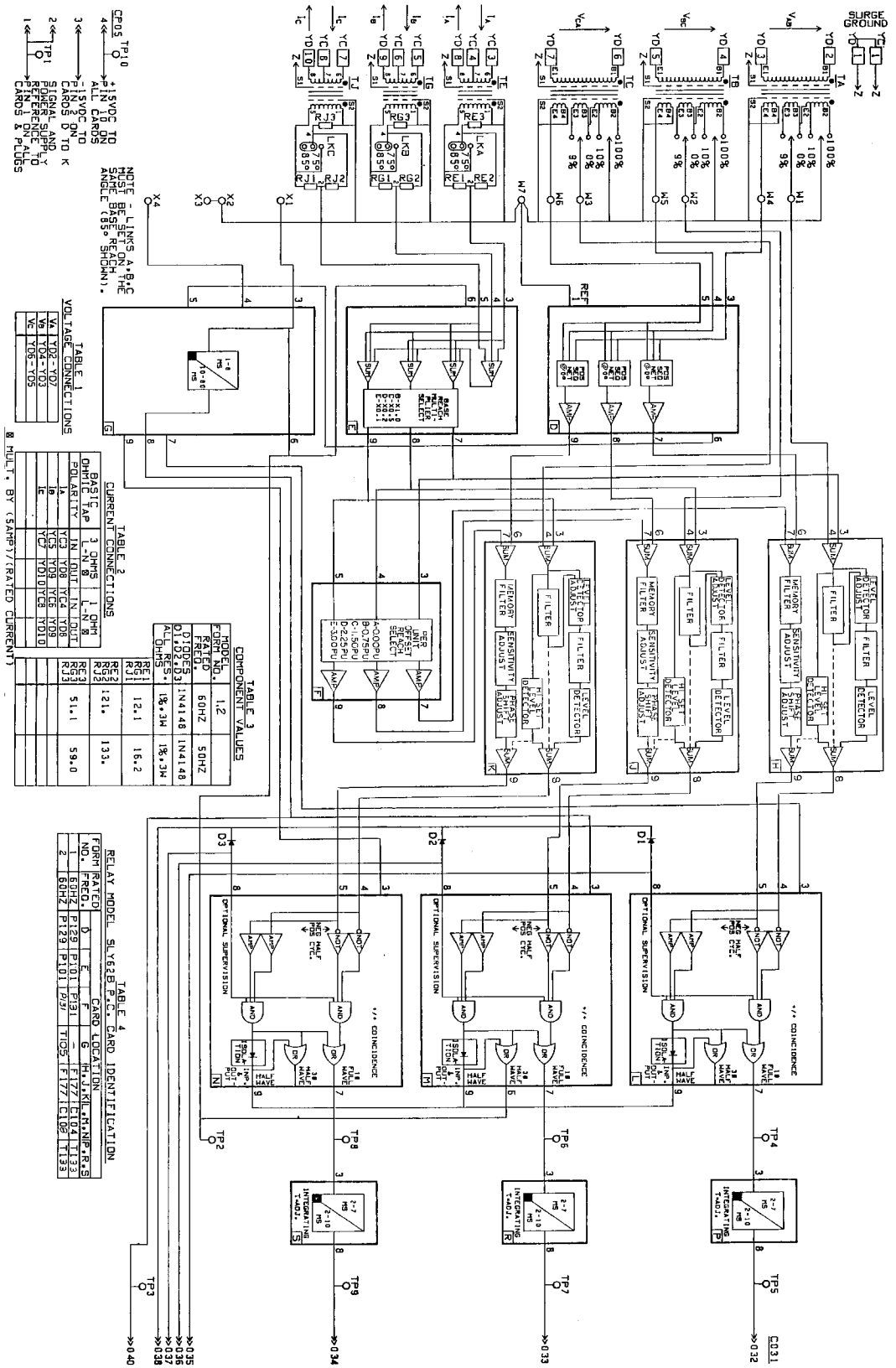
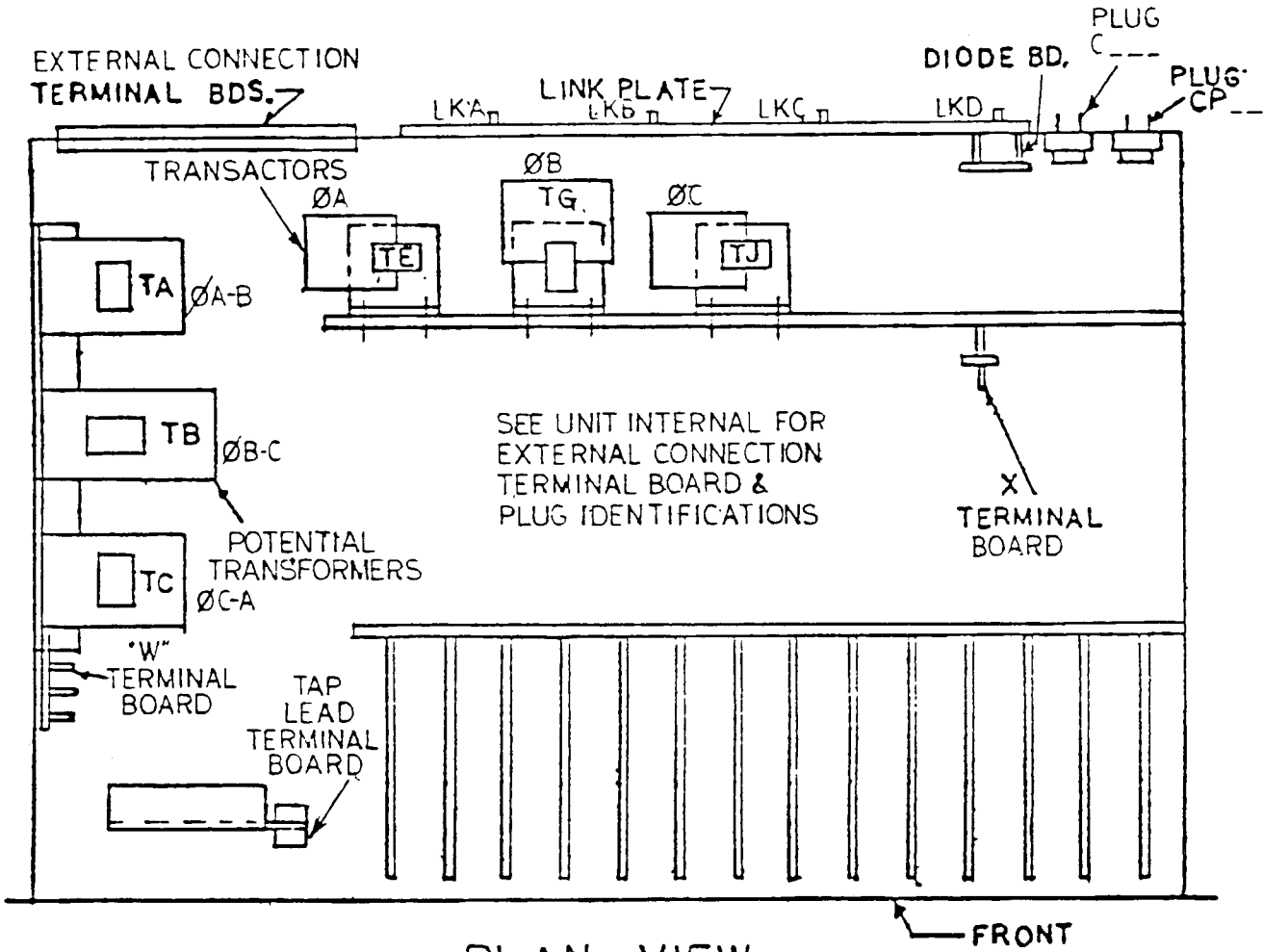
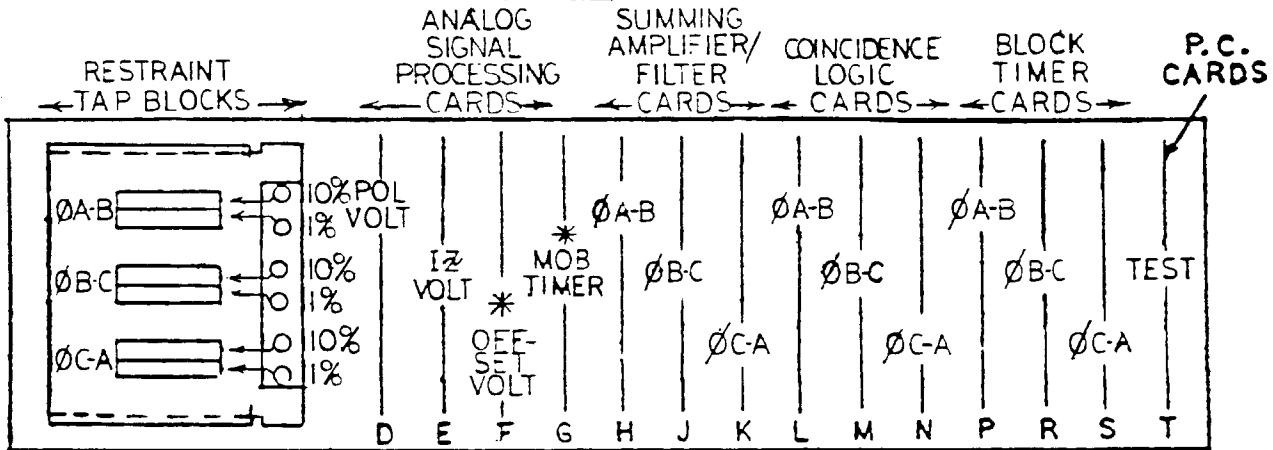


Fig. 2 (0136D4922-0) Internal Connection Diagram for the SLY62B Relay

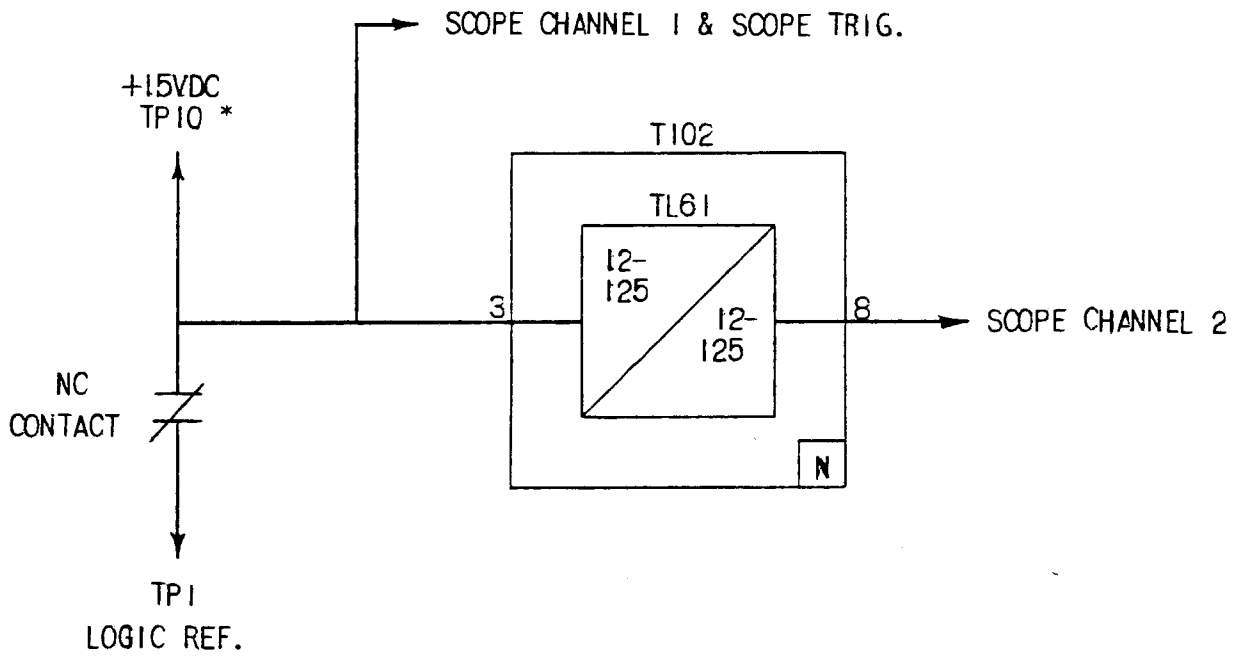


PLAN VIEW



FRONT VIEW

Fig. 3 (0269A3157-1) Component Location Diagram for the SLY62B Relay



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

Fig. 4 (0246A7987-0) Timer Test Circuit

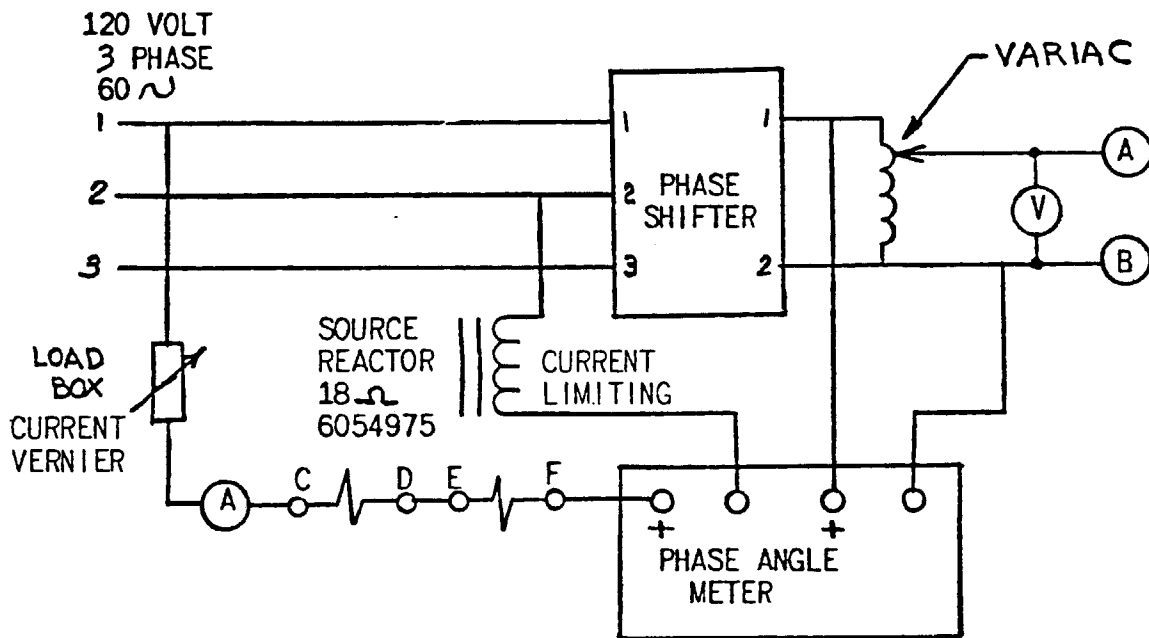


Fig. 5 (0178A7029-3) Alternate MT/MOB Function Test Circuit

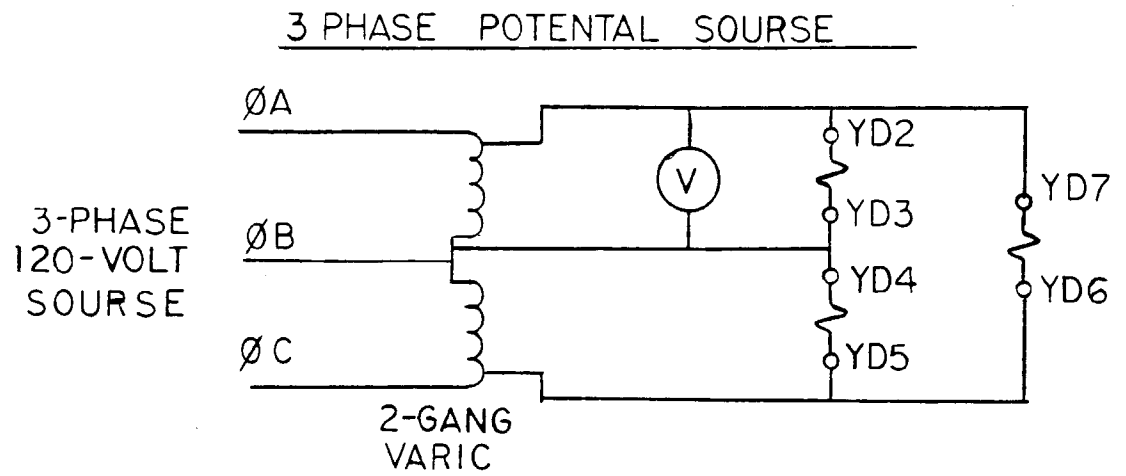


Fig. 6 (0285A6177-0) Test Circuit and Wave Form for Polarizing Sensitivity Setting

TEST SOURCE MUST
BE BALANCED

OUTPUT MUST
BE BALANCED

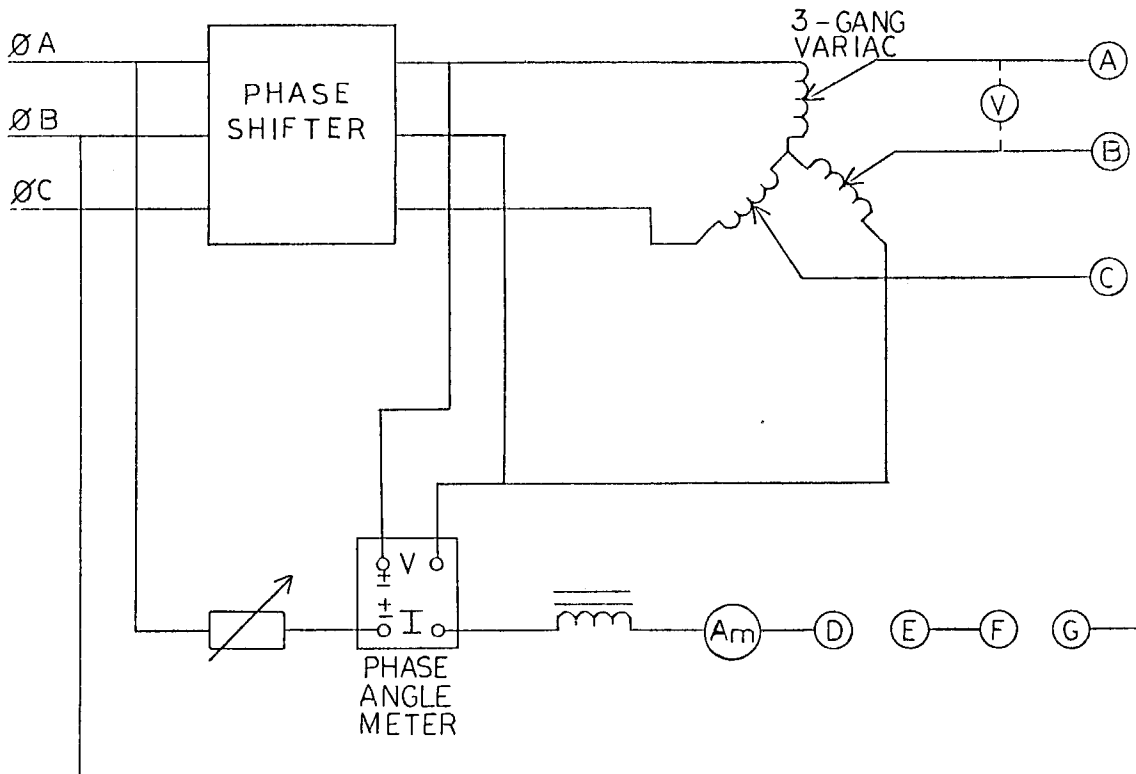


Fig. 7 (0246A6880-1) MT/MOB Function Test Circuit

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