INSTRUCTIONS

GEK-49813C

STATIC, THREE-PHASE DIRECTIONAL GROUND-DISTANCE RELAY

TYPE SLYG81A

GENERAL ELECTRIC

CONTENTS

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STATIC, THREE-PHASE DIRECTIONAL GROUND-DISTANCE RELAY

TYPE SLYG81A

DESCRIPTION

The Type SLYG81A relay is a three-phase, first- or second zone static ground-distance, relay. It is available with ratings of 60 hertz, 5 amperes; 50 hertz, 5 amperes; or 50 hertz, 1 ampere. Five-ampere-rated relays are available with continuously adjustable ohmic-reach ranges of 0.1 to 4 ohms or 0.75 to 30 ohms. One-ampere rated relays are available with continuously adjustable ohmic-reach ranges of 0.5 to 20 ohms or 3.75 to 150 ohms. DC power-supply voltages available are 48, 110, or 125. A 250 volt rating is available with an external pre-regulator. Contact outputs are provided for tripping (two contacts, each with target) and there is contact connected to positive for auxiliary functions. The relay is mounted in a deep, large-size, double-ended drawout (L2D) case.

The Type SLYG81A relay may be used in a "stepped distance" protection as the first, second or third zone of ground protection. It may also be used as an underreaching or overreaching tripping relay in any of the directional-comparison scheme. If the directional-comparison scheme uses ground-distance blocking relays, the Type SLYG82A blocking relay (described in instruction book GEK-49814) should be used in the scheme to coordinate with the SLYG81A tripping relay.

The SLYG81A has a "variable mho" characteristic, which provides an optimum accommodation of fault resistance.

The functional block diagram is shown in Figure 1. The internal connections are shown in Figure 2 and the external connections are shown in Figure 3.

These instructions do not purport to cover all details or variations in equipment nor 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.

APPLICATION

The SLYG81A utilizes a four-input phase-angle comparator for ground-distance measurement for each phase. The four inputs for the phase-A-to-ground measurement are:

(a) $(I_A - I_0) Z_{RI} + K_0 I_0 Z_{R0} - T V_{AG}$.....Operating Quantity

(b) $\frac{V_{BC}}{\sqrt{3}} \angle 90°$..#1 Polarizing Quantity

(c) $c K_0 I_0 Z_{R0} - V_0$................................#2 Polarizing Quantity

(d) $I_0 Z_{R0}$...Overcurrent Supervision

where:

I_A is the faulted phase current
I_0 is the zero-sequence component

Z_{R1} is the phase (positive- and negative-sequence) base reach tap with an impedance angle 85°

Z_{R0} is the neutral (zero-sequence) base reach with an impedance angle of 75°

$T V_{AG}$ is the "adjustable" phase-to-ground restraint voltage

$\frac{V_{BC}}{\sqrt{3}} \angle 90°$ is the "quadrature" voltage shifted 90 leading

K_0 is a ratio tap compensate for the magnitude ratio between the zero- and positive-sequence lines impedance

c is a design constant (0.5 per unit)

V_0 is the zero-sequence voltage at the relay

The use of a four-input comparator produces many advantages over previous designs in simplifying the application of a ground-distance relay for either first- or second-zone applications.

The first and second inputs (a and b) to the comparator produce the well known quadrature-polarized ground-distance unit with a "variable mho" characteristic. The "variable mho" characteristic increases in size as the source impedance increases, to accommodate increasing fault resistance.

The use of the second polarizing quantity (c) restricts the distance measurement to the faulted phase, thereby eliminating the need for checking the unfaulted phase unit for incorrect directional sensing on unusual-sequence current-distribution factors, or overreaching on heavy-load transfer.

The second polarizing quantity (c) also precludes the possibility of the distance unit overreaching on a double-line-to-ground fault with high zero-sequence fault resistance. The high zero-sequence fault resistance can cause a fault beyond the reach of a relay to appear within the operating characteristic of a relay when only the (a) and (b) inputs above are used.

The fourth input (d) provides overcurrent supervision to prevent operation on potential failure or on the line de-energizing transients that are associated with lines with shunt reactors. The line de-energizing transients present a problem if a relay operates on the transient voltages just prior to a high-speed reclosure.

In addition, the third and fourth inputs (c and d) act as a zero-sequence directional unit that provides excellent directional integrity.

The SLYG81A has an adjustable characteristic that 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 applied, a lens-shaped characteristic is recommended.

RATINGS

GENERAL

The Type SLYG81A relay is designed for continuous operation in ambient temperatures between -20°C and + 55°C per ANSI standard C37.90-1978. In addition, these relays will not malfunction nor be damaged if operated in an ambient up to 65°C.

The current circuits of the relays that are rated 5 amperes rms will carry 10 amperes rms continuously and will carry 250 amperes rms for 1 second. The current circuits of the relays that are rated 1 ampere rms will carry 2 amperes rms continuously and will carry 50 amperes rms for 1 second. The potential circuits are rated 69 volts rms line-to-neutral and can withstand 110% of this value continuously.

These relays are available with either short or long impedance ranges as shown in Table I.

TABLE I

AVAILABLE REACHES

CURRENT TRANSFORMER RATING	TYPE	Z_{R1} BASE REACH TAP IN POSITIVE-SEQUENCE OHMS	Z_R IMPEDANCE RANGE IN POSITIVE-SEQUENCE OHMS
5 AMP	SHORT	0.1	0.1 to 1.0
		0.2	0.2 to 2.0
		0.4	0.4 to 4.0
5 AMP	LONG	0.75	0.75 to 7.5
		1.5	1.5 to 15
		3.0	3 to 30
1 AMP	SHORT	0.5	0.5 to 5.0
		1.0	1.0 to 10.0
		2.0	2.0 to 20.0
1AMP	LONG	3.75	3.75 to 37.5
		7.5	7.5 to 75.0
		15.0	15.0 to 150.0

Selection of the desired base-reach tap (Z_{R1}) is made by means of the four tap screws at the lower rear of the relay (see Figure 4). All four tap screws (ØA, ØB, ØC, and neutral) must be in equal ohmic-tap positions.

The relay reach (Z_R) of the relay is continuously adjustable, within the range shown in Table I for a particular tap, by means of a three-gang precision potentiometer at the lower front of the relay (see Figure 5). The 10-turn dial of this potentiometer is calibrated in percent restraint setting (T) and is adjustable from 10% (fully counterclockwise) to 110% (fully clockwise). The maximum recommended setting is 100%. An enlarged picture of the dial is shown in Figure 15.

The relay reach is given by equation(1):

$$\text{Relay Reach} = Z_R = \frac{100 \times Z_{R1}}{T} \qquad (1)$$

where T = Restraint setting in percent

Z_R = Relay reach in ohms

Z_{R1} = Base reach tap in position-sequence ohms

The relay should be within 5% of the value given by equation (1) if the ambient temperature is within the rated range of – 20°C to + 55°C.

SURGE-WITHSTAND CAPABILITY

These relays will withstand ANSI C37.90A-1974 surge test without incorrect operation or damage to any component.

POWER SUPPLY

Models are available with ratings of 48 volts DC (38 to 56 volts), 110 volts DC (88 to 120 volts), or 125 volts DC (100 to 140 volts). The power supply contains a DC-to-DC converter to provide isolation between the DC input control power and the solid-state circuitry of the relay. On relays with DC control voltage in excess of 125 volts, an external pre-regulator is used. This reduces the control voltage to 125 volts, suitable for input to the relay terminals.

CONTACTS

All three of the output contacts of the Type SLYG81A will make and carry 30 amperes for tripping duty, but their continuous-current ratings are limited by the target ratings as listed in Table III. The interrupting ratings are given in Table II.

TABLE II

INTERRUPTING RATINGS OF OUTPUT CONTACTS

	AMPS	
AC VOLTS	INDUCTIVE††	NON-INDUCTIVE
115	0.75	2.0
230	0.5	1.0
DC VOLTS		
48	1.0	3.0
125	0.5	1.5
250	0.25	0.75

††The inductive rating is based on an L/R ratio of 0.04 second

TARGET

Targets having 0.6 and 2 ampere taps are provided for the output contacts between studs 11 and 12 and between studs 13 and 14. The ratings of each of these targets are given in Table III.

TABLE III

TARGET RATINGS

	0.6 Amp Tap	2.0 Amp Tap
Minimum Operating	0.6 amps	2.0 amps
Carry Continuously	1.2 amps	2.6 amps
Carry 30 Amps for	0.5 sec.	3.5 secs.
Carry 10 Amps for	5 secs.	30 secs.
DC Resistance	0.78 ohm	0.18 ohm
60 Hertz Impedance	6.2 ohms	0.65 ohm

CHARACTERISTICS

OPERATING PRINCIPLES

The mho characteristic in the SLYG81 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 (X_A, X_B, $X_{C,\ and}$ X_O) that are air gap reactors with secondary windings. The transactors are tapped on the primary to provide the basic ohmic tap selection of 0.1, 0.2 or 0.4 ohms for the 5 ampere short-reach relay or 0.75, 1.5 or 3 ohms for the 5 ampere long-reach relay. The 1-ampere-rated relay taps are 0.5, 1.0, or 2.0 ohms for the short-reach relay and 3.75, 7.5 and 15 ohms for the long-reach relay.

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 of the relay.

Two additional quantities ("I_0Z_{R0}" and "$cK_0I_0Z_{R0}-V_0$") are also compared to provide security for faults other than single-line-to-ground.

The phase angle between the four signals is compared in a "Coincidence Logic" (CL) circuit that puts out a rectangular voltage pulse when these signals are coincident. The width of this block of voltage is measured by an "Integrating Timer" (IT) circuit which provides a trip-signal output when the pulse width exceeds a preset duration. If the timer is set for 90° (that is, 4.16 milliseconds in a 60 hertz system or 5 milliseconds in a 50 hertz system), a circular R-X characteristic is obtained. If the timer is set for less than 90°, an expanded (tomato shaped) characteristic is obtained. If the timer is set for more than 90°, a contracted circle (lens shaped) is obtained. Relays are shipped from the factory with the timer set for 90°.

The timing diagram for a typical condition is shown in Figure 8.

If the 100% restraint setting is used and K_0 is set equal to the ratio of Z_0'/Z_1', phase-to-neutral reach of the relay at the angle Ø is equal to the IZ base-reach tap chosen. If a voltage tap other than 100% is chosen, reach is increased in inverse proportion to the voltage tap. For example, if the 50% voltage tap is used, relay operation still occurs for the same voltage applied to the measuring circuit, but since the actual line voltage is twice this amount, the relay reach is twice as great.

Relay reach at the angle of maximum reach can be calculated from the expression:

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

where: T = restraint setting in percent

Z_{R1} = base-reach tap setting in positive-sequence ohms

Z_R = relay-reach in positive-sequence ohms

To set the relay for the desired reach, it is necessary first to select the proper "Base Reach Tap". This tap should be the highest "Base Reach Tap" that is smaller than the desired ohmic reach. The setting of the "Base Reach Tap" is explained under the section titled CONSTRUCTION in this book. After the "Base Reach Tap" is selected, the "Percent Restraint Setting" may now be chosen to produce the required relay reach.

OPERATING TIME

Operating time is a function of the length of line being protected, the source impedance and the location of the fault. Figure 9 shows the average operating time for a Type-SLYG81A relay when set for first zone protection of a typical 100 mile radial transmission line with a source impedance equivalent to a 25 mile line. Figure 10 shows the average operating time for the same line when the relay is set for second-zone protection.

SENSITIVITY

Sensitivity is defined as the steady-state rms voltage or current (at the relay terminals) required for a particular quantity to pick up the relay if all quantities are in the optimum phase relationship. The nominal sensitivities for the sign in the SLYG81A relay are as follows:

1. Polarizing #1 Sensitivity (Quadrature Polarizing)
   Sensitivity is 10% of rated voltage

2. Polarizing #2 Sensitivity
   Sensitivity is 1.25 volts $(-V_0 + cK_0 I_0 Z_{R0})$

3. Overcurrent Supervision Sensitivity $I_0 Z_{R0}$
   $3I_0 \geqq 0.2 \frac{3}{Z_{R1}}$ amperes   For $Z_{R1} = 3$ ohms, $3I_0 = 0.2$

4. Operate Circuit Sensitivity

   See Figure 11 for sensitivity in terms of $V_{LN} \frac{(\%T)}{100}$

To determine current sensitivity, the ratio of I_0 to I_ϕ must be known or assumed, and the ratio of Z_{0L} to Z_{1L} must be known. The current sensitivity can then be determined from the formula:

$$(I_\phi - I_0) Z_{R1} + I_0 K_0 Z_{R0} = \frac{0.16}{1-X}$$

where

$$X = \frac{\text{actual reach}}{\text{nominal reach}}$$

For example, if $I_\phi = 3I_0$ and $K_0 Z_{R0} = 3Z_{R1}$

then $2/3\, I_\phi Z_{R1} + I_\phi Z_{R1} = \frac{0.16}{1-X}$

if $X = 0.8$,

$$5/3\, I_\phi Z_{R1} = \frac{0.16}{1-.8} = 0.8$$

$I_\phi = \frac{0.48}{Z_{R1}}$ For $Z_{R1} = 3$ ohms, $I_\phi = 0.16$ amperes

BURDENS

The potential-circuit burden per phase at 69 volts rms line-to-neutral voltage is as follows:

0.2 volt-amperes
0.17 watts
0.10 vars

The impedance of each current circuit, measured at its rated current, is shown in Table IV below. The values are given in ohms.

TABLE IV

	5 AMPERE RATED RELAY		1 AMPERE RATED RELAY	
	PHASE	GROUND	PHASE	GROUND
Z	0.030	0.018	0.210	0.160
R	0.027	0.018	0.200	0.150
X	0.013	0.002	0.065	0.050

The overall current drains of the DC control-power input (Studs 19 and 20) are as follows:

RATED VOLTAGE IN DC VOLTS	RELAY K2	INPUT CURRENT IN MILLIAMPERES
48	Dropped Out	200
48	Picked up	315
110	Dropped Out	90
110	Picked Up	175
125	Dropped Out	80
125	Picked Up	155
250	Dropped Out	260†
250	Picked Out	260†

† Input to studs A and C of external pre-regulator.

CIRCUIT DESCRIPTION

The internal connections for the Type-SLYG81A relay are shown in Figure 2. The terminal numbers at the top and bottom of this diagram represent the external connections to the relay. The external connections can be grouped as shown in Table V.

TABLE V

EXTERNAL CONNECTIONS

TERMINAL NUMBERS	DESCRIPTIONS
1 through 8	AC Current Inputs
9	Contact (Other End Connected to #19)
10	Surge Ground
11 through 14	Contacts with Targets
15 through 18	AC Potential Inputs
19 through 20	DC Control Power Input

The phase-to-neutral input voltages are connected to the primaries of 10:1 step-down transformers (TA, TB and TC). One secondary of these potential transformers is connected to the signal processing (SP) card as well as to a three-gang precision potentiometer. The voltages on the sliders of the potentiometer are also connected as inputs to the SP card.

A second set of secondaries on these potential transformers is connected in broken delta to derive the V_0 signal required as an input to the SP card.

The input phase currents pass through the primaries of transactors (XA, XB and XC). These transactors produce secondary voltages proportional to their primary currents in magnitude; however, the secondary voltages lead their respective primary currents by a phase angle of 85°. The input zero-sequence current passes through the primary of a transactor (X0) similar to XA, XB and XC except that the secondary voltage of X0 leads its primary current by 75°. The secondary voltages of all four transactors are connected to the SP card.

The SP card combines the above mentioned quantities to produce various output signals that are then fed as inputs to other cards. Table VI indicates the types of output signals produced by the SP card, and which other card are fed by each signal.

TABLE VI

OUTPUTS FROM SP CARD

OUTPUT SIGNAL FROM SP CARD	INPUT TO CARD
$V_{AN}, V_{BN}, V_{CN}, -V_{AN}, -V_{BN}, -V_{CN}$	Quadrature Polarizing (QP)
$cK_0I_0Z_{R0} - V_0$	Coincidence Logic (CL)
$(I_A - I_0) Z_{R1} + K_0I_0Z_{R0} - TV_{AN}$	
$(I_B - I_0) Z_{R1} + K_0I_0Z_{R0} - TV_{BN}$	Operate Signal (0S)
$(I_C - I_0) Z_{R1} + K_0I_0Z_{R0} - TV_{CN}$	

The "Quadrature Polarizing" (QP) card produces a voltage $V_{BC} \angle 90°$ ($j V_{BC}$) by algebraic summations of V_{BN} and V_{CN}. This j VBC is then filtered in an active band-pass filter with a natural frequency (f_0) equal to system frequency. Similarly-filtered jV_{CA} and jV_{AB} voltages are produced in the QP card and all three outputs are fed to the CL card as the main (1) polarizing voltages.

The "Operate Signal" (OS) card filters its signals from the SP card in active band-pass filters with natural frequencies equal to system frequency. Circuitry is also provided to bypass this filtering for (IZ-TV) signals of large magnitudes. The outputs of the OS card are fed to the CL card as operating signals.

Each phase of the CL card has four input signals and produces a high logic (+15 volts DC) output signal whenever these signals have the proper instantaneous phase relationship. Table VII shows the various input signals for one phase and where the signals are obtained. In order for the output of CL to be high, inputs 1, 3 and 4 must have the same polarity and input 2 must have an opposite polarity.

TABLE VII

INPUTS TO CL CARD

INPUT NO.	INPUT SIGNAL	DERIVED FROM
1	Quadrature Polarizing	QP Card
2	Operate Signal	OS Card
3	$cK_0I_0Z_{R0} - V_0$	SP Card
4	I_0Z_{R0}	X_0 Transactor

The output of the CL card has a high logic value if any one, or more, of its phases has the proper phase relationship between its input signals.

The CL card output is fed to the integrating-timer (IT) card, which measures the time that the CL output signal is high. If the input signal to the IT card is high for 4.16 milliseconds on a repetitive basis (50 hertz relay - 5.0 milliseconds) (or 5.5 milliseconds on a single-shot basis) (50 hertz relay - 6.0 milliseconds), the output of the IT card will go to a high logic value, which picks up a reed relay (K1) mounted on the power-supply (PS) card. A normally-open contact on K1 energizes a telephone relay (K2) mounted on the front panel. Two normally-open contacts of K2 are connected in series with the coils of targets to provide the main tripping contacts (terminal numbers 11 to 12 and 13 to 14). In addition, a third normally-open contact of K2 is connected between terminals 19 and 9, without a target, for auxiliary functions.

The input DC control power (48, 110, or 125 volts) is connected to the power supply (PS) card, which contains a DC-to-DC converter. The outputs of the DC-to-DC converter are + 15 and -15 volts DC regulated, which supply the necessary control power to the other cards. The transformer in the DC-to-DC converter provides isolation between the solid-state circuitry of the relay and the input DC control power (i.e. station battery). A yellow LED monitors the output voltage from this internal power supply.

The internal connections and card layouts for each printed-circuit card are listed in Table VIII. The printed-circuit cards have test points accessible from the front of the cards. Each test point, except the reference connection "OV" on the PS card, is buffered by a resistor to prevent a disturbance to the circuitry if a test point is accidentally short-circuited. The test points are labeled functionally; i.e., the A phase input to the integrating timer is labeled "AIN". The internal connection drawings show the test points with the same label.

TABLE VIII

INTERNAL CONNECTIONS FOR CARDS

CARD DESIGNATION	CARD FUNCTION	FIGURE NUMBER OF INTERNAL CONNECTIONS	FIGURE NUMBER OF CARD LAYOUT
SP	Signal Processing	16A	16B
QP	Quadrature Polarizing	17A or B	17C
OS	Operate Signal	18A or B	18C
CL	Coincidence Logic	19A	19B
IT	Integrating Timer	20A	20B
PS	Power Supply (125 Volts DC)	21A	22
PS	Power Supply (48 Volts DC)	21B	22
PS	Power Supply (110 Volts DC)	21C	22

CALCULATION OF SETTINGS

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

$$Z_1 = 42 \angle 83°, Z_0 = 130 \angle 78°$$

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

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

$$Z_0 sec = 130\left(\frac{1000}{5}\right)\left(\frac{1}{2000}\right) = 13 \angle 78°$$

FIRST ZONE RELAY SETTING

The first-zone relay can be set up to 85% of the line impedance for positive-sequence impedance angles above 75° and 80% for positive-sequence impedance angles above 70°. For line angles lower than 70°, refer to the local GE Sales Office. Hence the reach ZR = 0.85 (4.2) = 3.57 ohms.

(a) Select Z_{R1} (phase base-reach tap). The highest tap should be selected that is less than ZR, which, in this case, is the 3 ohm tap on the long-reach relay.

(b) Select Z_{R0} (neutral base-reach tap) and the K0 multiplier such that:

$$\frac{K_0 Z_{R0}}{Z_0 sec} \leq \frac{Z_{R1}}{Z_1 sec}$$

In general, Z_{R0} will equal Z_{R1}, and hence the K_0 tap (2.5, 3.5, 4, 4.5) will be selected to be equal to or slightly less than Z_0 sec/Z1 sec, or, in this case, 13/4.2 = 3.09; select K_0 = 3.

(c) Select restraint setting (10% to 100%). The restraint setting is obtained from the formula:

$$T = \frac{Z_{R1}}{Z_R}(100\%) = \frac{3.0}{3.57}(100) = 84.0\%$$

NOTE:	SEE THE **CONSTRUCTION** SECTION OF THIS BOOK FOR DETAILS ON HOW TO OBTAIN THE BASE REACH TAP AND RESTRAINT SETTING CALCULATED IN THIS SECTION.

SECOND-ZONE RELAY SETTING

The second-zone relay is set in the same manner as the first-zone relay except that a different reach is required. Assume that the second-zone unit is used in a directional-comparison scheme and a reach of 175% is desired, Z_R = 1.75 (4.2) = 7.35 ohms.

(a) Select Z_{R1}. Use 3 ohm base tap.

(b) Select Z_{R0} and K_0. Use Z_{R0} = 3 ohms and K_0 = 3, the same as the first-zone relay.

(c) Restraint Setting

$$\frac{Z_{R1}}{Z_1}100 = \frac{3}{7.35}(100) = 40.8\%$$

NOTE:	THE K_0Z_{R0} SETTING SHOULD NOT BE GREATER THAN TWICE THE ZERO-SEQUENCE IMPEDANCE OF THE LINE.

CONSTRUCTION

The type-SLYG81A relay is assembled in a deep, large-sized, double-ended (L2D) drawout case having studs at both ends in the rear for external connections. The electrical connections between the relay unit and the case studs are through stationary molded inner and outer blocks, between which nests a removable connecting plug that completes the circuits. The outer blocks attached to the case have the studs for the external connections, and the inner blocks have the terminals for the internal connections.

Every circuit in the drawout case has an auxiliary brush, as shown in Figure 12, to provide adequate overlap when the connecting plug is withdrawn or inserted. Some circuits are equipped with shorting bars (see internal connections in Figure 2), and on these circuits it is especially important that the auxiliary brush make contact, as indicated in Figure 12, with adequate pressure to prevent the opening of important interlocking circuits.

The relay is mounted in a steel framework called the cradle and is a complete unit, with all leads terminated at the inner blocks. This cradle is held firmly in the case with a latch at both top and bottom and by a guide pin at the back of the case. The connecting plug, besides making the electrical connections between the respective blocks of the cradle and case, also locks the latch in place. The cover, which is drawn to the case by thumbscrews, holds the connecting plugs in place. The target reset mechanism is a part of the cover assembly.

The relay case is suitable for either semiflush or surface mounting on all panels up to two inches (2") thick and appropriate hardware is available. However, panel thickness must be indicated on the relay order to make sure that proper hardware is available. Outline and panel drilling is shown in Figure 13. For DC supply voltages greater than 125 volts it is necessary to use an external pre-regulator.

The pre-regulator is packaged in a box made from compound plates and perforated steel siding. It can be mounted on the rear of the relay or at a convenient location near the relay. The outline and mounting dimensions for the pre-regulator are shown in Figure 28.

A separate testing plug can be inserted in place of the connecting plug to test the relay in place on the panel, either from its own source of current and voltage, or from other sources. Or the relay can be drawn out and replaced by another that has been tested in the laboratory.

The potential transformers (TA, TB and TC) and the transactors (XA, XB, XC and X0) are mounted at the rear of the cradle as shown in Figure 4. The tap block below the transactors is used to set the base reach to the value determined in the **CALCULATION OF SETTINGS** section of this book. The four leads tagged A, B, C and N should be connected to the desired ohmic value labeled ØA, ØB, ØC and NEUT respectively. For example, Figure 4 shows a base reach (Z_{R1}) setting of 0.4 ohms and the leads are connected as follows:

lead C ----------→ position 1
lead B ----------→ position 4
lead A ----------→ position 7
lead N ----------→ position 10

A base-tap indicator is provided on the nameplate. The knob should be rotated until the number corresponding to the base-reach setting is exposed.

Figure 14 shows a front view of the relay with the nameplate removed. This view shows the targets, the telephone relay and all adjustments other than the base-reach tap described above.

The dial of the restraint-setting potentiometer (T) is calibrated directly in percent with the number in the window indicating the 10's digit and two digits on the dial indicating the units and decimal digits. An example is shown in Figure 15 with a setting of 84%. The dial can be adjusted from 10% to 110%. The lock must de disengaged (by turning the lever counterclockwise) in order to change the restraint setting, but should be engaged again after the desired setting is made.

The value of "K_0" selected in the **CALCULATION OF SETTINGS** section is set by means of the K0 plug indicated in Figure 14. This plug should connect the horizontal jacks labeled "2.5", "3.0", "3.5", "4.0" or "4.5" on the SP card to obtain a K_0 value of 2.5, 3.0, 4.0 or 4.5 respectively.

The other adjustments indicated in Figure 14 are trim potentiometers located on printed-circuit cards. These adjustments are set in the factory and should not normally require readjustment. See the ACCEPTANCE TESTS section of this book for the recommended procedures if readjustment is required.

RECEIVING, HANDLING AND STORAGE

These relays, when not included as a part of a control panel, will be shipped in cartons designed to protect them against damage. Immediately upon receipt of a relay, examine it 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 notify the nearest General Electric Sales Office.

Reasonable care should be exercised in unpacking the relay in order that none of the parts are injured nor the adjustments disturbed.

If the relays are not to be installed immediately, they should be stored in their original cartons in a place that is free from moisture, dust and metallic chips. Foreign matter collected on the outside of the case may find its way inside when the cover is removed and cause trouble in the operation of the relay.

ACCEPTANCE TESTS

Immediately upon receipt of the relay an INSPECTION AND ACCEPTANCE TEST should be made to make sure that no damage has been sustained in shipment and that the relay calibrations have not been disturbed.

These tests may be performed as part of the installation or of the acceptance tests, at the discretion of the user. Since operating companies use many different procedures for acceptance and installation tests, the following section includes applicable tests that may be performed on these relays.

VISUAL INSPECTION

Check the nameplate stamping to make sure that the model number and rating of the relay agree with the name requisition.

Remove the relay from its case and that there are no broken or cracked molded parts or other signs of physical damage, and that all screws are tight.

MECHANICAL INSPECTION

Case and Cradle Blocks

Check that the fingers on the cradle and the case agree with the internal-connection diagram. Each cradle finger should be flush or project above the barrier between fingers. Check that there is a coil spring under each finger. The case fingers, if not held down by a shorting bar, should come within one-sixteenth of an inch (1/16") of touching a straight-edge bridging the case block from side to side. If held down by a shortening bar, it should require at least one pound force (450 grams) to open the electrical circuit between the finger and the shortening bar. See Figure 12. Check that each auxiliary brush extends above the barrier fingers.

Target Unit

The target unit has an operating coil tapped at 0.6 and 2.0 amperes. The relay is shipped from the factory with the tap screw in the higher ampere position. The tap screw is the screw holding the right-hand tap plate. To change the tap setting, first remove one screw from the left-hand plate and place it in the desired tap on the right-hand plate. Next remove the screw from the undesired tap (on the right-hand plate) and place it on the left-hand plate where the first screw was removed. Following this procedure maintains the contact adjustments. See Figure 14. Screws should **never** be left in **both** taps at the same time.

TABLE IX

TARGET PICKUP CURRENTS

TAP	PICKUP CURRENT IN AMPERES
0.6	0.35 - 0.6
0.2	1.15 - 2.0

The backing strip should be so formed that the forked end (front) bears against the molded strip under the armature. **Since mechanical adjustments may affect the Seismic Fragility Level, it is advised that no mechanical adjustments be made if seismic capability is of concern.**

Telephone Relay

With telephone relays in the de-energized position all circuit-closing contacts should have a gap of at least 0.015 inch and all circuit-opening contacts should have a wipe of 0.005 inch. Gap may be checked by inserting a feeler gage between the contacts, and wipe can be checked by observing the amount of deflection on the stationary contact before parting the contacts. The armature should then be operated by hand and the gap and wipe again checked as described above (0.015" gap, 0.005" wipe).

ELECTRICAL TESTS, GENERAL

All alternating-current-operated devices (AC) are affected by frequency. Since non-sinusoidal waveforms can be analyzed as a fundamental plus harmonics of the fundamental frequency, it follows that alternating-current devices (relays) will be affected by the applied waveform. Therefore, in order to test alternating-current relays properly it is essential to use a sine-wave source of current and voltage.

DIELECTRIC TESTS

1. Introduction

The surge capacitors used in the type SLYG relay do not have voltage ratings to withstand AC hipot voltage; therefore, caution must be exercised when hipotting to avoid damaging these capacitors.

It is recommended that hipot tests be performed on a bench with the relay in its case. If the relay is to be hipot tested together with other apparatus in an equipment, **all** external connections to terminal 10 (surge ground) **must** be removed.

The hipot test voltage should be 1500 volts rms, 50 or 60 hertz for new relays, or 1125 volts rms, 50 or 60 hertz for other relays. New relays are defined as those that have not been in service, that are not more than one year old from the date of shipment, and that have been suitably stored to prevent deterioration. The duration of application of the test voltage should be 60 seconds.

2. Hipot Tests

(a) Common-Mode Hipot Tests (All terminals to case):

Temporary connections should be made to tie together all relay terminals, including terminal 10 together. Hipot voltage can then be applied between this common connection and the relay case.

(b) Transverse-Mode Hipot Tests (Between circuits):

For hipot tests between circuits of the relay, the surge capacitors must be temporarily disconnected from the surge capacitor buses inside the relay. The relay terminals should be jumpered to provide the four groups of circuits shown in Table X. Hipot voltage can then be applied between any two groups of circuits.

TABLE X

CIRCUIT GROUPING FOR TRANSVERSE-MODE HIPOT TESTS

CIRCUIT GROUP	JUMPER BETWEEN TERMINAL NUMBERS
AC Current	1, 2, 3, 4, 5, 6, 7 and 8
AC Potential	15, 16, 17 and 18
DC Control Power	9, 19 and 20
Output Contacts	11, 12, 13, and 14

An alternate test using a 500 volt DC Megger™ can be performed between the circuit groups of Table X with the surge capacitors connected in their normal manner. While this method does not test the relay to its full dielectric rating, it will detect some cases of degraded insulation.

3. Restoring Relay to Service

After the hipot or megger™ testing is completed, the surge capacitors should be reconnected to the surge capacitor buses, and all external wiring to terminal 10 should be reconnected. The reach tests described under the **ACCEPTANCE TESTS** section of this book should then be repeated.

DETAILED TESTING INSTRUCTIONS

1. Required Settings

Make certain all the relay settings have been made. These should be in accordance with the setting calculations. The settings are:

(a) Base reach (Z_{R1}) is set on the tap block at the rear of the relay. All three phase settings should be the same. The "Neutral" reach will normally be the same as the phase reach.

(b) Percent restraint (T) is set on the precision potentiometer on the front of the relay.
(c) Zero-sequence current compensation (K_0) is set by means of the K_0 plug on printed-circuit card "SP".

2. Relay Base-Reach Angle and Reach Check

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

a) Make the test connections shown in Figure 23 for the particular phase being tested.

b) Adjust the load box until the ammeter indicates the desired test current (I_T). See Table XI for the recommended test current for a desired reach.

TABLE XI

RECOMMENDED TEST CURRENT

5 AMPERE RATED RELAY		1 AMPERE RATED RELAY	
BASE REACH TAP	RECOMMENDED MINIMUM TEST CURRENT	BASE REACH TAP	RECOMMENDED MINIMUM TEST CURRENT
0.1	20††	0.5	4††
0.2	20††	1.0	4††
0.4	10††	2.0	2
0.75	8	3.75	1.6
1.5	4	7.5	0.8
3	2	15	0.4

†† The relay is not rated to carry this current continuously. It should not be applied longer than five (5) minutes, with an off time of at least five (5) minutes.

c) Adjust the phase for the nominal base-reach angle of 80°.

d) Observe the waveform at the following test point (on OS card) with an oscilloscope.

1) "AOUT" for phase A
2) "BOUT" for phase B
3) "COUT" for phase C

e) Lower the voltage V_T to the value given in equation (2) below:

$$V_T = \left[2 + K_0\left(\frac{Z_{R0}}{Z_{R1}}\right)\right]\left[\frac{I_{IN} Z_{R1}}{3T/100}\right] \quad (2)$$

where

I_N = operating current

K_0 = zero-sequence current compensation tap setting (plug on SP card)

T = restraint voltage setting in percent

V_T = pickup voltage at the base-reach angle in volts rms

Z_{R1} = base-reach tap in ohms

f) As the voltage is lowered, observe the waveform at the test point designated in step d) above. At the point where the telephone relay (K2) picks up, a slight adjustment of the phase angle and input voltage will cause the waveform to be reduced to a null consisting of only third and fifth harmonics. At this null point (2) the angle on the phase-angle meter is the base-reach angle, Ø, and should be within two degrees (2°) of the nominal value of 80°. The voltage V_T at this null condition should be within five percent (5%) of the value calculated by equation (2).

NOTE: THE MEASURED PICKUP SHOULD AGREE WITH THE CALCULATED VALUE WITHIN ± 5%. IF THE VALUES DO NOT AGREE WITHIN THESE LIMITS, IT IS RECOMMENDED THAT THE TEST SETUP AND METER CALIBRATIONS BE CHECKED BEFORE THE FACTORY SETTINGS ON THE RELAY ARE DISTURBED. ONE GOOD METHOD OF CHECKING THE TEST SETUP AND PROCEDURE IS TO REPEAT THE TESTS ON A DUPLICATE RELAY.

g) If it is desired to readjust the reach so that measured pickup occurs at a value closer to the calculated value, this may be accomplished by means of the trim potentiometers on the SP card. The potentiometer to be adjusted for each phase is shown in Table XII. These potentiometers should be turned clockwise to increase the reach.

TABLE XII

REACH ADJUSTMENTS LOCATIONS

PHASE UNDER TEST	POTENTIOMETER DESIGNATION	POTENTIOMETER LOCATION
A	P1	Top
B	P2	Middle
C	P3	Bottom

3. Testing Mho Characteristics

The complete mho characteristic (see Figure 6) can be measured by the same test circuit (Figure 23) as used for the preceding Reach Tests. The procedure is similar except that the phase shifter is adjusted until the phase-angle meter indicates the angle of interest. Reduce the voltage out of the variable autotransformer until the relay picks up; value of V_{IN} at this point should be:

$$†VIN = \left|2 + K_0\left(\frac{Z_{R0}}{Z_{R1}}\right)\right|\left[\frac{IINZR1}{3T/100}\right] cos\,(\alpha - \phi) \quad (3)$$

† V should not be more than 10% above the relay rated voltage. If V is greater, reduce I until V is correct.

where α = angle read by phase-angle meter in degrees.
ϕ = 80° = angle of maximum reach in degrees.

All other parameters are as defined under equation (2).

4. Alternate Test Method for Reach Tests

An alternate method of testing the relay characteristic is shown in Figure 24, where the R-X test combination is employed. The circuit uses the test box (102L201), test reactor (6054975) and test resistor (6158546) described in GEI-44236. Since a limited number of resistor-reactor fault impedances are available, only a few points on the relay characteristic can be checked.

5. Integrating-Timer Tests

The integrating timer (IT) card has three adjustments as indicated in Table XIII.

TABLE XIII

TIMER ADJUSTMENT LOCATIONS

POTENTIOMETER DESIGNATION	POTENTIOMETER LOCATION	FUNCTION	60Hz RELAY FACTORY SETTING MILLISECONDS	50 Hz RELAY FACTORY SETTING MILLISECONDS
P1	Bottom	Transient Pickup Time	5.5 ms	6.6 ms
P2	Top	Steady State Pickup Time	4.16 ms	5.0 ms
P3	Middle	Dropout Time	5.0 ms	6.0 ms

These potentiometers have been factory set and should not be adjusted unless a plot of the mho characteristic indicates an improper pickup-time setting. The timer has a 5.5,4/5 (50 Hz-6.6,5/6) time setting. The P1 potentiometer, used for transient operation, has been set in coordination with the P2 potentiometer at the factory and sealed. Potentiometer P1 must **not** be readjusted. Potentiometer P2 is set for a 4.26 milliseconds (50 Hz-5.0 milliseconds) pickup time. The 4.16 milliseconds (50 Hz-5.0 milliseconds) time is important in making the 90° measurement and affects the shape of the mho characteristic; times characteristic. Turning the P2 potentiometer clockwise will increase the pickup time delay. Potentiometer P3 is set for 5 millisecond (50 Hz-6.0 milliseconds) dropout-time delay. Turning the P3 potentiometer clockwise will increase the dropout-time delay.

The test circuit of Figure 23 may be used to check the steady-state pickup time setting. A dual-trace oscilloscope should be used, with channel "A" connected to test point "A_{IN}" on the IT card and channel "B" on test point "OUT" on the IT card. Connect unused inputs "AIN","BIN" or "CIN" on IT card to "OV" test point on PS card. In order to observe the pickup-time delay, the dropout-time delay must be reduced by turning P3 counterclockwise so that the output resets each half cycle. Reduce "V_{IN}" until the relay picks up; the output (channel B) should go positive 4.16 milliseconds (50Hz-5.0 milliseconds) after the input (channel A) goes positive. After the pickup time is checked, P3 should be turned clockwise until the output (channel B) produces a continuous positive signal. P3 should then be turned clockwise for one additional turn.

As a final check on the accuracy of the 4.16 milliseconds (50 Hz-5.0 milliseconds), the mho characteristic may be rechecked and compared with the desired characteristic.

To check the transient pickup-time setting, the following procedure should be used:

(a) Remove the CL card.
(b) Connect the test circuit of Figure 25.
(c) With the oscilloscope trigger on positive slope, open the normally-closed contact. The Channel Two trace should step positive 5.5 milliseconds (50 Hz-6.6 milliseconds) (± 0.1 millisecond) after the Channel One trace steps positive.

INSTALLATION PROCEDURE

INTRODUCTION

The relay should be mounted on a vertical surface. The outline and panel-drilling diagram is shown in Figure 13.

The location should be clean, dry, free from dust or excessive vibration and well lighted to facilitate inspection and testing.

The internal-connection diagram for the relay is shown in Figure 2 and typical external connections are shown in Figure 3.

NOTE:	PHASE SEQUENCE IS CRITICAL FOR THE PROPER OPERATION OF THE TYPE SLYG81A RELAY. PHASE SEQUENCE SHOULD BE CHECKED AT THE RELAY STUDS TO MAKE SURE THAT IT IS 1-2-3 AT RELAY STUDS 15-16-17 RESPECTIVELY.

SURGE GROUND AND RELAY CASE GROUND CONNECTIONS

One of the mounting studs or screws should be permanently connected to ground by a conductor not less than No. 12 AWG copper wire or its equivalent. This connection is made to ground the relay case. In addition, the terminal designated as "surge ground" on the internal-connections diagram must be tied to ground for the surge-suppression networks in the relay to perform properly. This surge-ground lead should be as short as possible to ensure maximum protection from surges (preferably 10 inches or less to reach a solid ground connection).

With Terminal 10 connected to ground, "surge ground" is connected electrically to the relay case. The purpose of this connection is to prevent high-frequency transient potential differences from entering the solid-state circuitry. Therefore, with Terminal 10 connected to ground, the surge capacitors are connected between the input terminals and the case. When hipotting the relay, the procedure given in DIELECTRIC TESTS under the **ACCEPTANCE TESTS** section of this book **must** be followed.

TEST PLUGS

The relay may be tested without removing it from the panel by using a 12XLA13A test plug. This plug makes connections only with the relay and does not disturb any shorting bars in the case. Of course, the 12XLA12A test plug may also be used. Although this test plug allows greater testing flexibility, it also requires current transformer shorting jumpers and the exercise of greater care, since connections are made to both the relay and the external circuitry. Additional information on the XLA test plugs may be obtained from instruction book GEI-25372.

INSTALLATION TESTS

Since operating companies use many different procedures for acceptance and for installation tests, the section under **ACCEPTANCE TESTS** contains all necessary tests that may be performed as part of the installation procedure, at the discretion of the user.

The minimum suggested tests are as follows:

1. VISUAL INSPECTION

Repeat the items described under **ACCEPTANCE TESTS** - VISUAL INSPECTION.

2. MECHANICAL INSPECTION AND ADJUSTMENTS

Repeat the items described under **ACCEPTANCE TESTS** - MECHANICAL INSPECTION.

3. TARGET UNIT

Set the target unit tap screw in the desired position. The adjustment will not be disturbed if a screw is first transferred from the left plate to the desired tap position on the right tap plate and then the screw in the undesired tap is removed and transferred to the left plate. Screws should **never** be left in **both** tap positions on the right tap plate.

4. REACH TESTS

a) Using the values selected in the **CALCULATION OF SETTINGS** section of this book, set:

- Base reach (Z_{R1}) on the back of the relay
- Percent restraint (T) on the front panel potentiometer
- Zero-sequence current compensation (K_0) on printed- circuit card "SP", the lower right-hand card

b) Measure the relay reach at 80° as described in the **ACCEPTANCE TESTS** section of this book.

PERIODIC TESTING AND ROUTINE MAINTENANCE

In view of the vital role of protective relays in the operation of a power system it is important that a periodic test program be followed. It is recognized that the interval between periodic checks will vary depending upon environment, type of relay and the user's experience with periodic testing. Until the user has accumulated enough experience to select the test interval best suited to his individual requirements it is suggested that the points listed under **INSTALLATION PROCEDURE** be checked at an interval of from one to two years.

Check the items described under **ACCEPTANCE TESTS** - VISUAL INSPECTION and MECHANICAL INSPECTION. Examine each component for signs of overheating, deterioration, or other damage. Check that all connections are tight by observing that the lock washers are fully collapsed.

CONTACTS

Examine the contacts for pits, arc or burn marks, corrosion, and insulating films. For cleaning contacts, a flexible burnishing tool should be used. This consists of a flexible strip of metal with an etch-roughened surface, resembling in effect a superfine file. The polishing action is so delicate that no scratches are left, yet it will clean off any corrosion thoroughly and rapidly. Its flexibility ensures the cleaning of the actual points of contact. Do not use knives, files, abrasive paper or cloth of any kind to clean relay contacts.

ELECTRICAL TESTS

The reach tests described under the ACCEPTANCE TESTS section should be repeated and the results compared against the desired setting. If the measured value is slightly different the from that measured at a previous time, this is not necessarily an indication that the relay should be readjusted. The errors of all the test equipment are often additive and the total error of the present setup may be of opposite sign from the error at the previous periodic test. Instead of readjusting the relay it is recommended that, if the apparent error is acceptable, no adjustment be made and that the error be noted on the relay test record. After sufficient test data has accumulated, it will become apparent whether the measured errors in the setting are due to random variations in the test conditions or are due to a one-time drift in the characteristics of the relay.

SERVICING

CAUTION

Remove ALL power from the relay before removing or inserting any of the printed-circuit boards. Failure to observe this caution may result in damage to and/or misoperation of the relay.

A recommended troubleshooting procedure is shown in Table XIV.

TABLE XIV

TROUBLESHOOTING PROCEDURE

PROBLEM	PROBABLE CAUSE	TROUBLESHOOTING SEQUENCE
I. Relay picks up when it should not.	1. Voltage missing or wrong phase sequence.	1. Set balance input voltage: V_{AN} = 69 V_{BN} = 69∠ − 120 V_{CN} = 69∠ + 120 Check voltages at − V_{AN}, − V_{BN} and − V_{CN} on the QP card test points, which should be balanced at 6.9 volts, and phase sequence V_{AN}, V_{BN}, V_{CN}.
	2. Defective CL card.	2. Change CL card.
	3. Defective reed relay (K1).	3. Change PS card.
II. Relay will not pick up when it should on any of the three phases.	1. + 15 and/or -15 VDC is missing.	1. Check + 15V and -15V test points on PS card. If either of both voltages are not between 14 and 16 volts,check the following: a. Check that rated DC voltage (48 or 125 VDC) is on PS card pin 40(+) to pin 24(-). If not, check input terminals 19(+) to 20(-).
	2. Defective telephone relay (K2) or target (T1).	2. Remove PS card and jumper pins 17 and 40 of the PS card. If the relay does not pick up when power is restored, then K2 or T1 is defective.
	3. Defective reed relay(K1).	3. If the relay picks up with the jumper in the preceding step (2), then remove the jumper and reinsert PS card. Remove the CL card and the relay should pick up.If not, K1 relay is possibly defective. Change the PS card.
	4. Defective IT card.	4. If replacing the PS card in the preceding step (3) does not cause pickup (with the CL card still removed), the IT card is possibly defective. Change the IT card.

TABLE XIV

TROUBLESHOOTING PROCEDURE (Continued)

PROBLEM	PROBABLE CAUSE	TROUBLESHOOTING SEQUENCE
III. Relay will not pick up when it should on one phase, but picks up correctly on another phase.	1. Defective card.	1. Change printed-circuit cards, one at a time, in the followingorder; IT, CL, SP, QP, OS.
	2. Incorrect wiring and/or defectivecard.	2. Check wiring between all magnetics and the SP card. Check wiring between all PC cards. If an error in wiring is found and corrected and the relay still does not pick up, return to preceding step (1) to find defective PC card.
IV. Out of specification in maximum reach + 30° tests.	1. Incorrect steady-state pickup.	1. Set steady-state pickup-time pot and time on IT card recheck other phases
	2. Defective Card.	2. Change printed-circuit cards, one at a time, in the following order; SP, QP, IT, CL, OS.

RENEWAL PARTS

It is recommended that sufficient quantities of renewal parts be carried in stock to enable the prompt replacement of any that are worn, broken or damaged.

Should a printed-circuit card become inoperative, it is recommended that this card be replaced with a spare. A special tool (see Figure 26) is available for removing the printed-circuit cards from their sockets and this tool should always be used for removal (See Caution in **SERVICING** section). In most instances, the user will be anxious to return the equipment to service as soon as possible and the insertion of a spare card represents the most expeditious means of accomplishing this. The faulty card can then be returned to the factory for repair or replacement.

Although it is not generally recommended, it is possible with the proper equipment and trained personnel to repair cards in the field. This means that a trouble-shooting program must isolate the specific component on the card that has failed. By referring to the internal-connection diagram for the card, it is possible to trace through the card circuit by signal checking, and hence determine which component has failed. This, however, may be time consuming, and if the card is being checked in place in its unit, as is recommended, will extend the outage time of the equipment.

CAUTION

Great care must be taken in replacing components on the cards. Special soldering equipment suitable for use on the delicate solid-state components must be used and, even then, care must be taken not to cause thermal damage to the components, and not to damage or bridge over the printed-circuit buses. The repaired area must be recoated with a suitable high-dielectric plastic coating to prevent possible breakdowns across the printed-circuit buses due to moisture or dust.

ADDITIONAL CAUTION

Dual in-line integrated circuits are especially difficult to remove and replace without specialized equipment. Furthermore, many of these components are used on printed-circuit cards that have bus runs on both sides. These additional complications require very special soldering equipment and removal tools, as well as additional skills and training, which must be considered before field repairs are attempted.

When ordering renewal parts, address the nearest Sales Office of the General Electric Company, specify quantity required, name of the part wanted, and the complete model number of the relay for which the part is required.

APPENDIX I

DEFINITION OF SYMBOLS

I_A = total phase A current in relay in amperes rms

I_B = total phase B current in relay in amperes rms

I_C = total phase C current in relay in amperes rms

I_0 = total zero-sequence current in relay in amperes rms

I_T = relay current during test in amperes rms

T = relay voltage restraint setting in percent

V_{AB} = phase-A-to-phase-B voltage in volts rms

V_{BC} = phase-B-to-phase-C voltage in volts rms

V_{CA} = phase-C-to-phase-A voltage in volts rms

V_{AG} = phase-A-to-ground voltage in volts rms

V_{BG} = phase-B-to-ground voltage in volts rms

V_{CG} = phase-C-to-ground voltage in volts rms

V_{AB1} = positive sequence of V_{AB} voltage in volts rms

V_{BC1} = positive sequence of V_{BC} voltage in volts rms

V_{CA1} = positive sequence of V_{CA} voltage in volts rms

V_T = relay voltage during test in volts rms

Z_1 = system positive-sequence phase-to-neutral impedance in ohms

Z_{1L} = line positive-sequence phase-to-neutral impedance in ohms

Z_{1S} = source positive-sequence phase-to-neutral impedance in ohms

Z_2L = line negative-sequence phase-to-neutral impedance in ohms

Z_2S = source negative-sequence phase-to-neutral impedance in ohms

Z_F = system impedance between relay location and fault location in ohms

Z_R = relay reach in ohms

Z_{R1} = base-reach tap in positive-sequence ohms

Z_{R0} = base-reach tap in zero-sequence ohms

$\propto$ = phase-angle meter reading during test in degrees

Ø = relay base-reach angle in degrees

LIST OF FIGURES

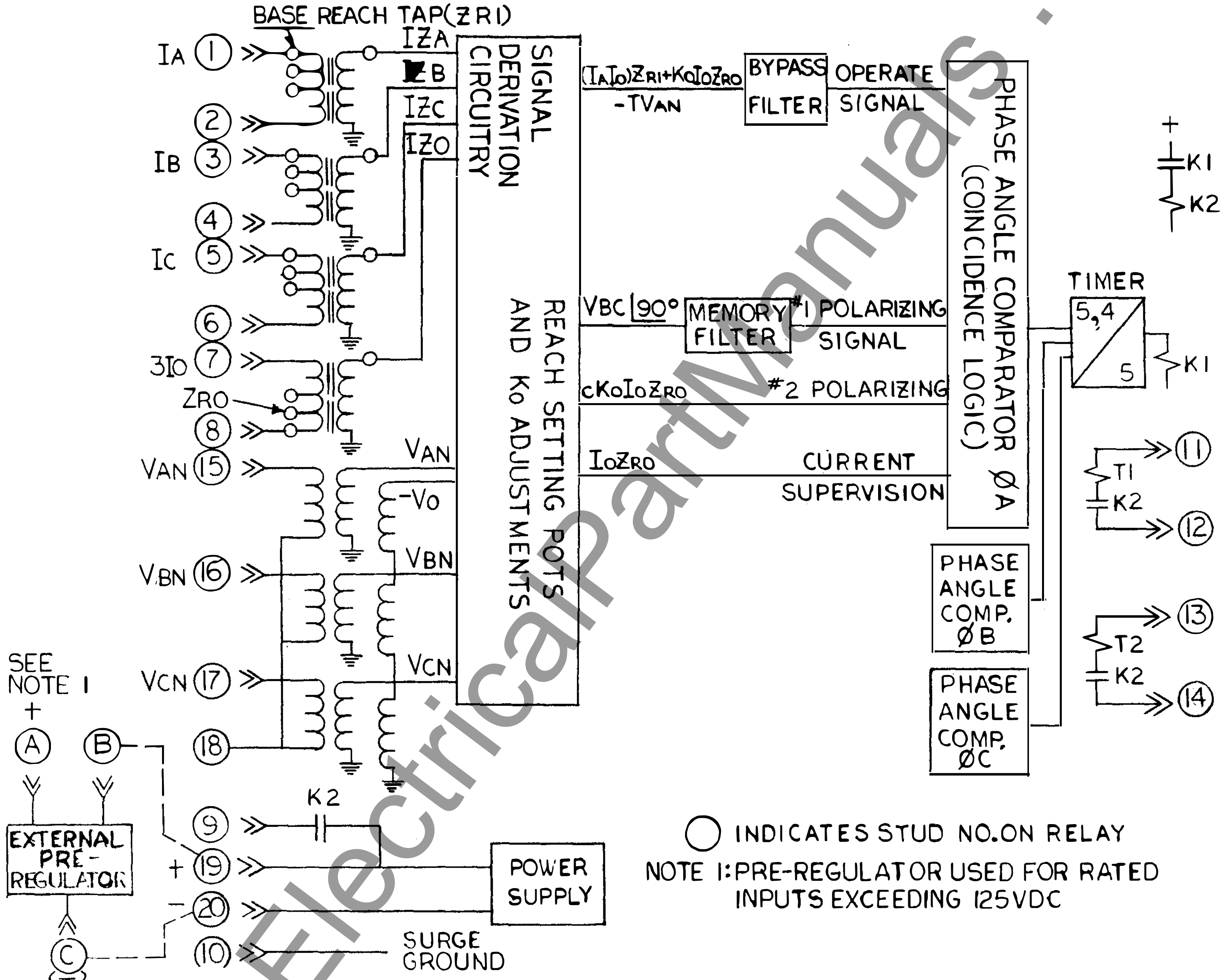


Figure 1 (0257A6179-3) SLYG81A Functional Block Diagram

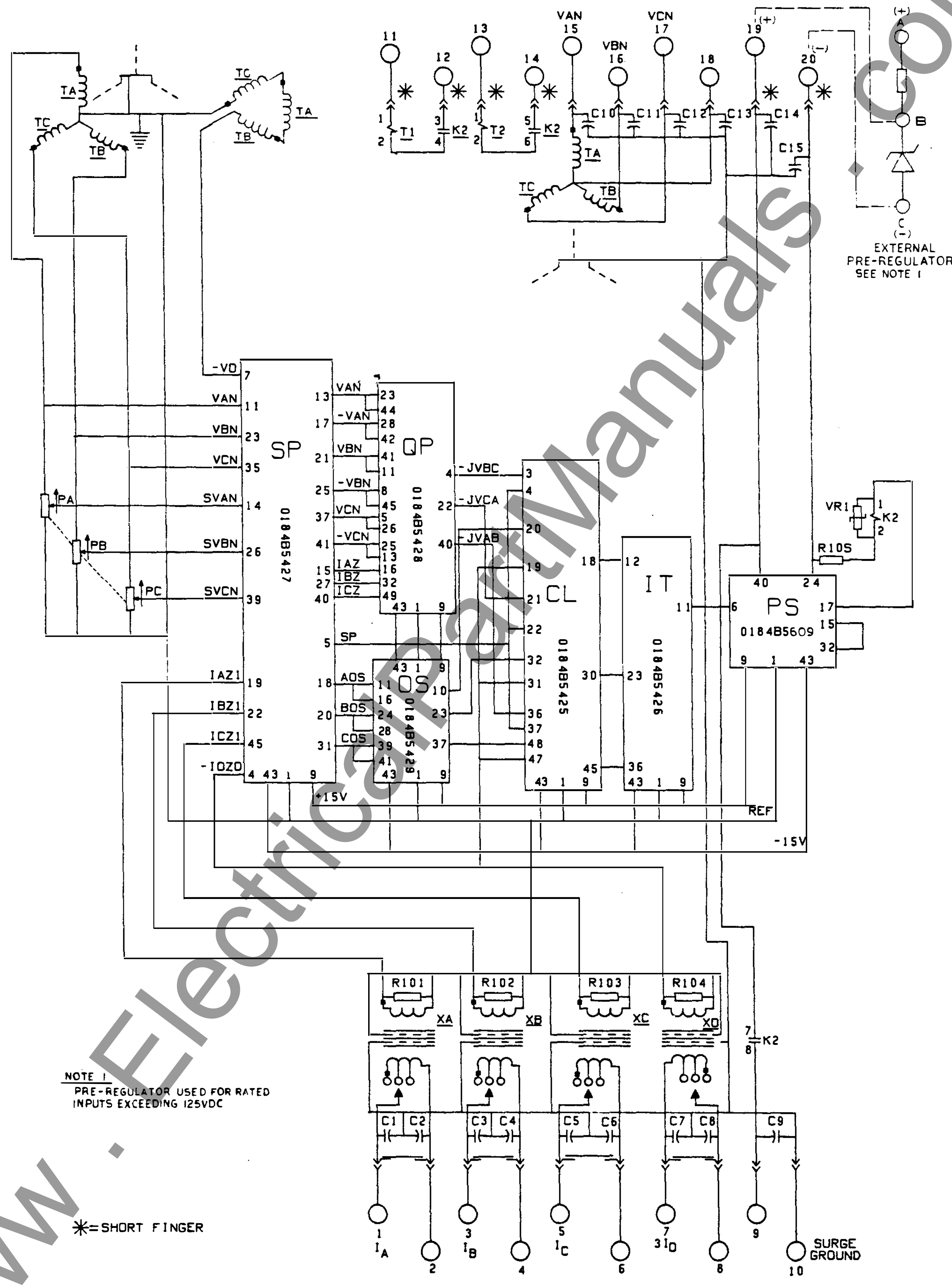


Figure 2 (0171C8426-4) SLYG81A Internal Connections

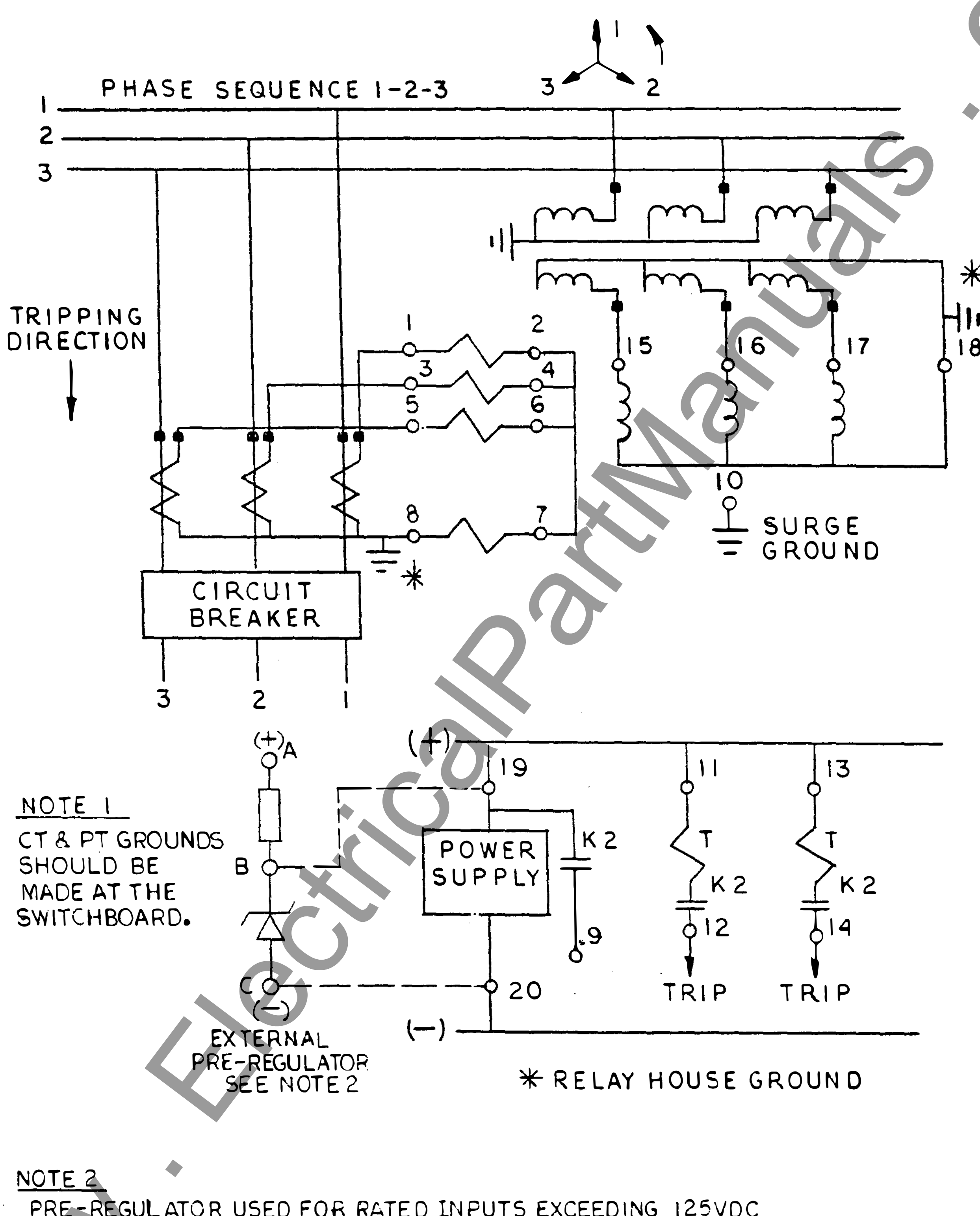


Figure 3 (0257A6175-2) SLYG81A External Connections

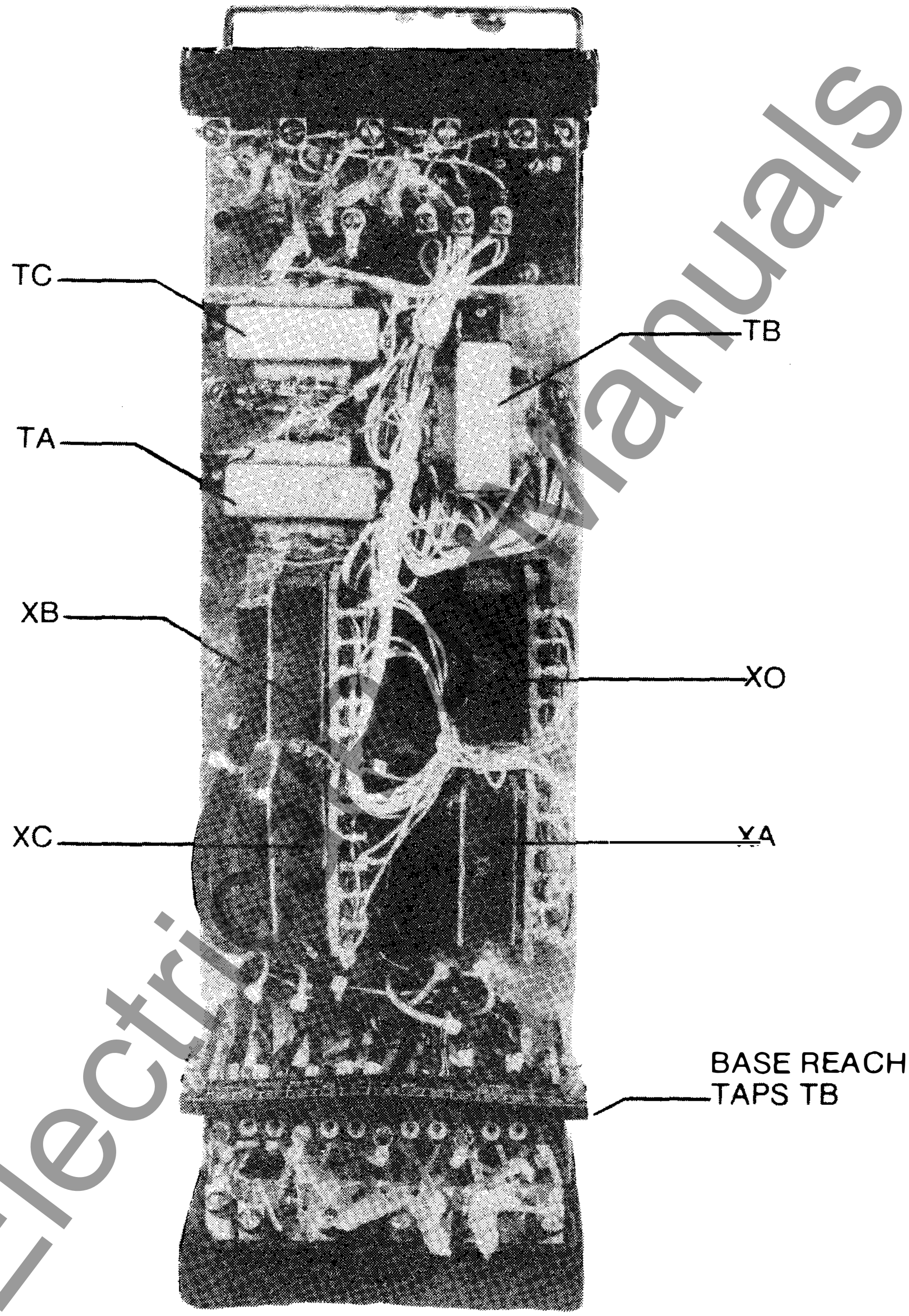


Figure 4 (8043554) Rear View of SLYG81A Short-Reach Model, Out of Case

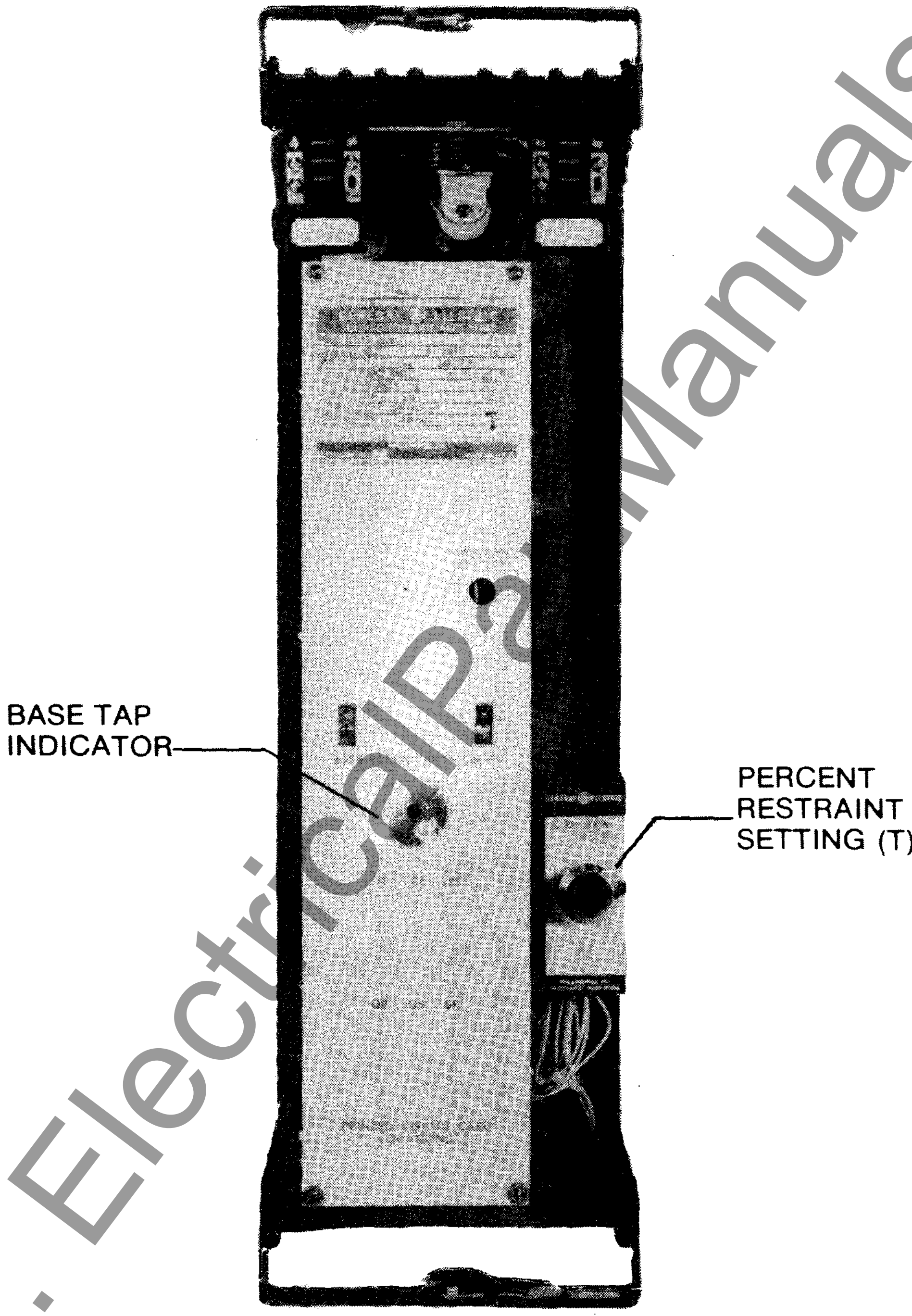


Figure 5 (8043552) Front View of SLYG81A Relay, Out of Case

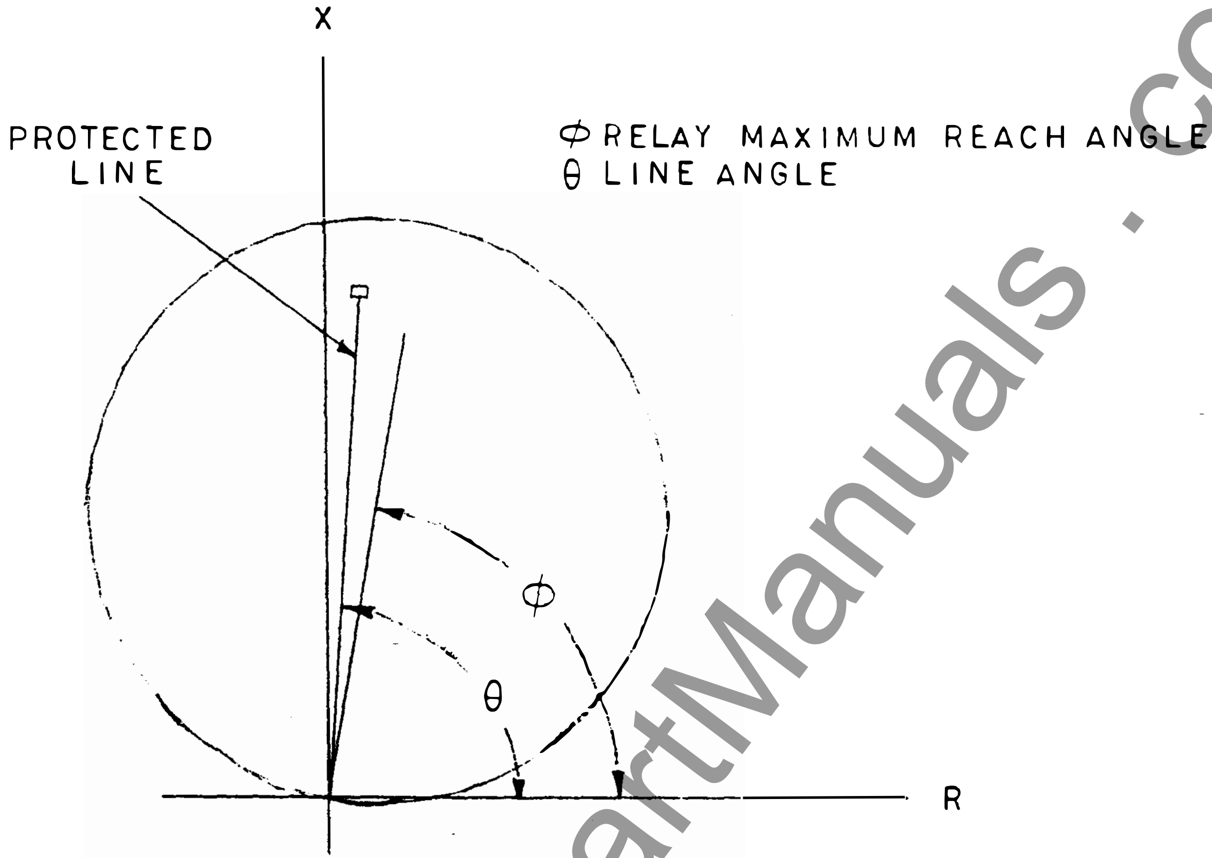


Figure 6 (0257A6183) Typical MHO Characteristic

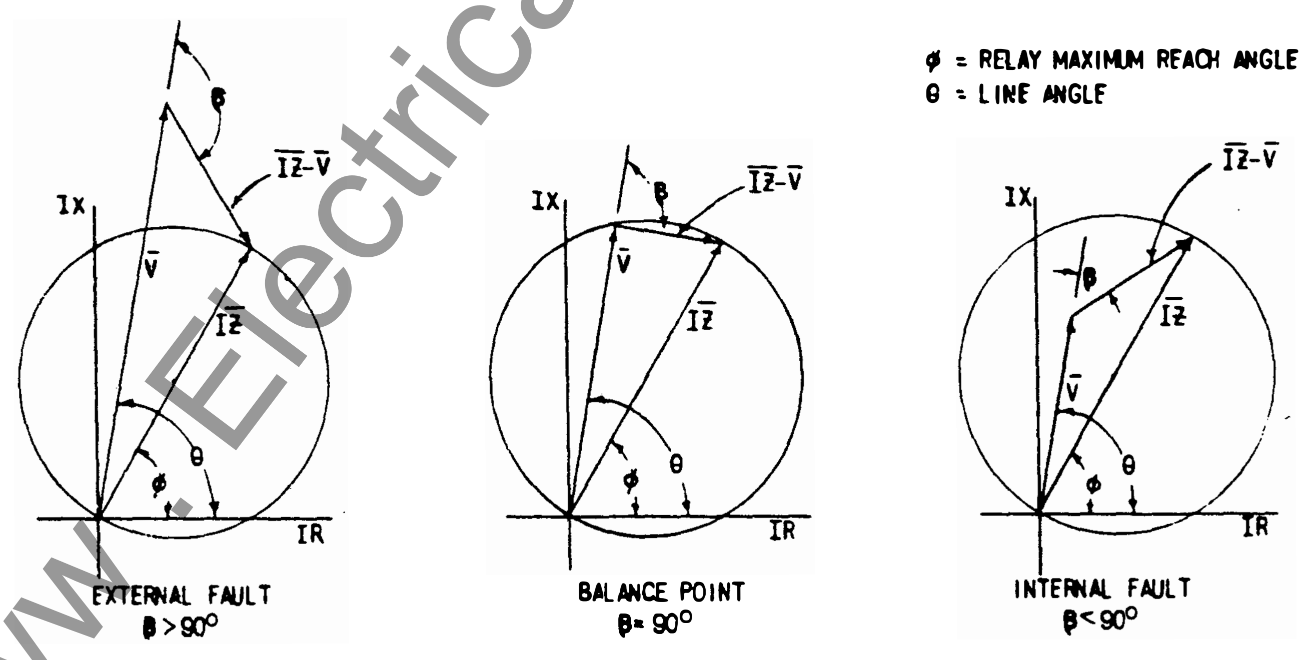


Figure 7 (0227A2090) MHO Characteristic by Phase-Angle Measurement

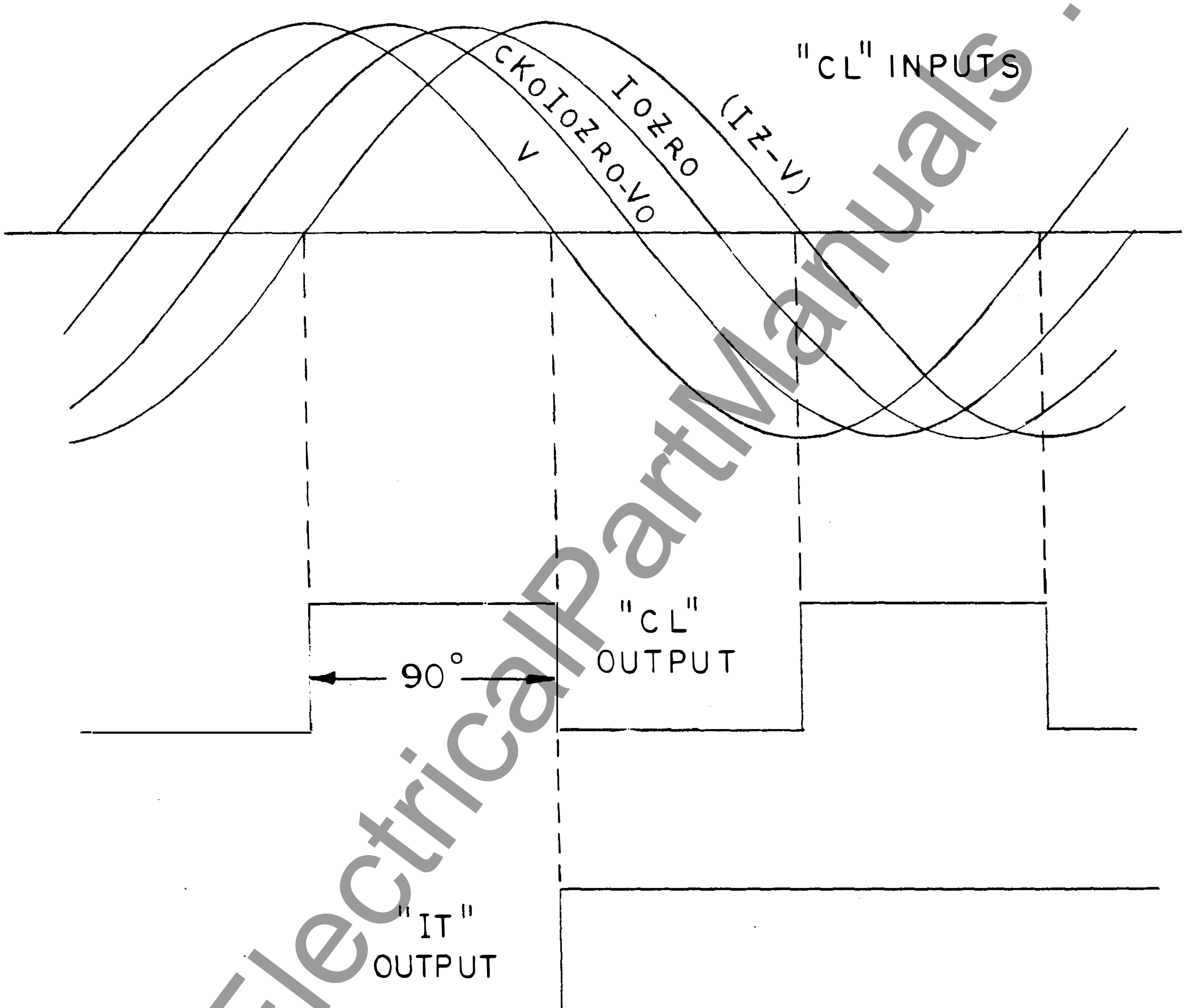


Figure 8 (0257A6184-1) Measurement Principle

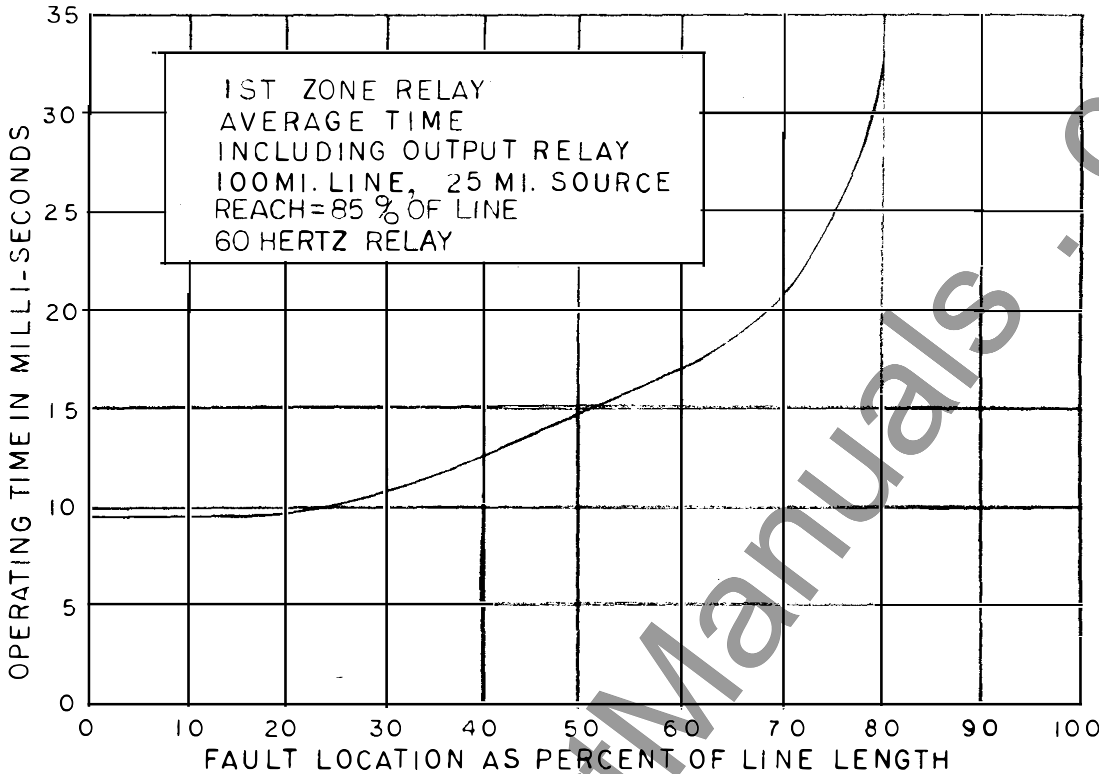


Figure 9A (0257A6180 Sh-1 3) Typical Operating Time for a 60 Hertz First-Zone Relay

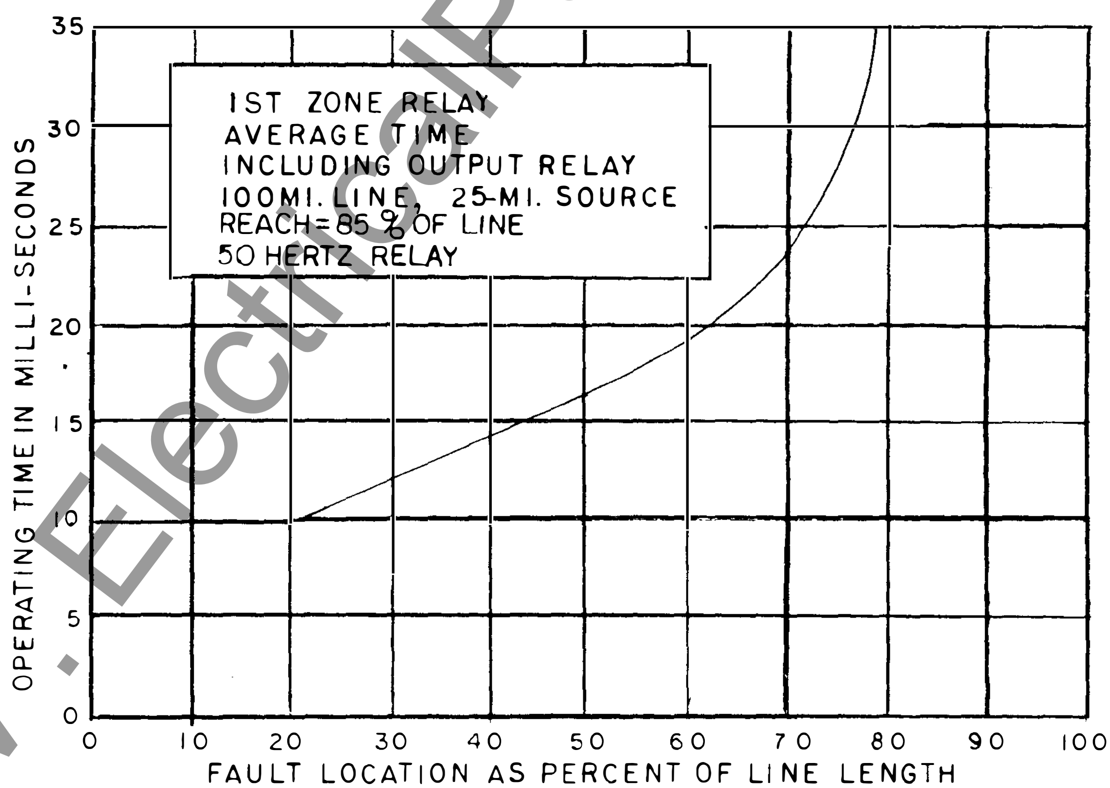


Figure 9B (0257A6180 Sh-2) Typical Operating Time for a 50 Hertz First-Zone Relay

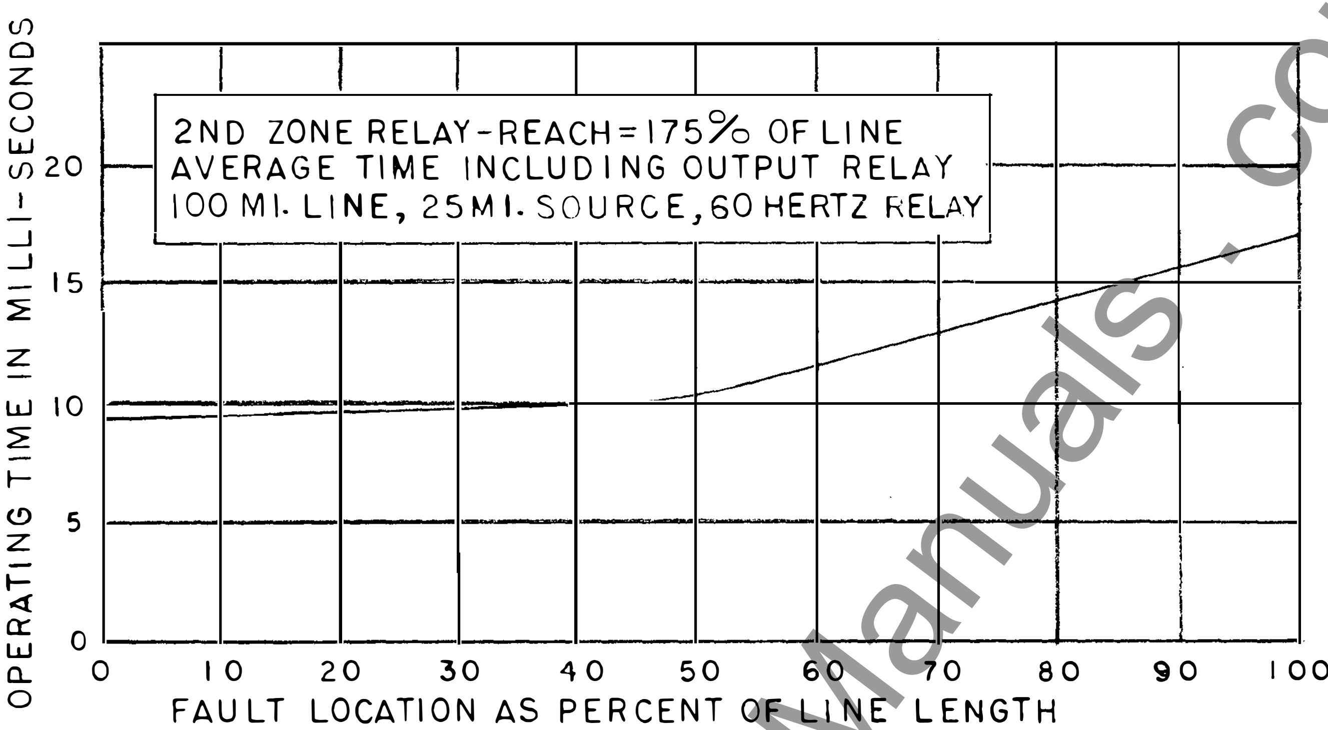


Figure 10A (0257A6176 Sh.1 2) Typical Operating Time for a 60 Hertz Second-Zone Relay

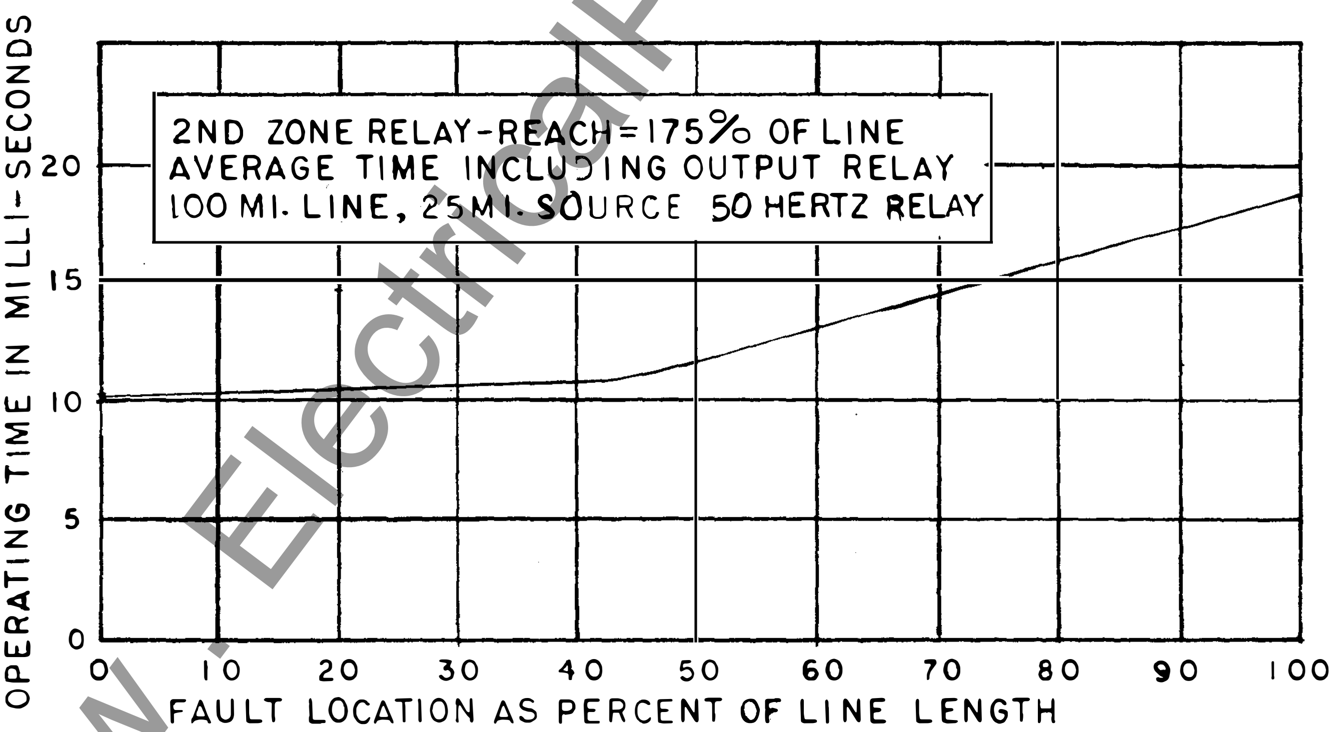


Figure 10B (0257A6176 Sh.2) Typical Operating Time for a 50 Hertz Second-Zone Relay

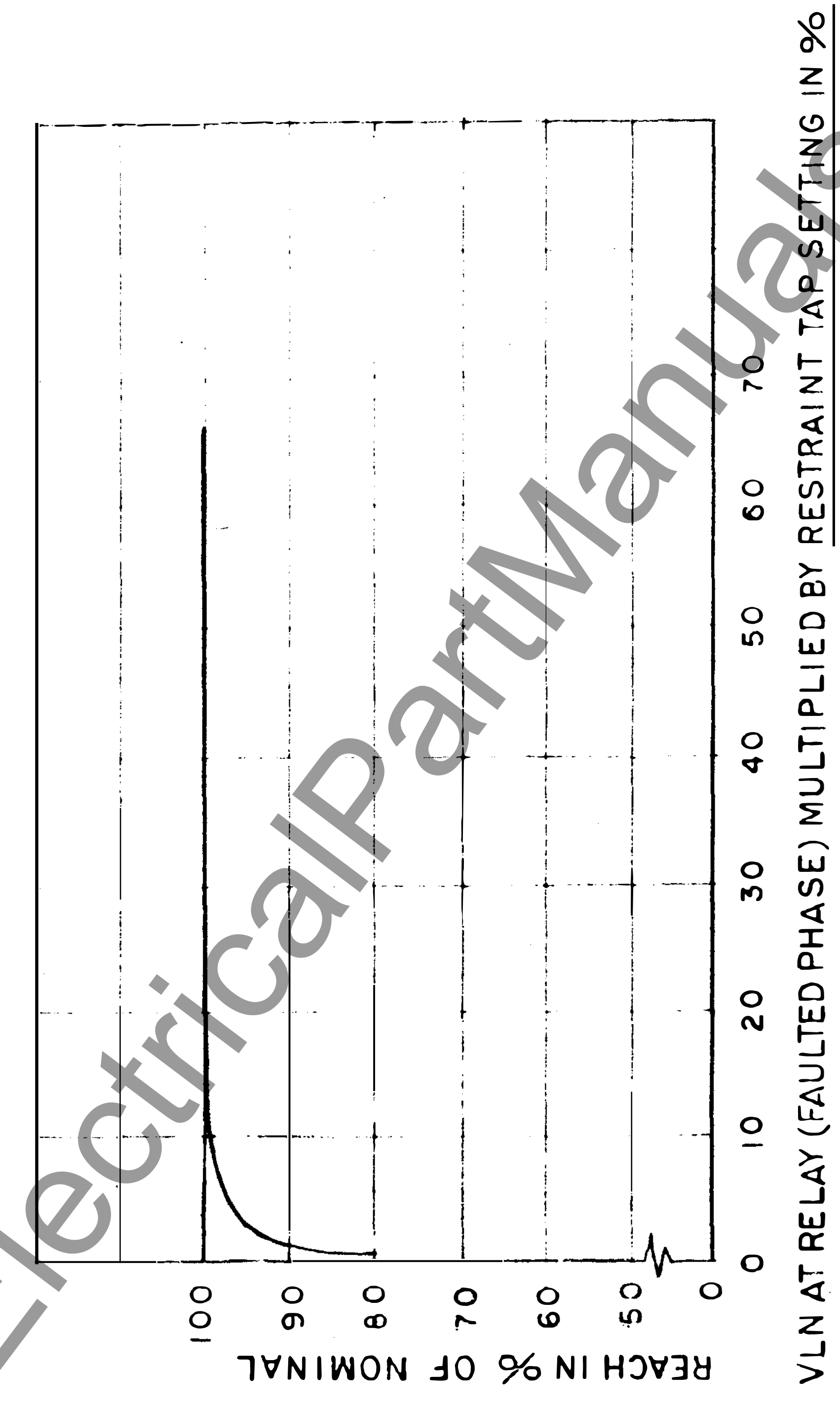
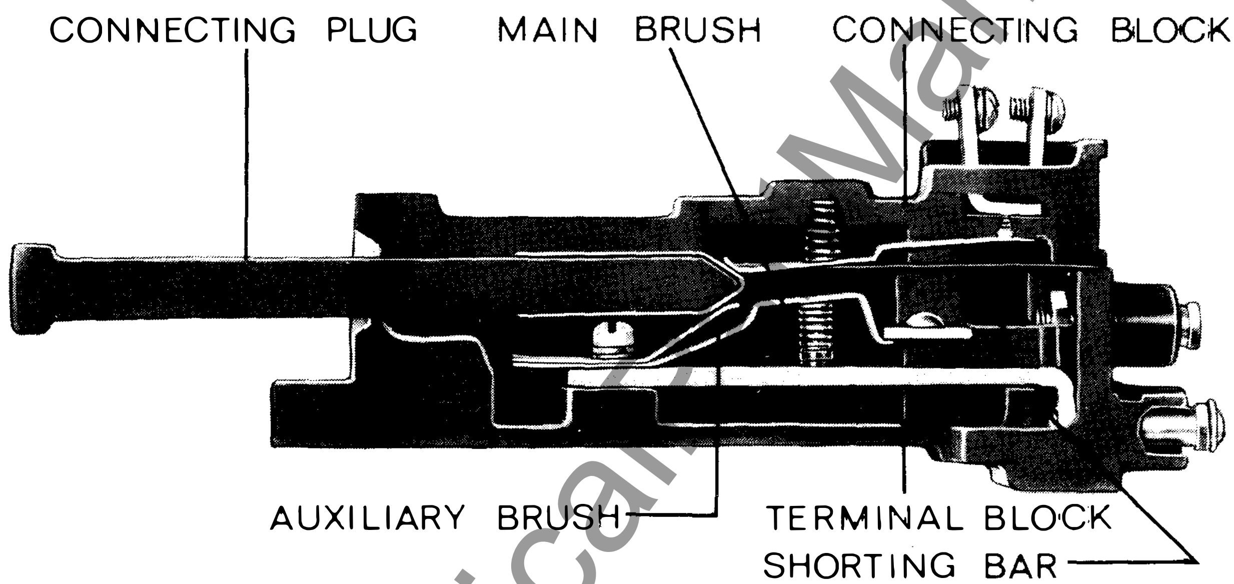


*Figure 11 (0257A6177) Reach Versus Faulted-Phase Voltage

*Revised since last issue



NOTE: AFTER ENGAGING AUXILIARY BRUSH CONNECTING PLUG TRAVELS 1/4 INCH BEFORE ENGAGING THE MAIN BRUSH ON THE TERMINAL BLOCK

Figure 12 (8025039) Cradle Block and Terminal Block Cross Section

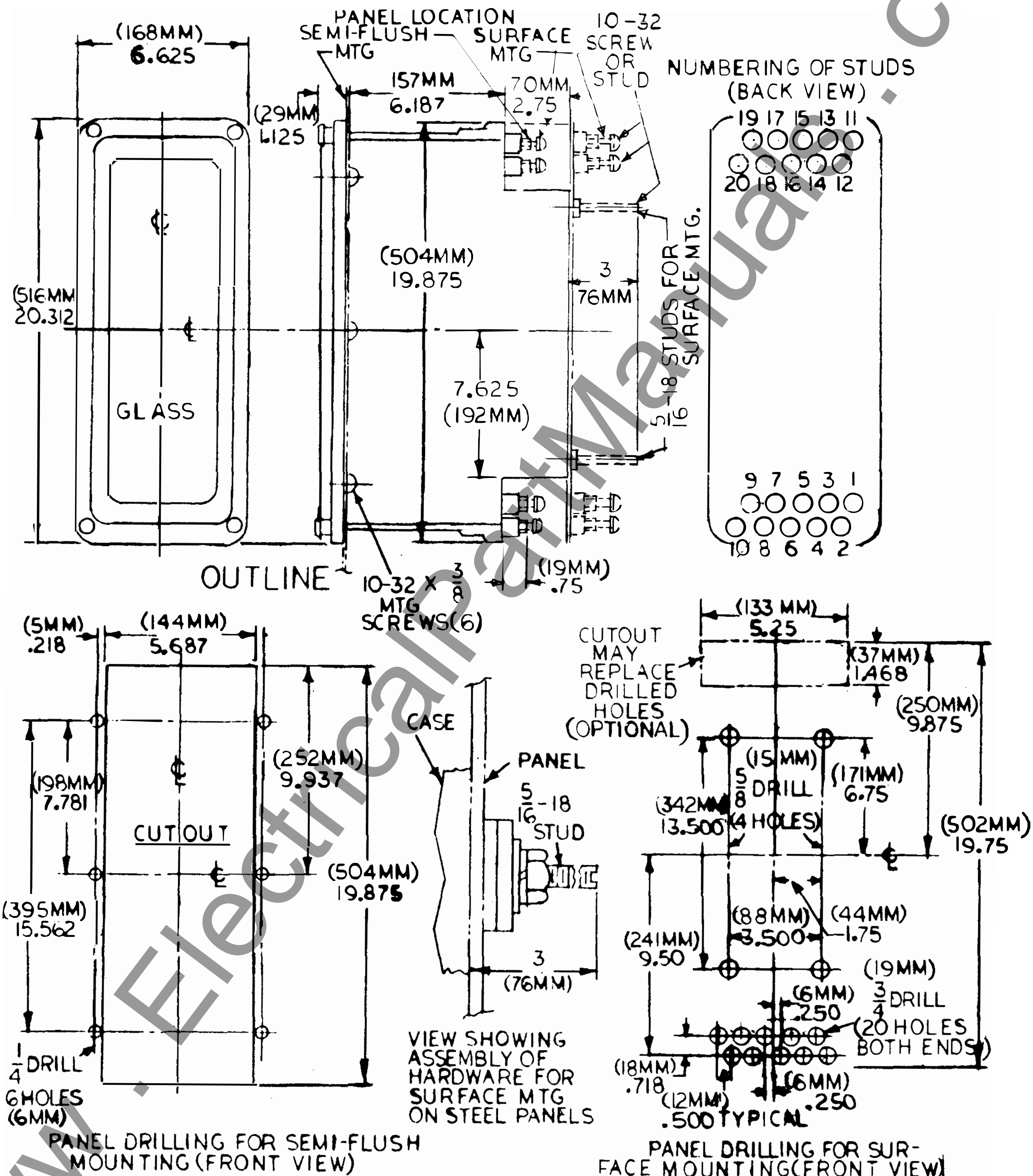


Figure 13 (0178A7336-4) Outline and Panel Drilling for Type SLYG81A Relay

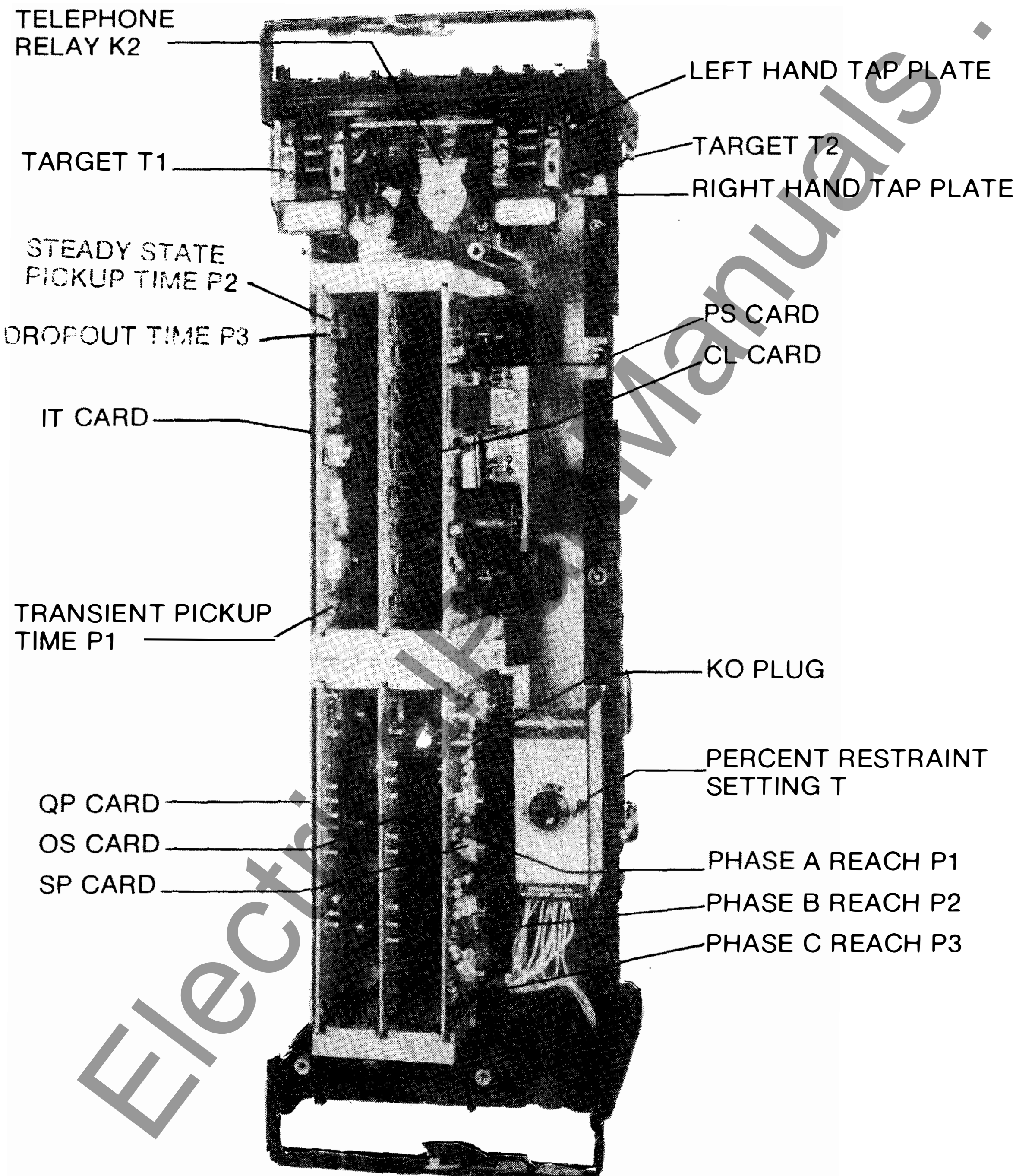


Figure 14 (8043553) Front View of Relay, Out of Case, with Nameplate Removed

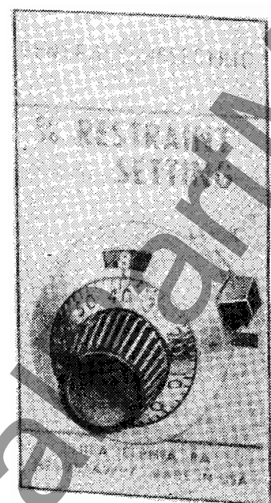


Figure 15 (8042986) Restraint-Setting Dial (Set for 84%)

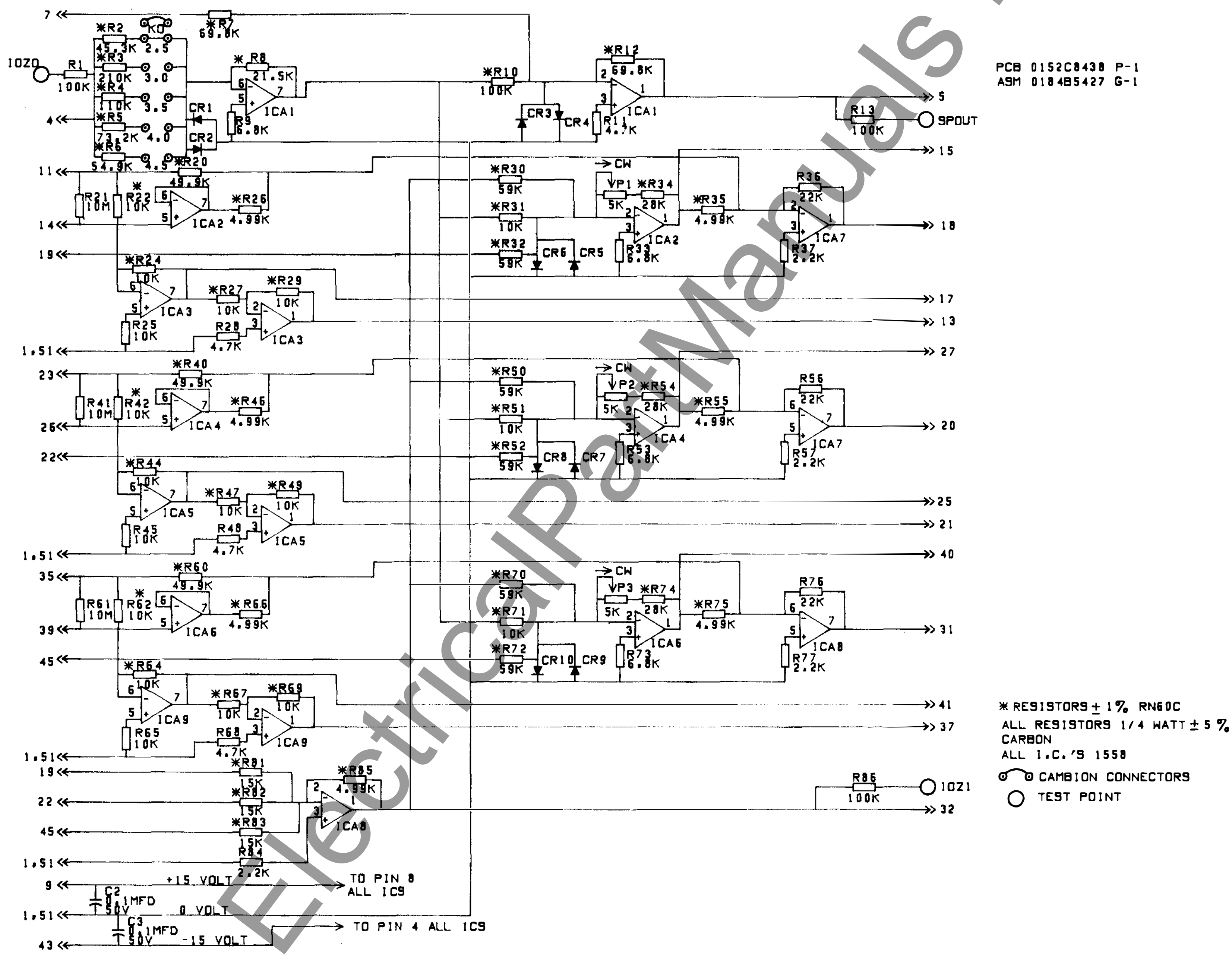


Figure 16A (0152C9085 Sh.1 1) Internal Connections for Signal-Processing Card (SP)

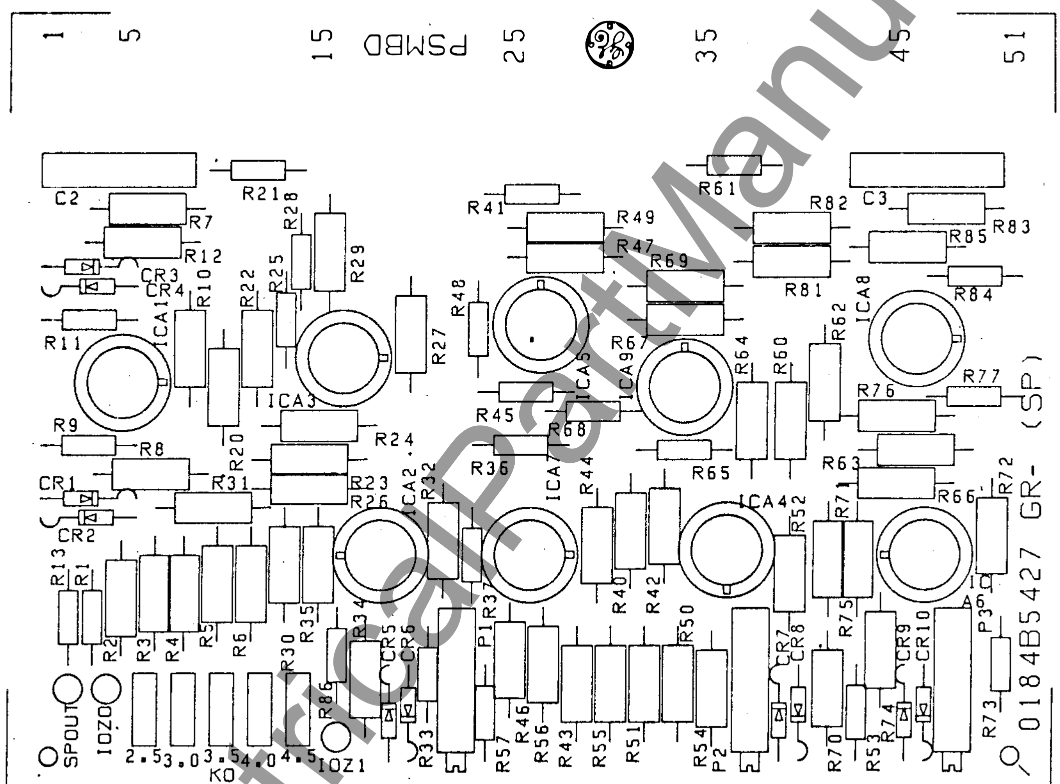


Figure 16B (0152C8438 Sh.1 3) Card Layout for Signal-Processing Card (SP)

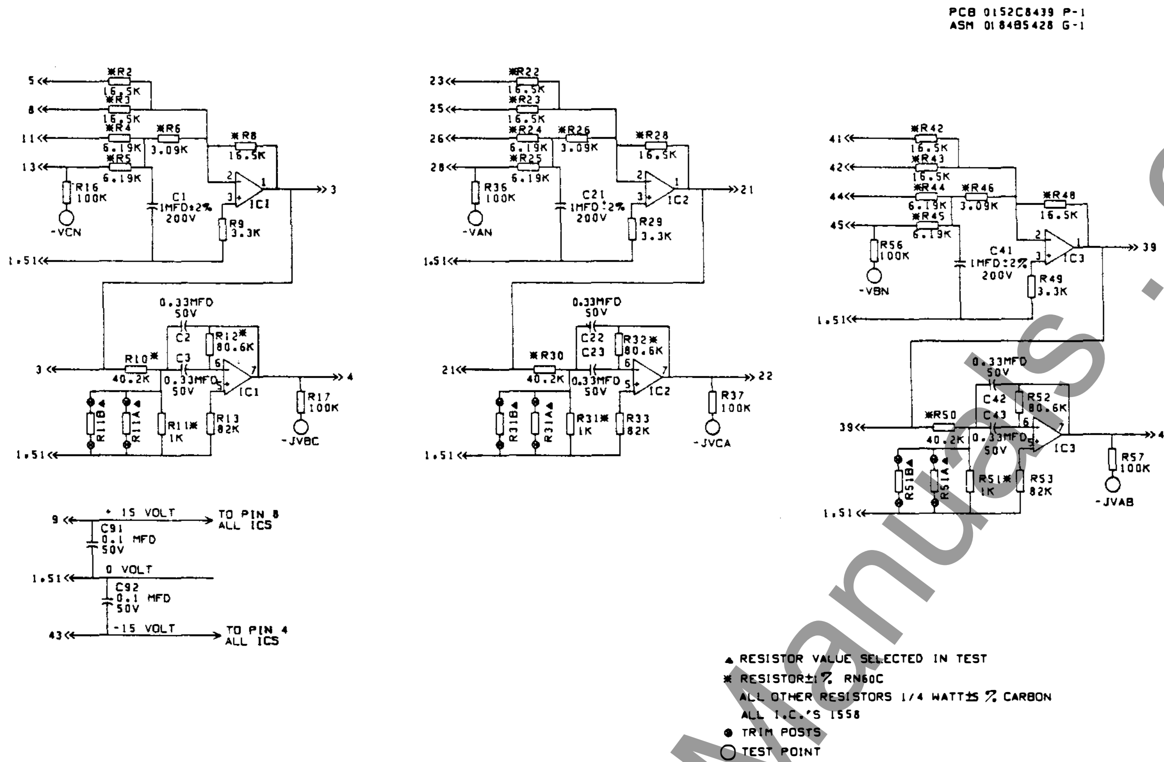


Figure 17A (0152C9086 Sh.1 1) Internal Connections for a 60 Hertz Quadrature-Polarizing Card (QP)

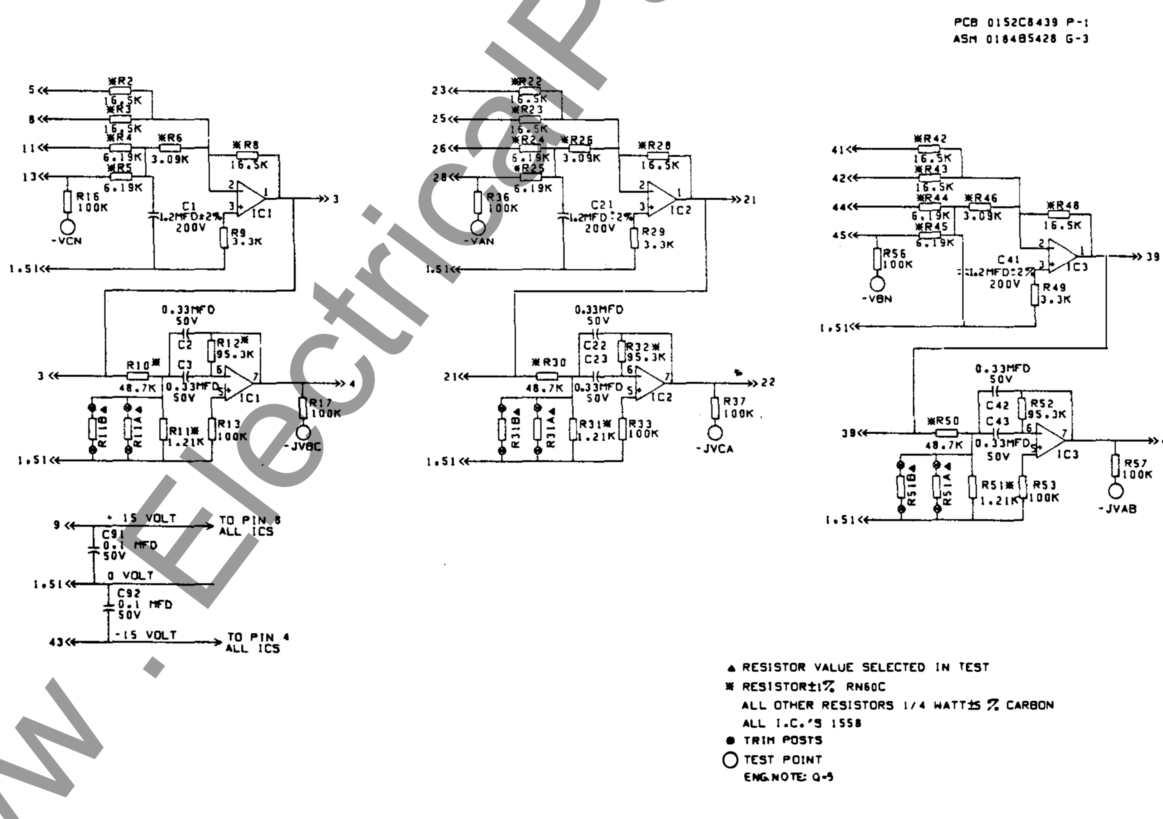


Figure 17B (0152C9086 Sh.3) Internal Connections for a 50 Hertz Quadrature-Polarizing Card (QP)

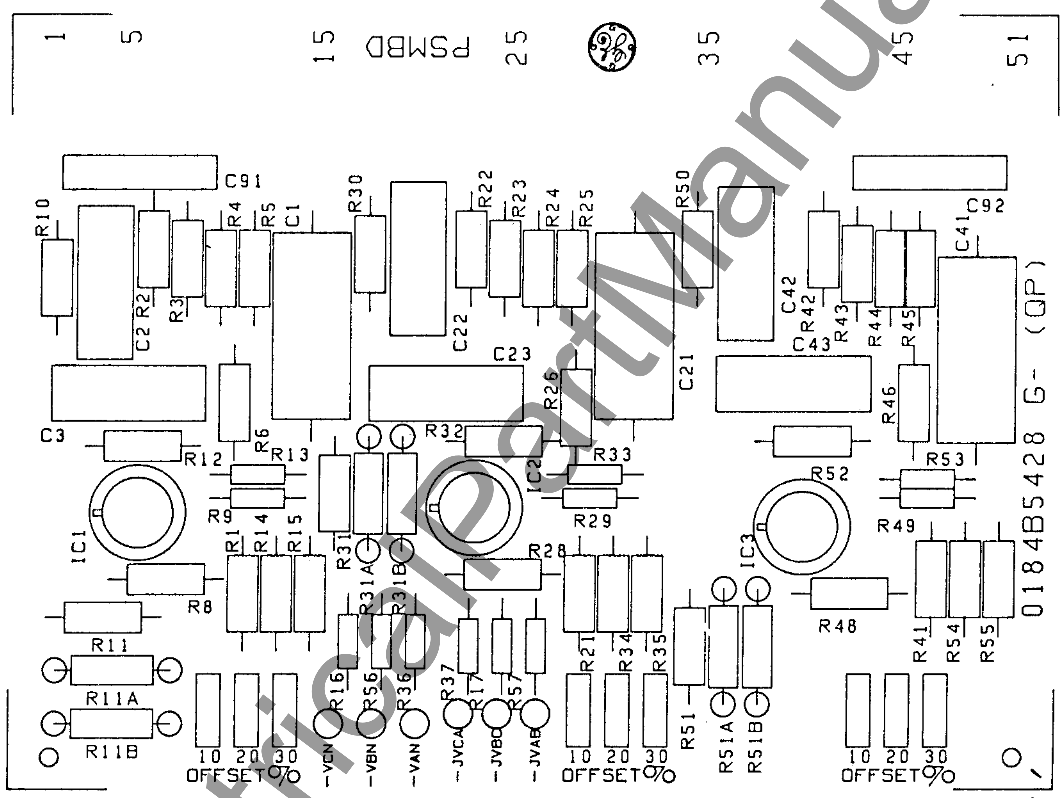


Figure 17C (0152C8439 Sh.1 3) Card Layout for Quadrature-Polarizing Card (QP)

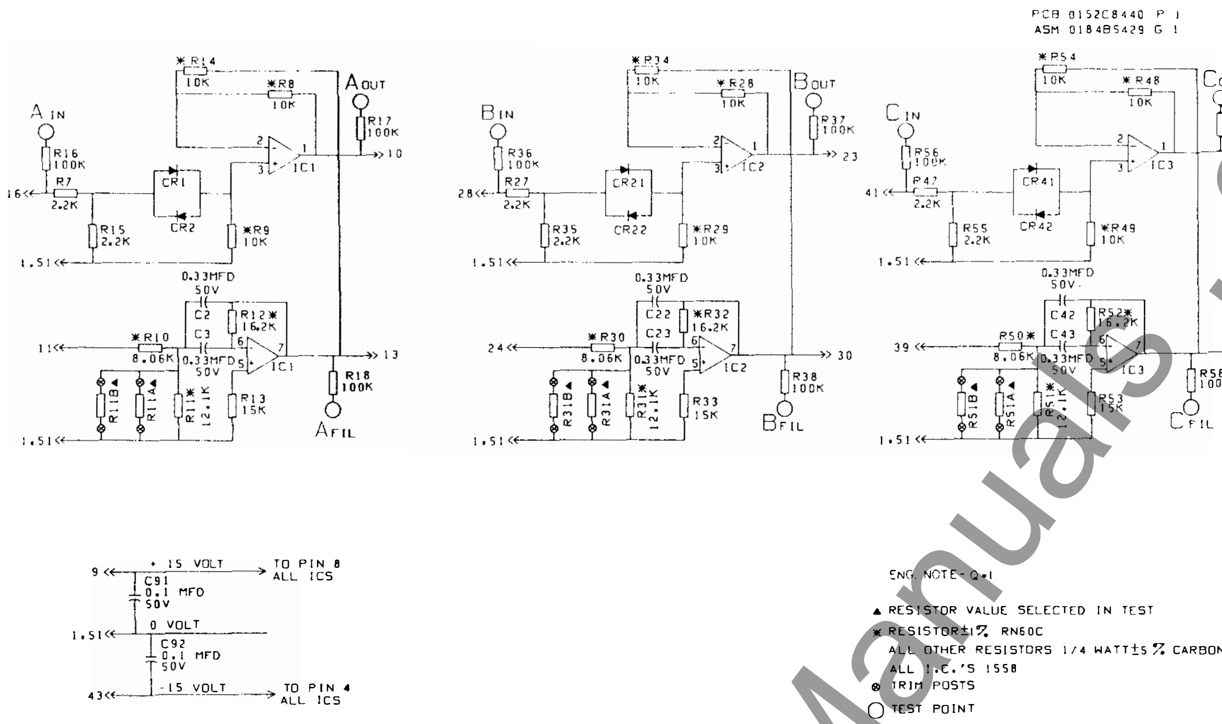


Figure 18A (0152C9087 Sh.1 2) Internal Connections for a 60 Hertz Operate-Signal Card (OS)

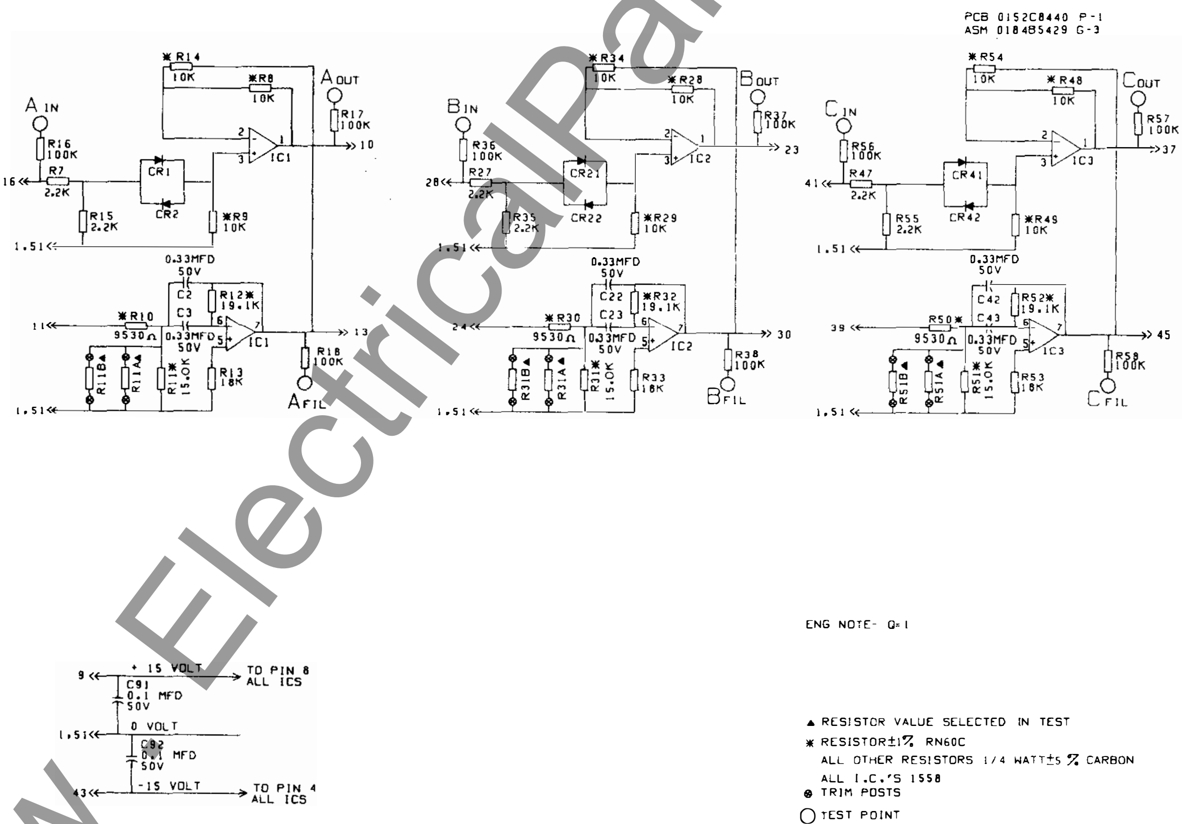


Figure 18B (0152C9087 Sh.3 1) Internal Connections for a 50 Hertz Operate-Signal Card (OS)

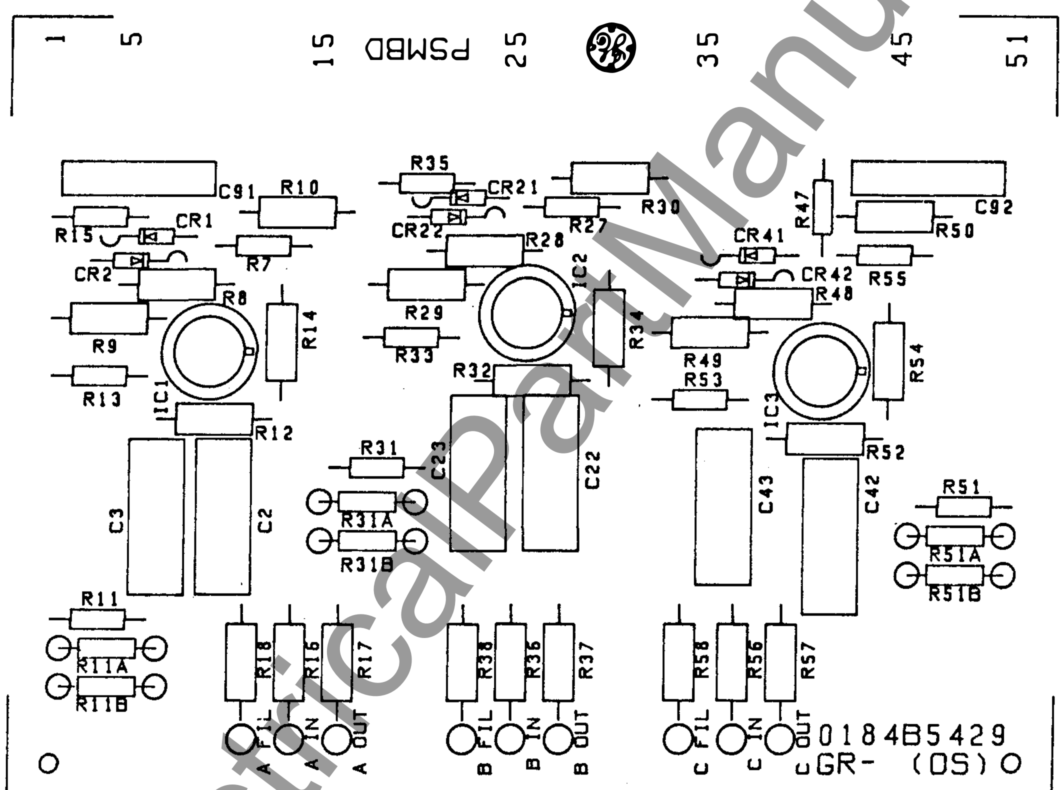


Figure 18C (0152C8440 Sh.1 3) Card Layout for Operate-Signal Card (OS)

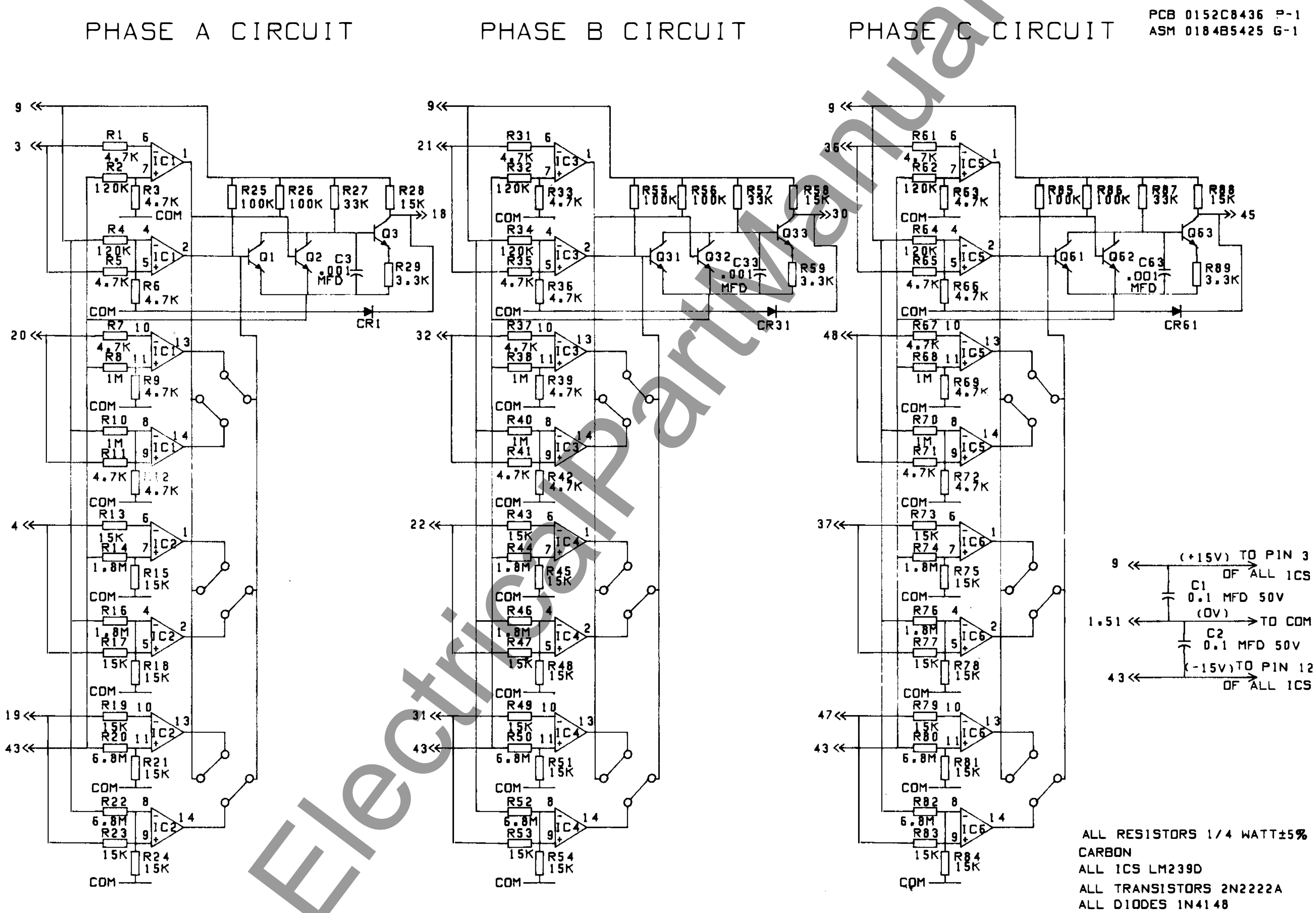


Figure 19A (0152C9083 Sh.1 1) Internal Connections for Coincidence-Logic Card (CL)

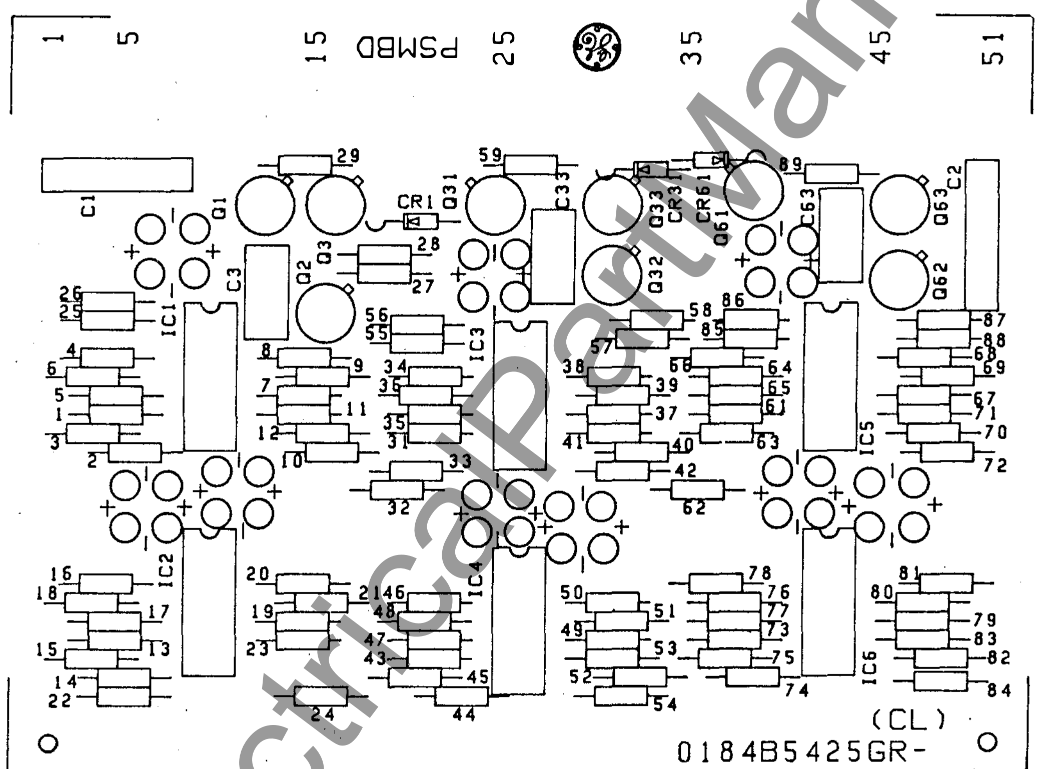


Figure 19B (0152C8436 Sh.1 4) Card Layout for Coincidence-Logic Card (CL)

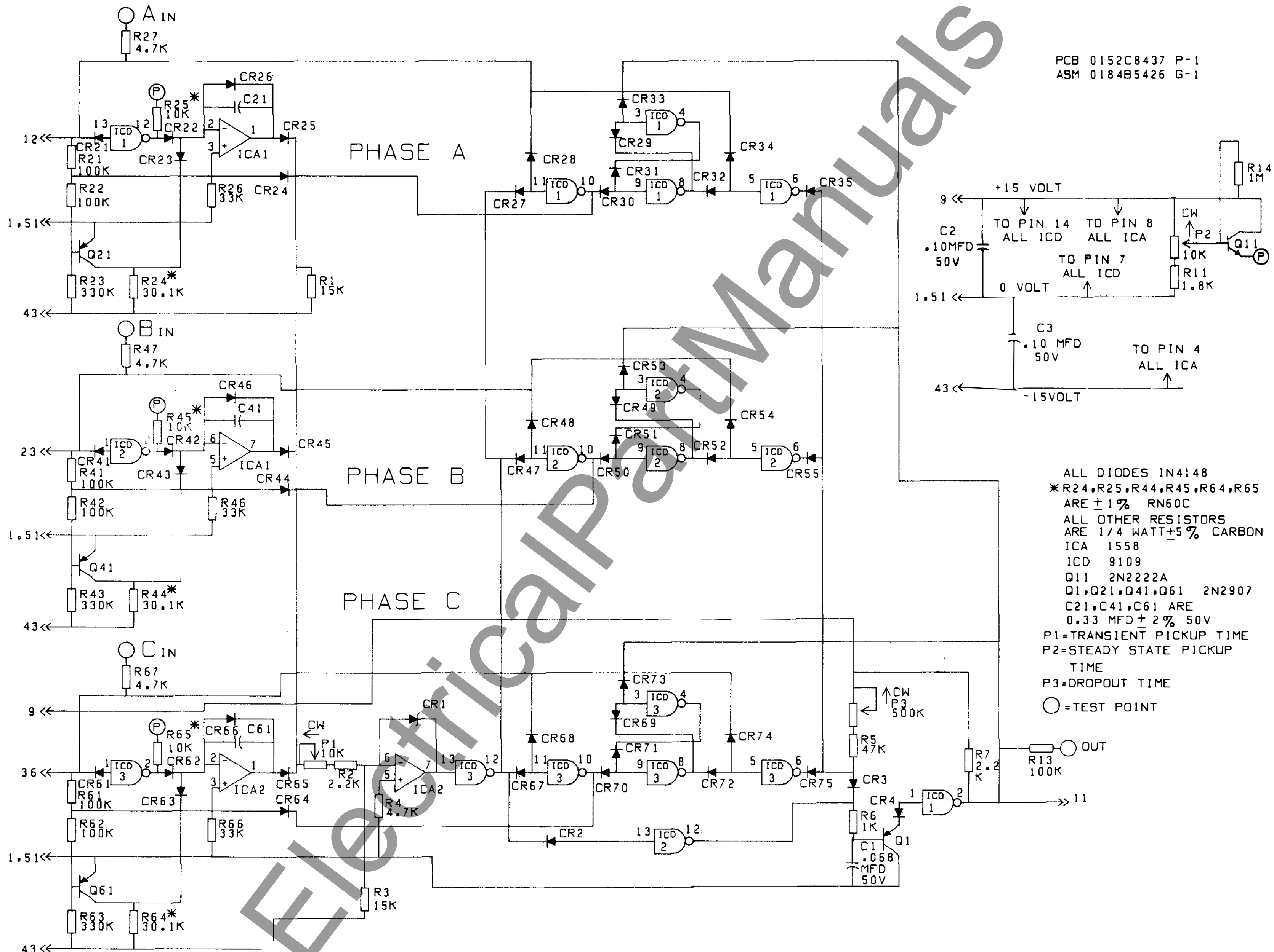


Figure 20A (0152C9084 Sh.1 2) Internal Connections for Integrating-Timer Card (IT)

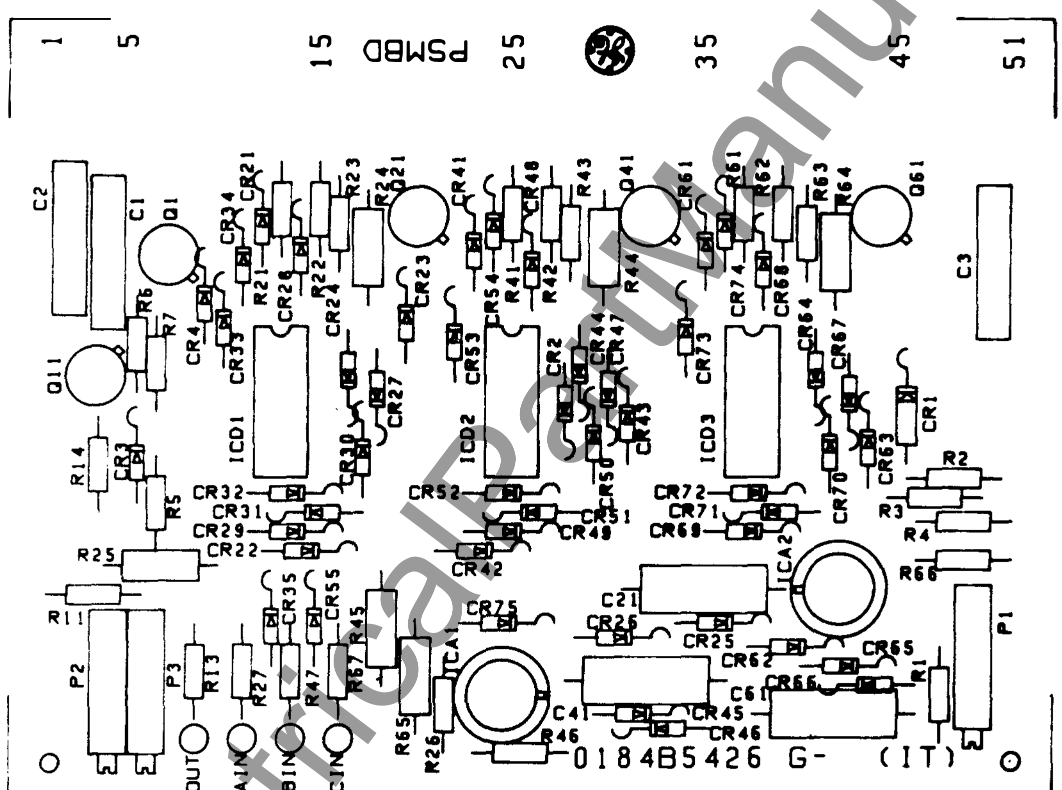


*Figure 20B (0152C8437 Sh.1 [6]) Card Layout for Integrating-Timer Card (IT)

*Revised since last issue

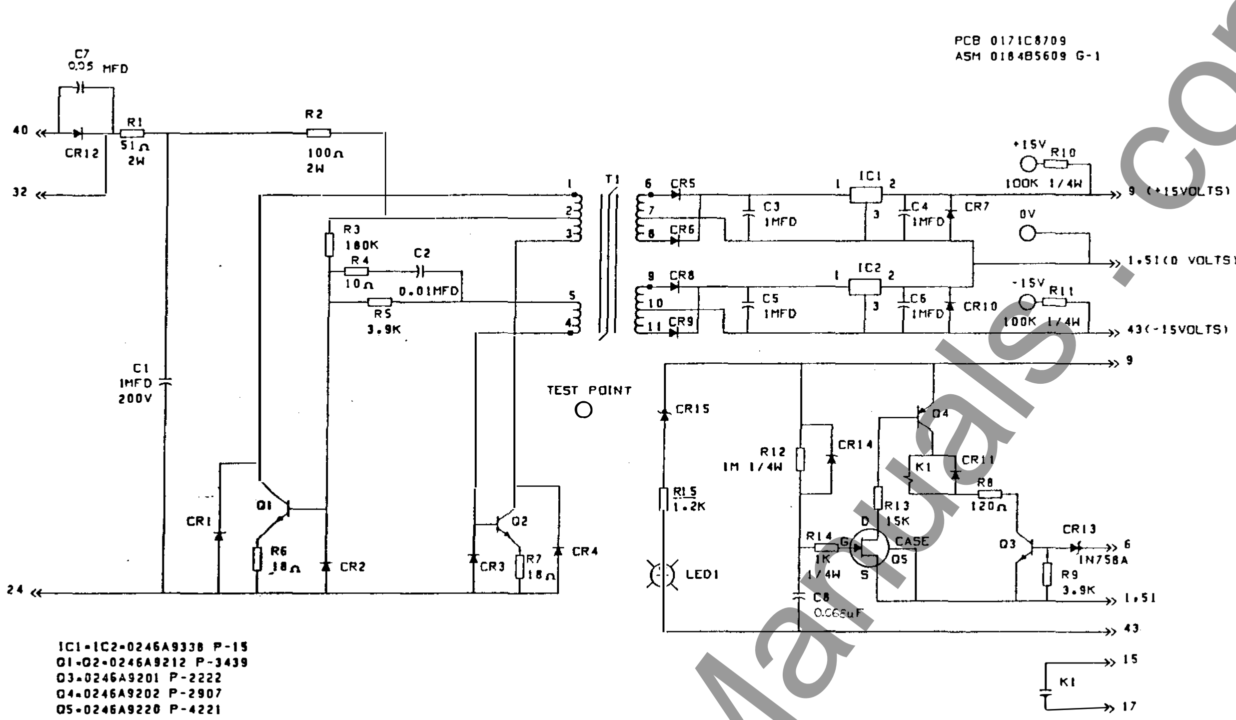


*Figure 21A (0152C8465 Sh.1 [4]) Internal Connections for 125 VDC Rated Input Power-Supply Card (PS)

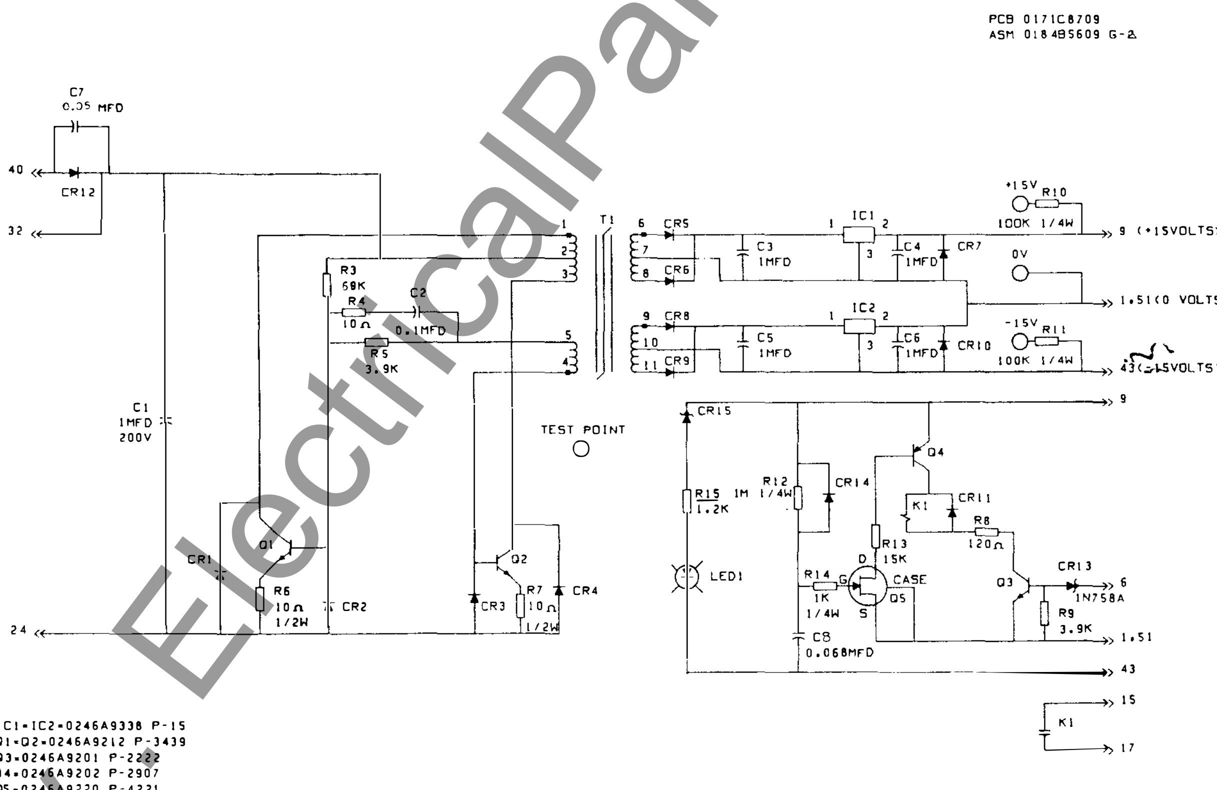


Figure 21B (0152C8465 Sh.2 2) Internal Connections for 48 VDC Rated Input Power-Supply Card (PS)

*Revised since last issue

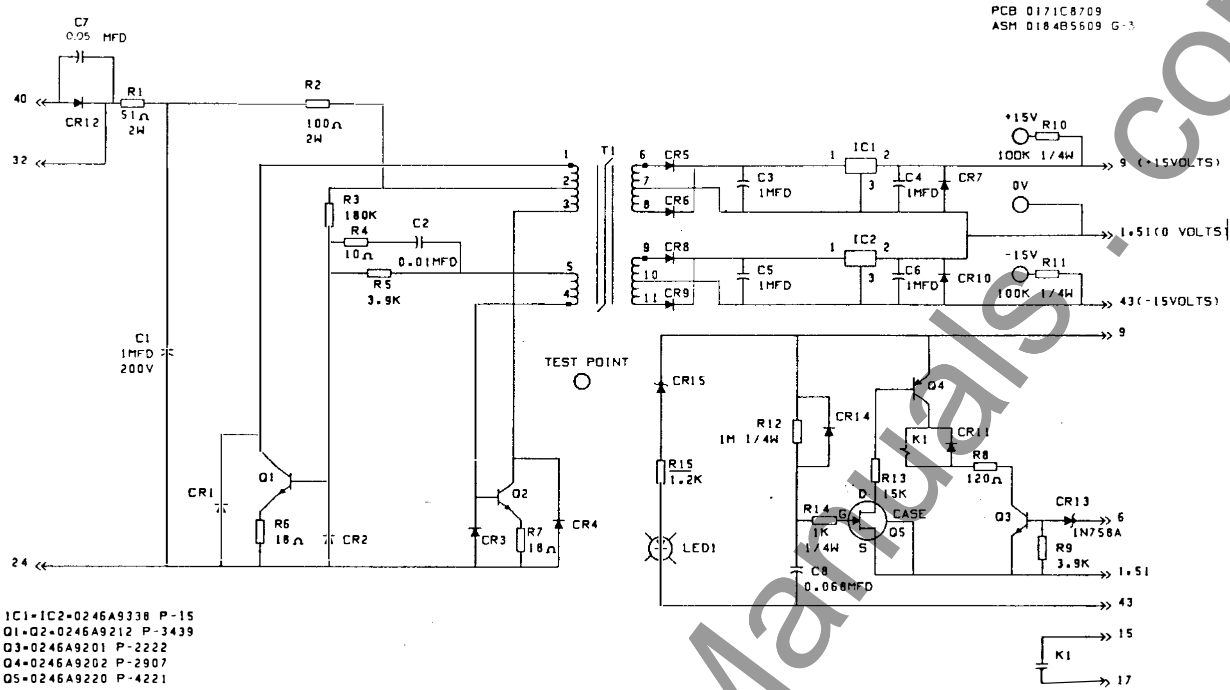


Figure 21C (0152C8465 Sh.3 2) Internal Connections for 110 VDC Rated Input Power-Supply Card (PS)

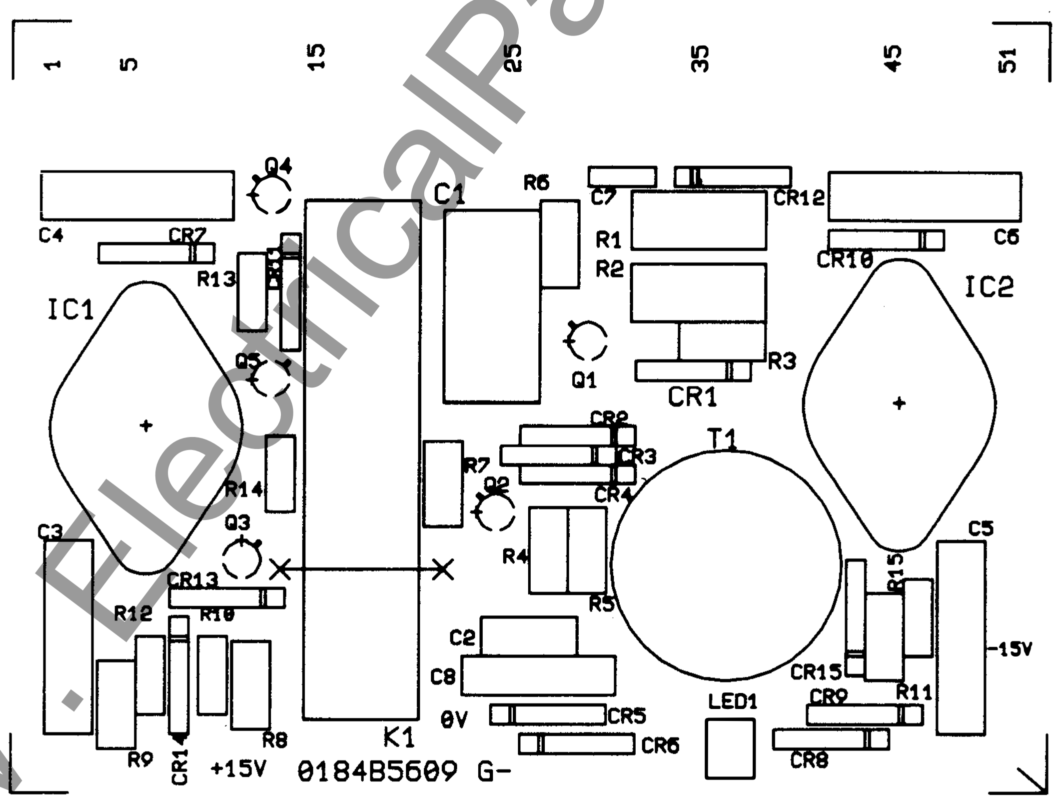
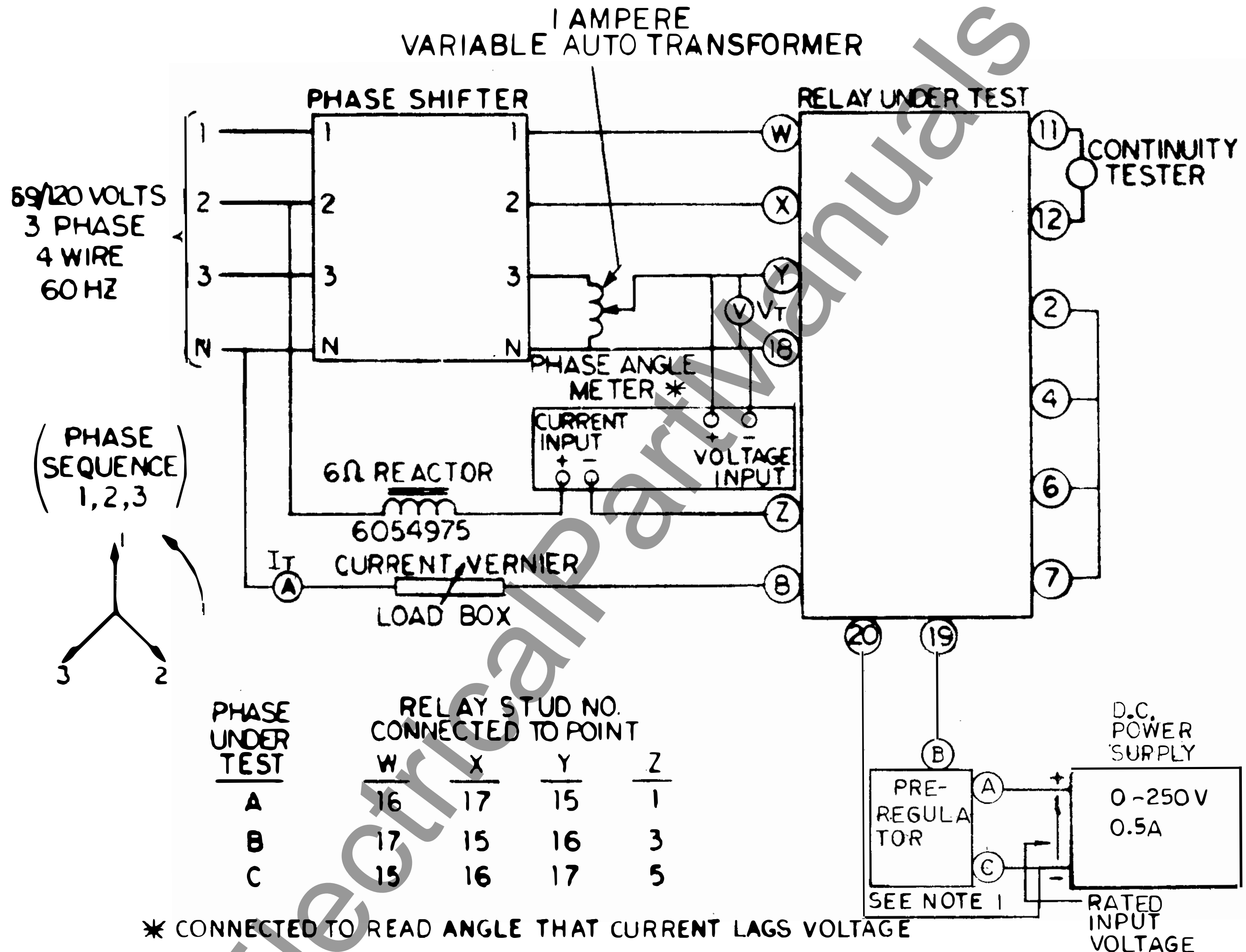


*Figure 22 (0171C8709 Sh.1 [8]) Card Layout for Power-Supply Card (PS)

*Revised since last issue

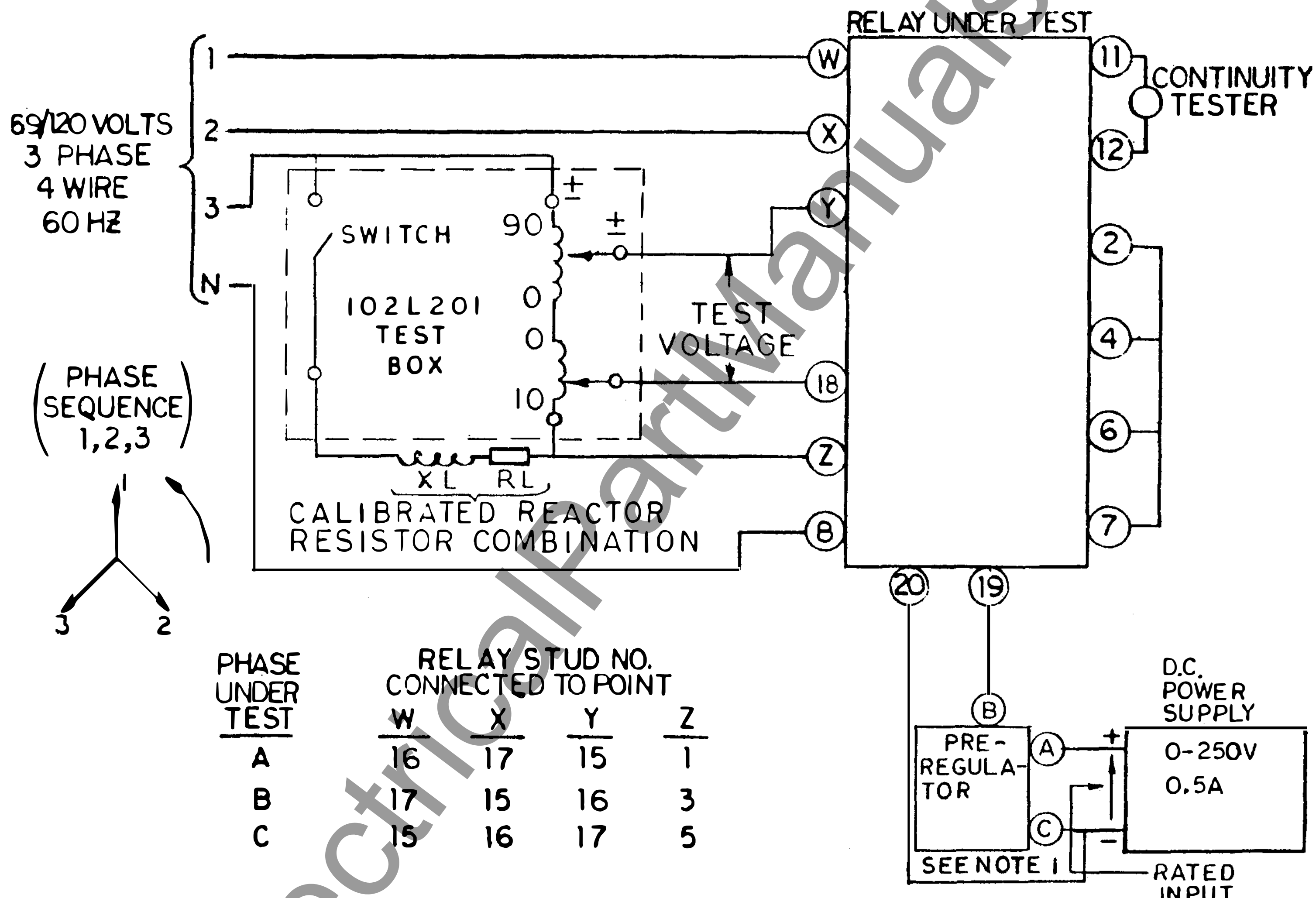


PHASE UNDER TEST	RELAY STUD NO. CONNECTED TO POINT W	X	Y	Z
A	16	17	15	1
B	17	15	16	3
C	15	16	17	5

* CONNECTED TO READ ANGLE THAT CURRENT LAGS VOLTAGE

NOTE 1: PRE-REGULATOR USED FOR RATED INPUTS EXCEEDING 125 VDC

Figure 23 (0257A6181-3) Test Circuit for Reach Tests

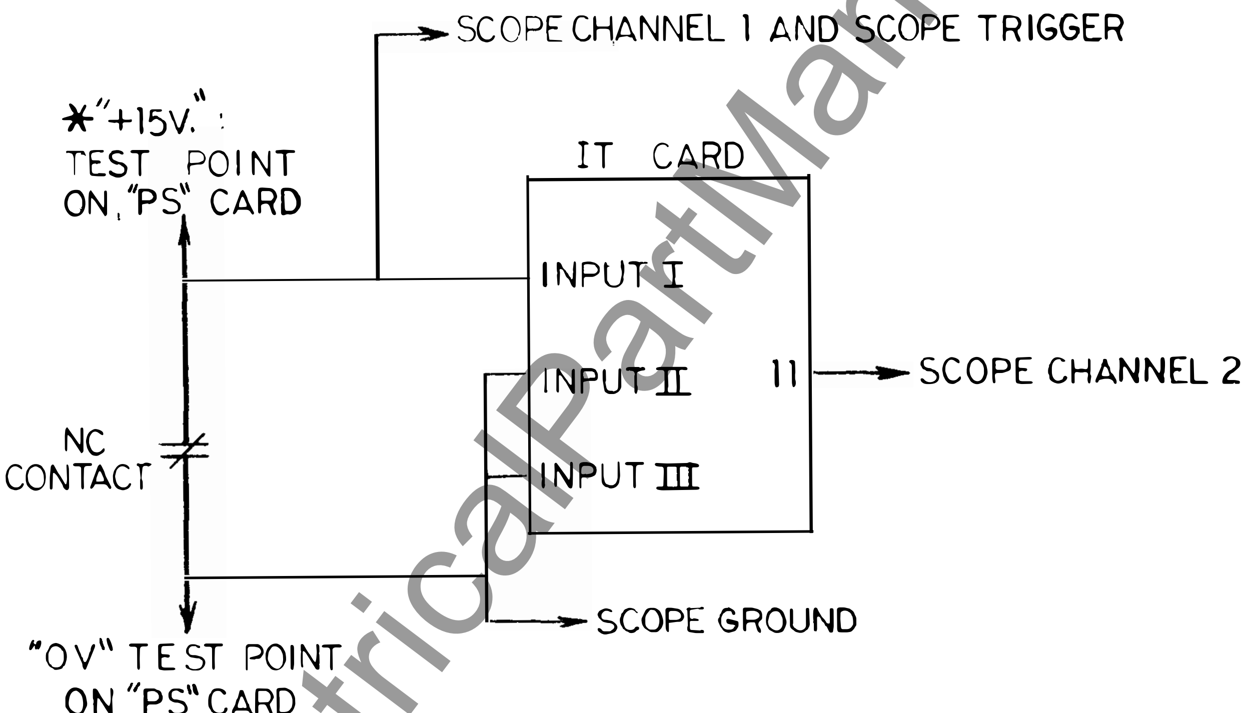


PHASE UNDER TEST	RELAY STUD NO. CONNECTED TO POINT W	X	Y	Z
A	16	17	15	1
B	17	15	16	3
C	15	16	17	5

NOTE 1: PRE-REGULATOR USED FOR RATED INPUTS EXCEEDING 125 VDC

Figure 24 (0257A6187-1) Characteristic Test Circuit Using Test Box, Reactor and Resistor

* THE "+15V." TEST POINT HAS A 100K OHM CURRENT LIMITING RESISTOR MOUNTED ON THE "PS" CARD.



PHASE UNDER TEST	PIN No. OF CARD		
	INPUT I	INPUT II	INPUT III
A	12	23	36
B	23	12	36
C	36	12	23

Figure 25 (0257A6185) Timer-Card Test Circuit

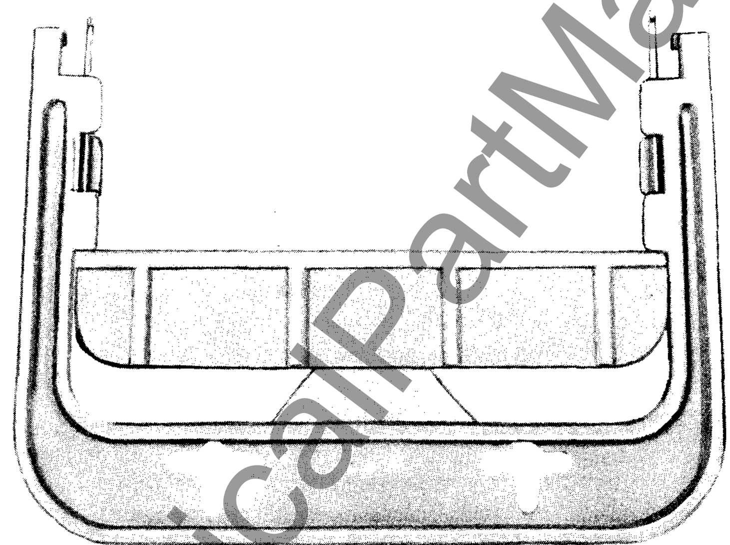
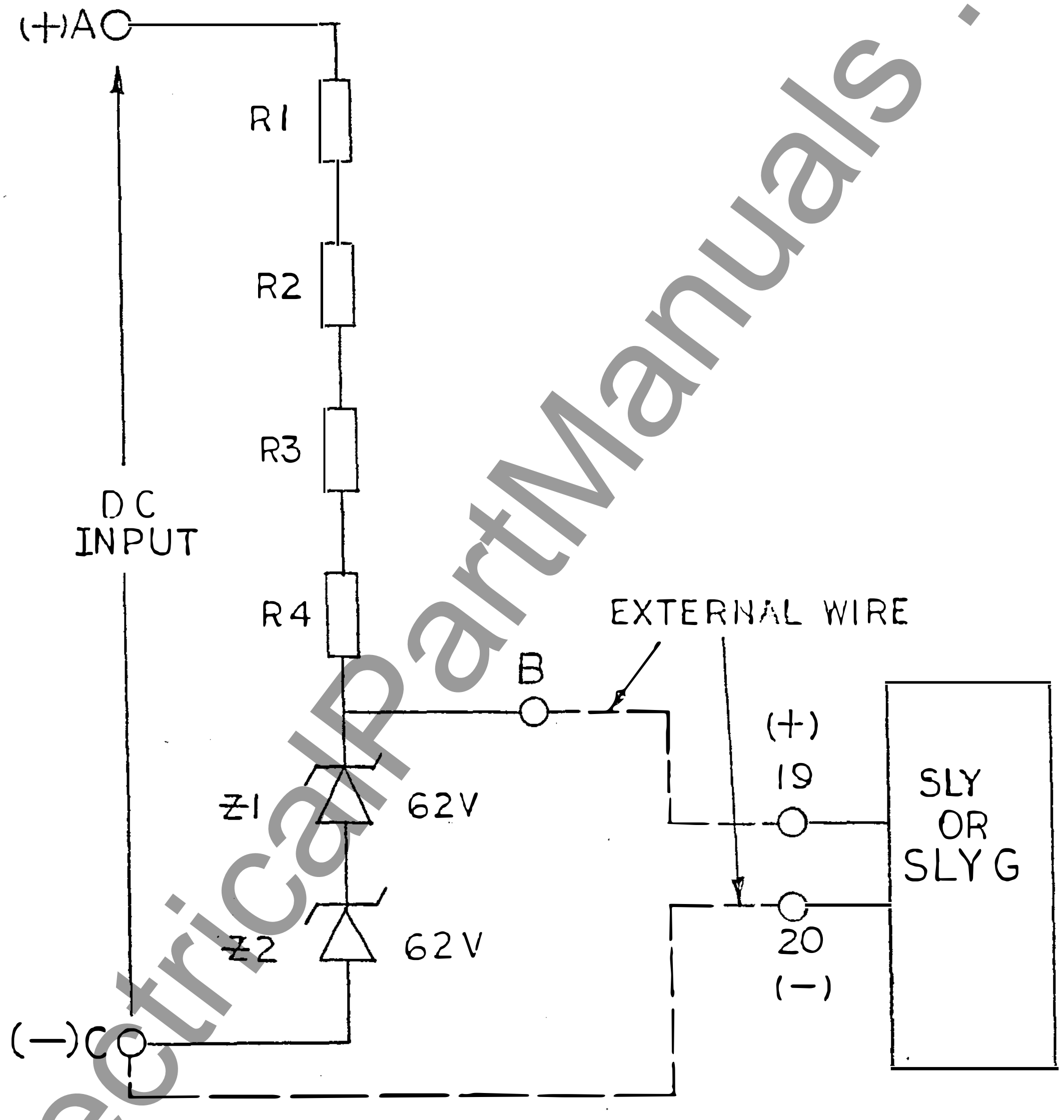


Figure 26 (8043016) Printed-Circuit-Card Extracting Tool



DC INPUT	R1	R2	R3	R4
250 VOLTS	150Ω	150Ω	100Ω	100Ω

*Figure 27 (0275A4336-1) Internal-Connections Diagram for External Pre-Regulator

*Revised since last issue

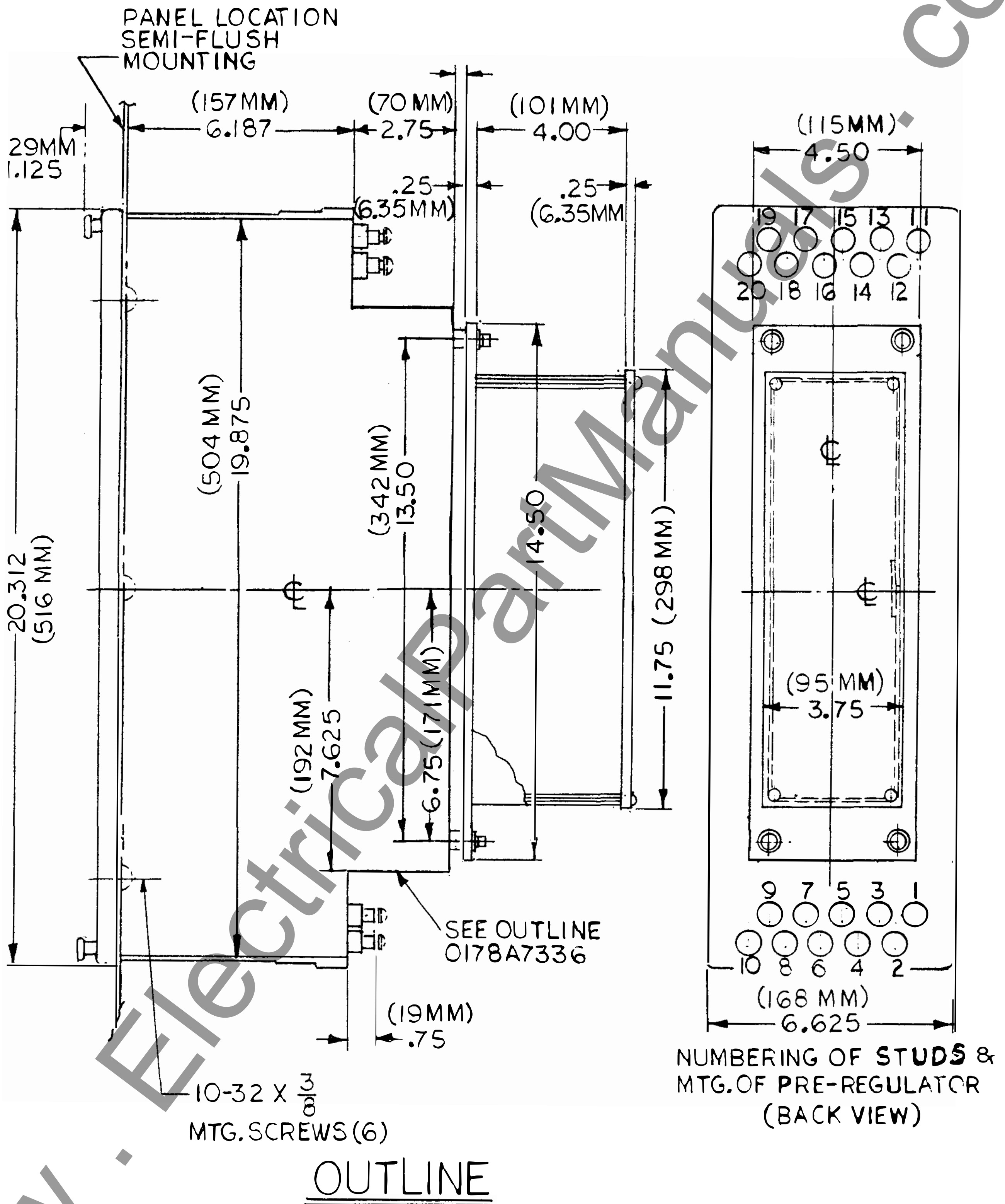


Figure 28 (0275A4339) Outline and Mounting Dimensions for External Pre-Regulator

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Business Department

(2/92) (1200)

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