# INSTRUCTIONS

GEK-45333

OVERCURRENT RELAY

TYPE SLC51C

POWER SYSTEMS MANAGEMENT DEPARTMENT

GENERAL ELECTRIC

PHILADELPHIA, PA.

CONTENTS

# OVERCURRENT RELAY

## TYPE SLC51C

## DESCRIPTION

The SLC51C is a static three phase and ground overcurrent relay which includes both direct tripping and supervising overcurrent functions for directional comparison line protection with single pole trip and reclose. The SLC51C relay is packaged in a four rack unit (1 R.U. = 1-3/4 inch) metal enclosed case suitable for 19 inch rack mounting. The outline and mounting dimensions are shown in Figure 1. Component locations are shown in Figure 2.

The SLC51C outputs are 15 volt d-c logic signals to the SLA unit employed in the particular scheme. Regulated ±15 volt d-c power from the equipment SSA power supply is required for operation of the SLC51C circuits. The internal connections for the SLC51C are shown in Figure 3.

The following overcurrent functions are included in the SLC51C relay:

$I_M$ - Sensitive current detector for pole position indication and supervision of distance tripping functions. One per phase.

$I_{3\phi}$ - Three phase fault detector for overcurrent trip supervision of phase MT functions.

$I_A, I_B, I_C$ - High set direct trip overcurrent for phase-to-phase faults, and pole indication on ground faults.

G1 - Ground overcurrent carrier start function.

G2 - Ground overcurrent carrier trip fault detector.

G4 - Ground high set direct trip overcurrent.

$I_o$ - Ground fault detector to block 3-pole tripping for MT operation on phase-to-ground faults.

## APPLICATION

The SLC51C static overcurrent relay is designed to provide the overcurrent functions required in directional comparison blocking schemes utilizing suitable phase relays and ground relays, and a phase selector relay to permit single pole switching for single line-to-ground faults.

The SLC51C relay is not intended for use by itself, but rather is meant to be used as part of a complement of equipment to complete a protective relaying scheme. The additional relays and other equipment required to complete a specific scheme are described in the logic description that accompanies the overall logic diagram for that particular scheme.

Figure 4 illustrates the typical external connections to the SLC51C when it is used in a directional comparison carrier blocking scheme with single pole switching.

The measuring functions included in the relay are intended for use as indicated below.

### G1 AND G2

G1 is a non-directional zero sequence overcurrent function that is used to initiate carrier starting and so block tripping during external ground faults. G2, also a non-directional zero sequence overcurrent function, is used for tripping level supervision of the directional ground tripping function. The settings of G1 and G2 must be coordinated so that G1 will operate and initiate a carrier blocking signal on the occurrence of faults behind G1 before G2 at the other end can operate to initiate tripping. Because G1 and G2 are similar types of units, proper time coordination will be assured if the G1 function is set more sensitively than G2.

G1 is generally set as sensitively as possible, just so that it will not operate as a result of zero sequence currents produced as a result of system asymmetry during load conditions.

G2 must be set at a higher pickup level. If zero sequence charging current can be significant during fault conditions then it too must be accounted for in order to obtain proper coordination between G1 and G2. It is suggested that on two terminal line applications G2 be set on the following basis:

$$G2 = \frac{4}{3} G1 + 3I_{co}$$

where

G2 = G2 pickup setting

G1 = G1 pickup setting

$I_{co}$ = net zero sequence charging during single-line-to-ground fault at the remote end of the line including the effects of any shunt reactors on the protected line.

Suggestions and methods for determining the zero sequence charging current are presented in Appendix II.

On some three-terminal line applications it may be possible for the current at one terminal to be greater than and even approach twice the value of the current leaving either of the remote terminals. When this possibility exists, it is suggested that the G2 function be set as follows:

$$G2 = \frac{8}{3} G1 \times 3I_{co}$$

<u>I3Ø</u>

I3Ø is a three phase, non-directional overcurrent function that serves the following purposes:

(a) It provides a seal-in function that serves to keep the trip bus energized as long as I3Ø is picked up.

(b) It may be used to provide supervision to the phase mho tripping functions.

The seal-in (a) is required to insure that the trip bus and consequently the breaker failure initiate function (BFI) will remain energized during close-in (zero voltage) faults under a breaker failure condition. When I3Ø is used to provide the seal-in function alone, it must be set sensitive enough to detect the minimum close-in three phase fault. If I3Ø is used to provide supervision to the phase mho tripping functions, then it must be set to detect all faults in the protected line section, in which case the setting for seal-in purposes will automatically be met. Supervision of the phase mho functions by I3Ø is used to provide added security to the scheme and also to prevent undesired tripping by the phase mho functions if a-c potential is suddenly lost. If the setting required for supervision purposes is above full load, then protection against undesired tripping on loss of a-c potential will be in effect at all times; otherwise, the protection will be only partially effective. It must be remembered that the phase mho functions could still produce undesired tripping if an external fault occurred during the time that the a-c potential is lost. I3Ø responds to the highest of the three phase currents $I_A$, $I_B$ or $I_C$.

<u>$I_M$</u>

The $I_M$ functions are sensitive phase current detectors in each phase to provide pole position indication. The $I_M$ functions are used to supervise the phase and ground distance mho functions to assure that the MT and MTG functions associated with an open phase are disabled during the open pole period, when single pole switching a single line-to-ground fault. The $I_M$ outputs are also employed in the SLA logic to detect a condition of breaker pole disagreement to control other areas of the scheme logic. The $I_M$ functions have a fixed 0.5 ampere pickup, and no user adjustment is required.

## $I_A$ - $I_B$ - $I_C$

These are three instantaneous non-directional overcurrent fault detectors used to provide direct tripping for multiphase faults from the relay location to a distance somewhat short of the remote terminal. The pickup must be at least 125 percent of the maximum three phase fault current for external faults either beyond the remote terminal or behind the local terminal.

The pickup should also be coordinated with the G4 direct trip overcurrent function, since the $I_A$, $I_B$, and $I_C$ functions enable the appropriate phase gate for single pole G4 tripping on heavy single line-to-ground faults.

## G4

G4 is an instantaneous non-directional ground fault detector for high speed single pole direct tripping for single-line-to-ground faults from the relay location to somewhat short of the remote terminal. The pickup setting of G4 must be at least 125 percent of the maximum external single-line-to-ground fault current. Because G4 is non-directional, it is necessary to consider faults at the bus directly behind the relay as well as the remote bus.

The G4 setting must be coordinated with the $I_A$, $I_B$, $I_C$ setting since the proper phase gate is enabled, by these functions, to permit single pole G4 tripping.

## $I_O$

$I_O$ is used in the phase selector logic to identify phase-to-phase faults and set up 3-pole tripping, and to block 3-pole tripping for possible MT responses to single line-to-ground faults. $I_O$ pickup should be set as sensitive as practical without introducing the possibility of pickup on system unbalance, or "false residual" current due to CT saturation on heavy phase-to-phase faults.

## RATINGS

The Type SLC51C relays are designed for use in an environment where the air temperature outside the relay case does not exceed -20°C or +65°C.

The current circuits of the Type SLC51C relay are rated at 5 amperes, 60 hertz, for continuous duty and have a one-second rating of 300 amperes.

The range of adjustment of the functions in the Type SLC51C relay are listed below:

| | | |
|---|---|---|
| G1 | — | 0.2 to 3.2 amperes |
| G2 | — | 0.5 to 8.0 amperes |
| G4 | — | 2.5 to 40 amperes |
| $I_O$ | — | 0.5 to 8.0 amperes |
| $I_{3\emptyset}$ | — | 1 to 15 amperes |
| $I_A$,$I_B$,$I_C$ | — | 5 to 80 amperes |
| $I_{MA}$,$I_{MB}$,$I_{MC}$ | — | 0.2 amperes fixed |

## BURDENS

The current burden measured at 5 amperes line current is as follows:

| | | | | |
|---|---|---|---|---|
| Phase Current Burden | — | R = 0.093 | X = 0.06 | Z = 0.11 ∠33° |
| Neutral Burden | — | R = 0.029 | X = 0.019 | Z = 0.035 ∠33° |

## OPERATING PRINCIPLES AND CHARACTERISTICS

The functions in the SLC51C are adjustable non-directional overcurrent functions of which G1, G2, G4 and $I_O$ operate on residual current and $I_{3\emptyset}$, $I_A$, $I_B$, and $I_C$ operate on the highest line current. $I_{MA}$, $I_{MB}$, $I_{MC}$ are fixed pickup and operate on line current.

The internal connection diagram of the SLC51C relay (Figure 3) shows the current inputs on the left side, the small squares denote the specific points on the "RA" and "RB" terminal boards at the rear of the unit. The double arrow points on right side represent the plug connections between relay units.

The input currents are routed through transactors of which the output voltages are controlled by secondary loading set at the factory. These voltages are filtered, full wave rectified and fed to the user adjustable level detector. The detector output pulses are stretched to provide continuous output logic signals routed to the SLA logic unit via cables C071 and C081. The supervision outputs are routed to the SLY and SLYG relays via the C281 and CG291 cables respectively.

## CONSTRUCTION

The Type SLC51C relay is packaged in a metal enclosure designed for mounting on a 19 inch rack. The relay is 4 rack units high (one rack unit is 1-3/4 inches) and has a 90 degree hinged front cover and removable top cover. It contains the magnetics, filtering and printed circuit cards required to provide the phase and ground overcurrent functions previously listed.

The operating level of each overcurrent function is adjustable via a potentiometer mounted on the printed circuit card associated with the function. The card identification, such as D101, and its position denoted by th letter in the small square in the lower right corner is shown on the unit internal, Figure 3. Two test cards are included at the extreme right positions "T" and "AT". Test point #1 at the top of the "AT" card is connected to relay reference; TP10 at the bottom of the card is connected to the +15 VDC bus. Other test points are located at select points within the logic circuitry to permit test measurement of the various functions and facilitate troubleshooting.

The potentiometers, P1 to P7, located inside the case are factory set to provide the range of operation of the associated overcurrent function.

## RECEIVING, HANDLING AND STORAGE

The SLC51C relay will normally be supplied as a part of a static relay equipment, mounted in a rack or cabinet with other static relays and test equipment. Immediately upon receipt of a static relay equipment, it should be unpacked and examined for any damage sustained in transit. If injury or damage resulting from rough handling is evident, file a damage claim at once with the transportation company and promptly notify the nearest General Electric Sales Office.

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

Just prior to final installation the shipping support bolts 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.

### WARNING

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.

## TEST INSTRUCTIONS

### CAUTION

THE LOGIC SYSTEM SIDE OF THE D-C POWER SUPPLY USED WITH MOD III STATIC RELAY EQUIPMENT IS ISOLATED FROM GROUND. IT IS A DESIGN CHARACTERISTIC OF MOST ELECTRONIC INSTRUMENTS THAT ONE OF THE SIGNAL INPUT TERMINALS IS CONNECTED TO INSTRUMENT CHASSIS. IF THE INSTRUMENT USED TO TEST THE RELAY EQUIPMENT IS ISOLATED FROM GROUND, ITS CHASSIS MAY HAVE AN ELECTRICAL POTENTIAL WITH RESPECT TO GROUND. THE USE OF A TEST INSTRUMENT WITH A GROUNDED CHASSIS WILL NOT AFFECT THE TESTING OF THE EQUIPMENT. HOWEVER, A SECOND GROUND CONNECTION TO THE EQUIPMENT, SUCH AS A TEST LEAD INADVERTENTLY DROPPING AGAINST THE RELAY CASE, MAY CAUSE DAMAGE TO THE LOGIC CIRCUITRY. NO EXTERNAL TEST EQUIPMENT SHOULD BE LEFT CONNECTED TO THE STATIC RELAYS WHEN THEY ARE IN PROTECTIVE SERVICE, SINCE TEST EQUIPMENT GROUNDING REDUCED THE EFFECTIVENESS OF THE ISOLATION PROVIDED.

IF THE SLC51C RELAY THAT IS TO BE TESTED IS INSTALLED IN AN EQUIPMENT WHICH HAS ALREADY BEEN CONNECTED TO THE POWER SYSTEM, DISCONNECT THE OUTPUTS IN THE ASSOCIATED TYPE SLAT RELAY FROM THE SYSTEM DURING TEST.

## GENERAL TESTING INSTRUCTIONS

### INPUT CIRCUITS

The Type SLC51C relay has terminal blocks on the rear of the unit identified as "RA" and "RB". In a static relay equipment the terminal block is usually wired to the test panel where input currents can be supplied through the standard Type XLA test plug. Where other test facilities are used, input currents should be applied to test points which connect to the same RA and RB terminal points as those shown on the job elementary.

### OUTPUT SIGNALS

Output signals are measured with respect to the reference bus or TP1. Outputs are continuous signals of approximately +12 to +15 volts for the "ON" condition and 0 volts for the "OFF" condition. This output can be monitored with an oscilloscope, a portable high impedance d-c voltmeter, or with the test panel if available. To connect the test panel voltmeter, place the test lead in the proper test point pin jack and the other end in the pin jack on the test panel.

### TEST CARD ADAPTER

The test card adapter provides a convenient means of gaining access to any pin of a particular card. Detailed information on the use of the test adapter card is included in the card instruction book GEK-34158.

## DETAILED TESTING INSTRUCTIONS

### REQUIRED ADJUSTMENTS

The overcurrent function settings may be made and tested using a single phase test source. A possible test circuit is shown in Figure 5 with the input connections for the SLC51C given below in Table I.

CAUTION

THIS RELAY IS RATED AT 5 AMPERES CONTINUOUS DUTY. TO SET FOR HIGHER CURRENT LEVELS, APPLY TEST CURRENT TO THE RELAY ON MOMENTARY BASIS (APPROXIMATELY ONE SECOND).

To set the test circuit for higher current levels it is recommended that a resistance be connected between points "A" and "B" of Figure 4. The value of the resistance should be equal to the impedance of the a-c circuit to be tested (see above). When the desired current level is established, remove the resistor and connect the relay per Table I. Momentarily apply test current and monitor the output. Adjust the proper potentiometer for the desired operating point (clockwise pot rotation raises the operating point).

TABLE I

| FUNCTION | CONNECTIONS | | OUTPUT AT | ADJUST |
|---|---|---|---|---|
| | A | B | TP | POT ON CARD |
| G1 | RA3 | RA4 | 4 | AJ |
| G2 | RA3 | RA4 | 5 | AK |
| G4 | RA3 | RA4 | 14 | AL |
| $I_O$ | RA11 | RA12 | 6 | AM |
| $I_A$ | RA5 | RA6 | 11 | AP |
| $I_B$ | RA7 | RA8 | 12 | AR |
| $I_C$ | RA9 | RA10 | 13 | AS |
| $I_{MA}$ | RB5 | RB6 | 7 | – |
| $I_{MB}$ | RB7 | RB8 | 8 | – |
| $I_{MC}$ | RB9 | RB10 | 9 | – |
| *$I_{3Ø}$ ($I_A$) | RA5 | RA6 | 3 | AN |
| *$I_{3Ø}$ ($I_B$) | RA7 | RA8 | 3 | AN |
| *$I_{3Ø}$ ($I_C$) | RA9 | RA10 | 3 | AN |

*The $I_{3Ø}$ level detector operates on the highest line current input. Refer to the calibration procedure below if operating point differences are observed.

## CALIBRATION

The SLC51C relay calibration may be checked by applying a reactance limited single phase current per Figure 4 and Table II. Use of the card adapter will provide access to the required measurement points.

TABLE II

| FUNCTION | CONNECTIONS | | $I_{IN}$ AMPS | ADJ. | MEASURE PIN 3 TO PIN 1 | |
|---|---|---|---|---|---|---|
| | A | B | | | CARD | VOLTAGE |
| G1 | RA3 | RA4 | 3.2 | P1 | AJ | 5.9 VRMS |
| G2 | RA3 | RA4 | 4.0 | P2 | AK | 2.9 VRMS |
| G4 | RA3 | RA4 | 10.0 | P3 | AL | 1.4 VRMS |
| $I_O$ | RA11 | RA12 | 4.0 | P4 | AM | 2.9 VRMS |
| $I_{3\emptyset}$ ($I_A$) | RA5 | RA6 | 1.0 | P5 | AP | 0.5 $V_{o-p}$ |
| $I_{3\emptyset}$ ($I_B$) | RA7 | RA8 | 1.0 | P6 | AR | 0.5 $V_{o-p}$ |
| $I_{3\emptyset}$ ($I_C$) | RA9 | RA10 | 1.0 | P7 | AS | 0.5 $V_{o-p}$ |

# MAINTENANCE

## PERIODIC CHECKS

For any periodic testing of the Type SLC51C relay, the trip coil circuits of the circuit breaker should be opened by opening the disconnect switches or other test switches provided for this purpose.

## TROUBLESHOOTING

Test points are provided at selected points in the Type SLC51C relay to observe outputs if trouble-shooting is necessary. The use of a card adapter will make the pins on any one card available for testing.

For the physical location of components and cards refer to Figure 2, the component location diagram.

## SPARE CARDS

To minimize possible outage time, it is recommended that one spare card of each type be carried in stock. 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 SLC51C relay are included in the card book GEK-34158.

## CARD DRAWINGS

Details of the circuits of the printed circuit cards can be obtained in the printed circuit card book GEK-34158.

# APPENDIX I

## DEFINITION OF SYMBOLS

In the following appendices, and throughout other portions of this instruction book, the symbols used for voltages, currents, impedances, etc., are consistent. Note that all of the parameters listed below are secondary quantities based on the CT and PT ratios on the protected line terminal. Other symbols not defined here are to be defined as and where they are used.

### Voltage

$E_a$ = Phase A-to-neutral voltage.

$E_b$ = Phase B-to-neutral voltage.

$E_c$ = Phase C-to-neutral voltage.

$E_{am}$ = Phase A-to-median (midpoint of $E_{bc}$) voltage

$E_{bm}$ = Phase B-to-median (midpoint of $E_{ca}$) voltage

$E_{cm}$ = Phase C-to-median (midpoint of $E_{ab}$) voltage

$E_0$ = Zero sequence phase-to-neutral voltage.

$E_1$ = Positive sequence phase-to-neutral voltage.

$E_2$ = Negative sequence phase-to-neutral voltage.

$E_{ab} = (E_a - E_b)$

$E_{bc} = (E_b - E_c)$

$E_{ca} = (E_c - E_a)$

Note that when one of these symbols is primed, such as $E_a'$, is then represents the voltage at the location of the relay under consideration.

### Current

$I_a$ = Total phase A current in the fault.

$I_b$ = Total phase B current in the fault.

$I_c$ = Total phase C current in the fault.

$I_0$ = Total zero sequence current in the fault.

$I_1$ = Total positive sequence current in the fault.

$I_2$ = Total negative sequence current in the fault.

Note that when one of the above symbols is primed, such as $I_a'$, or $I_2'$, it then represents only that portion of the current that flows in the relays under consideration.

$I_0''$ = Zero sequence current flowing in a line that is parallel to the protected line. Taken as positive when the current flow in the parallel line is in the same direction as the current flowing in the protected line. While this current flows in the parallel line, the secondary value is based on the CT ratio at the protected line terminal under consideration.

### Distribution Ratios

C = Positive sequence current distribution ratio, assumed equal to the negative sequence current distribution ratio.

$C_0$ = Zero sequence current distribution ratio.

$$C = \frac{I_1'}{I_1} = \frac{I_2'}{I_2'} \qquad C_0 = \frac{I_0'}{I_0}$$

Impedance, Reactance

$Z_0$ = System zero sequence to-neutral phase impedance as viewed from the fault.

$Z_1$ = System positive sequence to-neutral phase impedance as viewed from the fault.

$Z_2$ = System negative sequence to-neutral phase impedance as viewed from the fault. Assume equal to $Z_1$.

$Z_0'$ = Zero sequence to-neutral phase impedance of the protected line from the relay to the remote terminal.

$Z_1'$ = Positive sequence to-neutral phase impedance of the protected line from the relay to the remote terminal.

$Z_2'$ = Negative sequence to-neutral phase impedance of the protected line from the relay to the remote terminal, assume equal to $Z_1'$.

$Z_{om}$ = Total zero sequence mutual impedance between the protected line and a parallel circuit over the entire length of the protected line.

$X_1'$ = Positive sequence to-neutral phase reactance of the protected line from the relay to the remote terminal.

$X_0'$ = Zero sequence to-neutral phase reactance of the protected line from the relay to the remote terminal.

$X_{om}$ = Total zero sequence mutual reactance between the protected line and a parallel line over the entire length of the protected line.

$Z_L$ = Line impedance

$Z_a$ = Phase A impedance for condition described.

All of the above are secondary ohms, where: Secondary Ohms = Primary Ohms X $\frac{\text{CT Ratio}}{\text{PT Ratio}}$ and $Z_{om}$ and $X_{om}$ are calculated using the CT ratio for the protected line.

Miscellaneous

T = Relay voltage restraint tap setting in percent.

$K_0$ = Zero sequence current compensation tap setting for the protected line; in percent, unless otherwise noted. (MOD III design; $K_0 = Z_0'/Z_1$)

$K_Q$ Constant depending on the ratio of $Z_0/Z_1$.

$T_B$ = Relay basic minimum ohmic tap at the set angle of maximum reach.

K' = Zero sequence current compensation tap setting for the protected line; in percent, unless otherwise noted. (MOD II design)

K" = Zero sequence current compensation tap setting for the parallel line; in percent, unless otherwise noted. (MOD II design)

S = Ratio of distances as defined where used.

M = Reach of mho function from the origin (relay location) in the direction of the protected line section as forward reach.

M* = Reach of mho function from the origin (relay location) away from the protected line section as reverse reach or reach in the blocking direction.

$\theta$ = Line angle

$\phi$ = Angle of maximum reach.

$\gamma, \beta$ or any lower case Greek letter (except $\pi$) = angles in degrees as defined where used.

## APPENDIX II

## DETERMINATION OF ZERO SEQUENCE CHARGING CURRENT

In many pilot schemes which operate on the blocking principle on ground faults, the blocking signal is initiated by a high-speed, non-directional fault detector operating on zero sequence current, and the tripping level is established by a second fault detector set at a higher value. That is:

$$FD_T = k\ FD_B \qquad \text{V-a}$$

where:

k = Desired margin between blocking and tripping levels = 4/3.

On applications where the zero sequence line charging current is significant, it must be taken into account if the margin k of equation V-a is to be retained:

$$FD_T = k\ FD_B + 3I_{OC} \qquad \text{V-b}$$

$I_{OC}$ = Zero sequence line charging current

Thus, in many applications of schemes involving instantaneous blocking and tripping level detectors, it becomes necessary to determine the zero sequence line charging current. The following steps are suggested in approximating this quantity:

Figure 6-2 shows a simplified representation of the sequence network connections for a single-phase-to-ground fault. For a grounded system $Z_0$ will not exceed $3Z_1$. Therefore, assuming that $Z_0 = 3Z_1$, the voltage $E_0$ will be 0.6 $E_{\emptyset N}$.

Figure 6-3 represents the zero sequence network for an external ØG fault beyond B of line A-B. The shunt capacitance in reality would be distributed along the line. The zero sequence charging current could be very closely approximated by assuming that the total shunt capacitance is lumped at the center of the line, and that the zero sequence voltage applied across the capacitance is the average zero sequence voltage across the line as represented by Figure 6-4.

As is apparent from Figure 6-4 however, this average voltage will depend on the magnitude of zero sequence source impedance at A, which in many applications can vary greatly. It will be pessimistic if it is assumed that the lumped shunt capacitance is located at the remote end of the line nearest the fault, and that the voltage applied across this shunt capacitance is $E_0$ at the fault. If we assume that the zero sequence shunt capacitance ($C_0$) is equal to 3/4 the positive sequence shunt capacitance (C), then the zero sequence capacitive reactance ($X_{C0}$) will be 4/3 the positive ($X_{C1}$). Then:

$$I_{c1} = \frac{E_{\emptyset N}}{X_{c1}}$$

$$I_{oc} = \frac{E_o}{X_{co}} = \frac{0.6\ E_{\emptyset N}}{(4/3)\ X_{c1}}$$

Substituting $I_{c1}$ for $E_{\emptyset N}/X_{c1}$:

$$I_{co} = 0.6\ (3/4)\ I_{c1}$$

$$\therefore\ I_{co} = 0.45\ I_{c1}$$

$$\text{or}\ 3I_{co} = 1.35\ I_{c1}$$

This value should be substituted into equation V-b in determining the required setting of the tripping fault detector $FD_T$. If the resulting setting of $FD_T$ is low enough to detect the minimum predicted internal fault, with margin, it can be used with assurance that the margin between the blocking and tripping levels will be conservative. If a lower setting is required to provide margin below the minimum internal fault, then the user will have to use a more precise method of determining $I_{co}$ in the hope that the resulting lower value of $3I_{co}$ in equation V-b will result in a sufficiently lower $FD_T$ setting. One such approach would be to assume the lumped shunt capacitance at the center of the line with average $E_0$ applied across it. This requires that the maximum possible source impedance at A ($Z_{0SA}$) be determined.

If compensating shunt reactors are present, either at one end or at both ends of the protected line, the lagging reactor current will reduce the net zero sequence charging current. This net current then should be used for the $3I_{co}$ quantity shown in equation V-b.

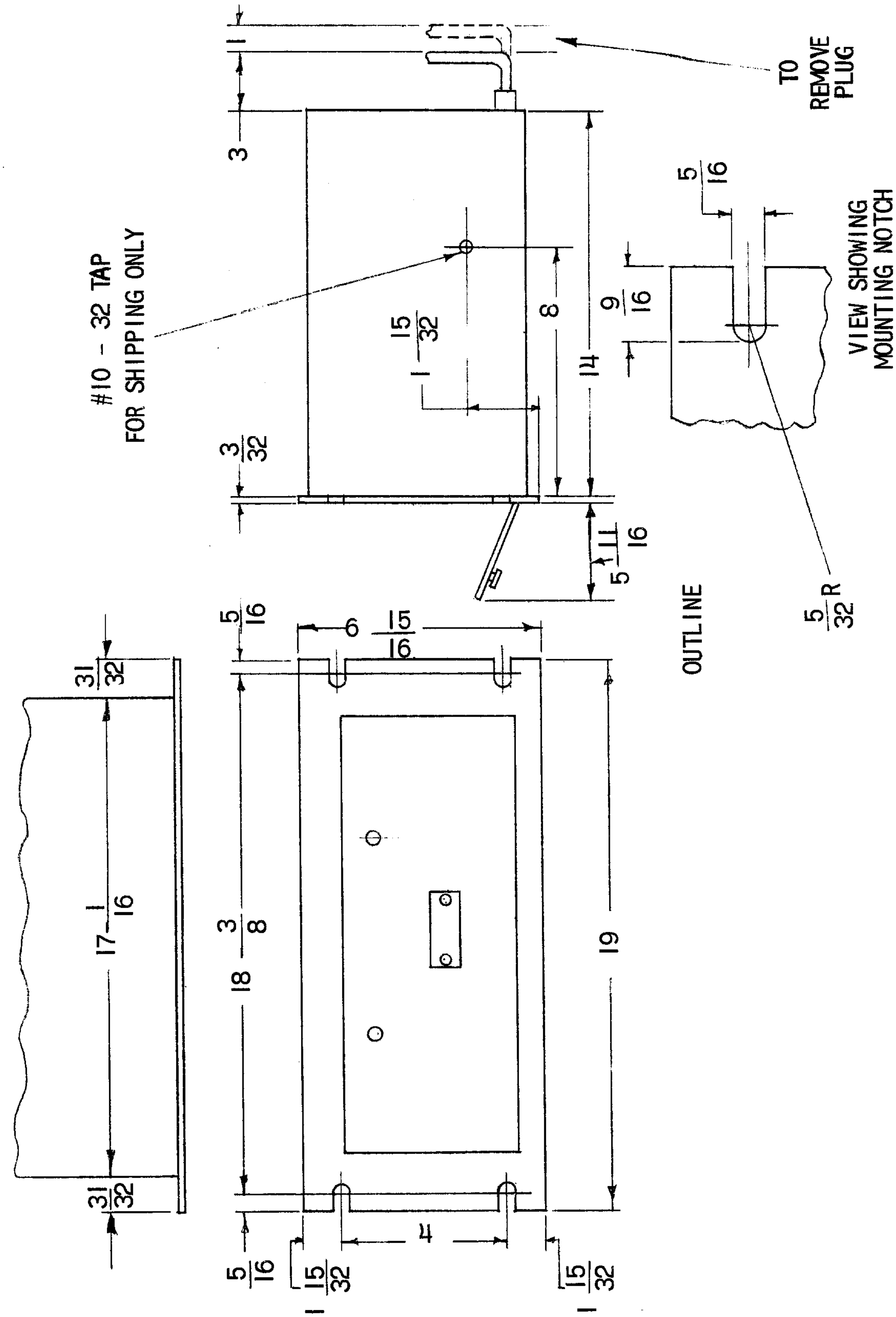



FIG. 1 (0227A2037-0) Outline and Mouting Dimensions

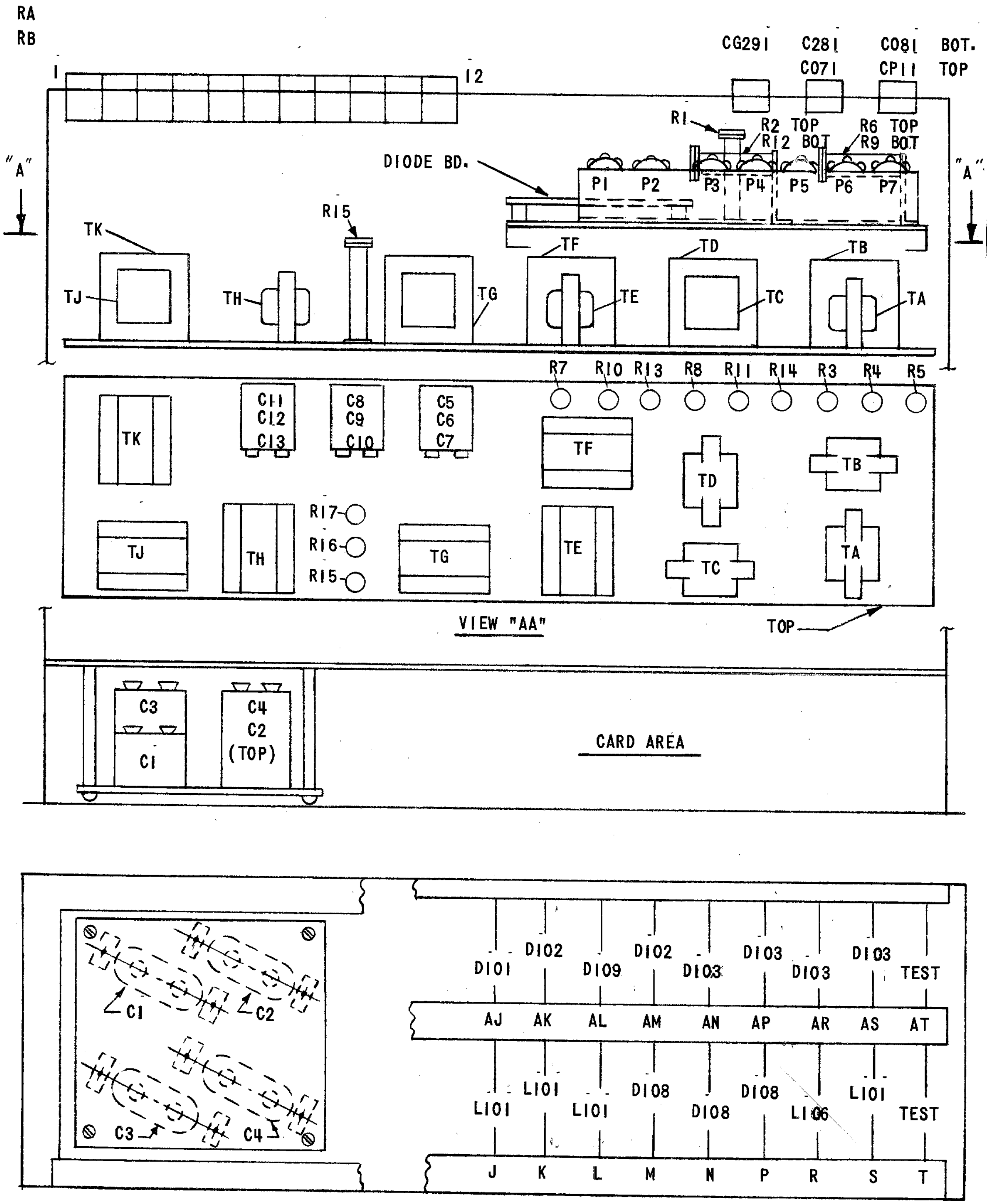
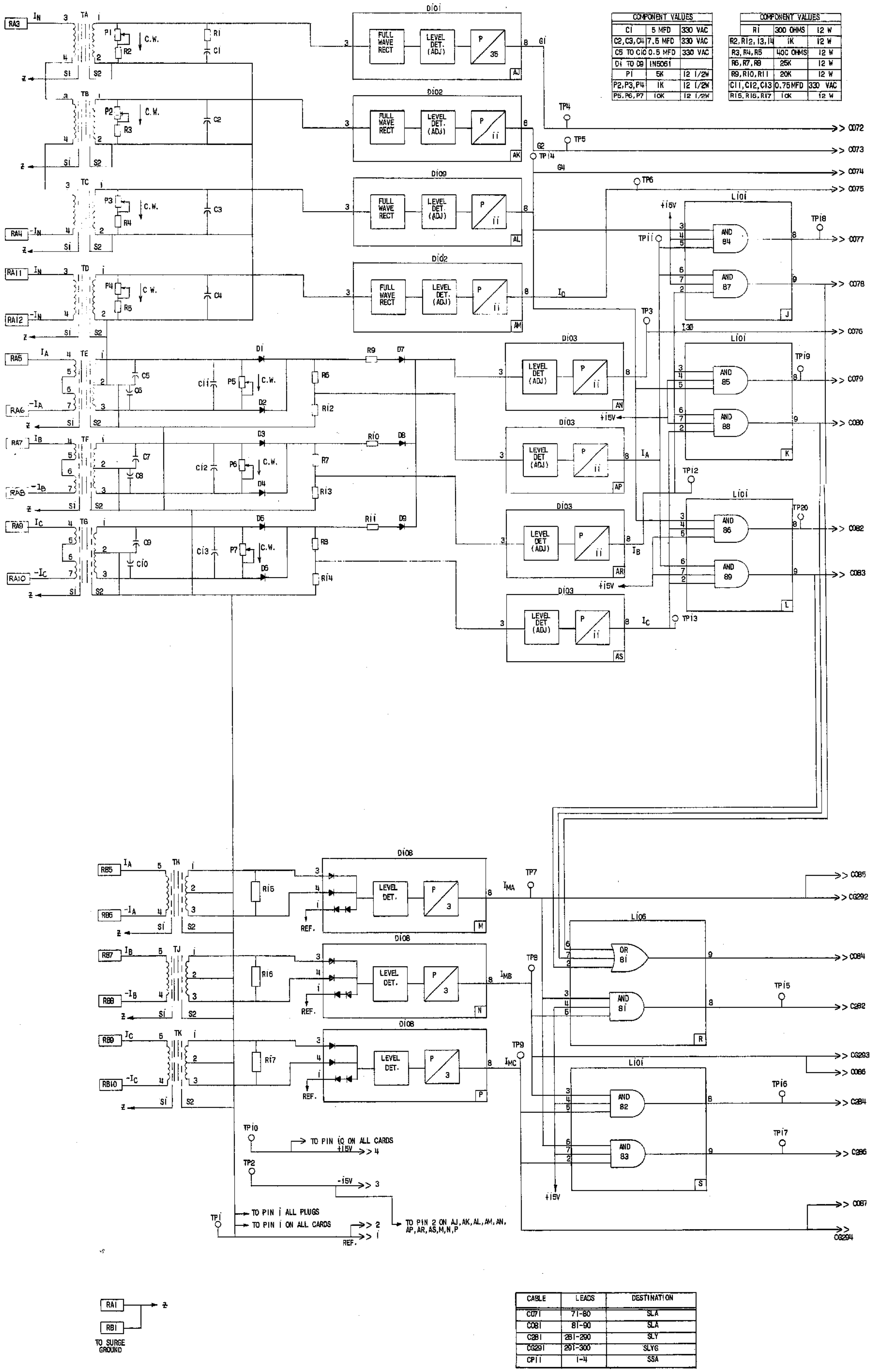



FIG. 2 (0257A6220-1) Component Location Diagram

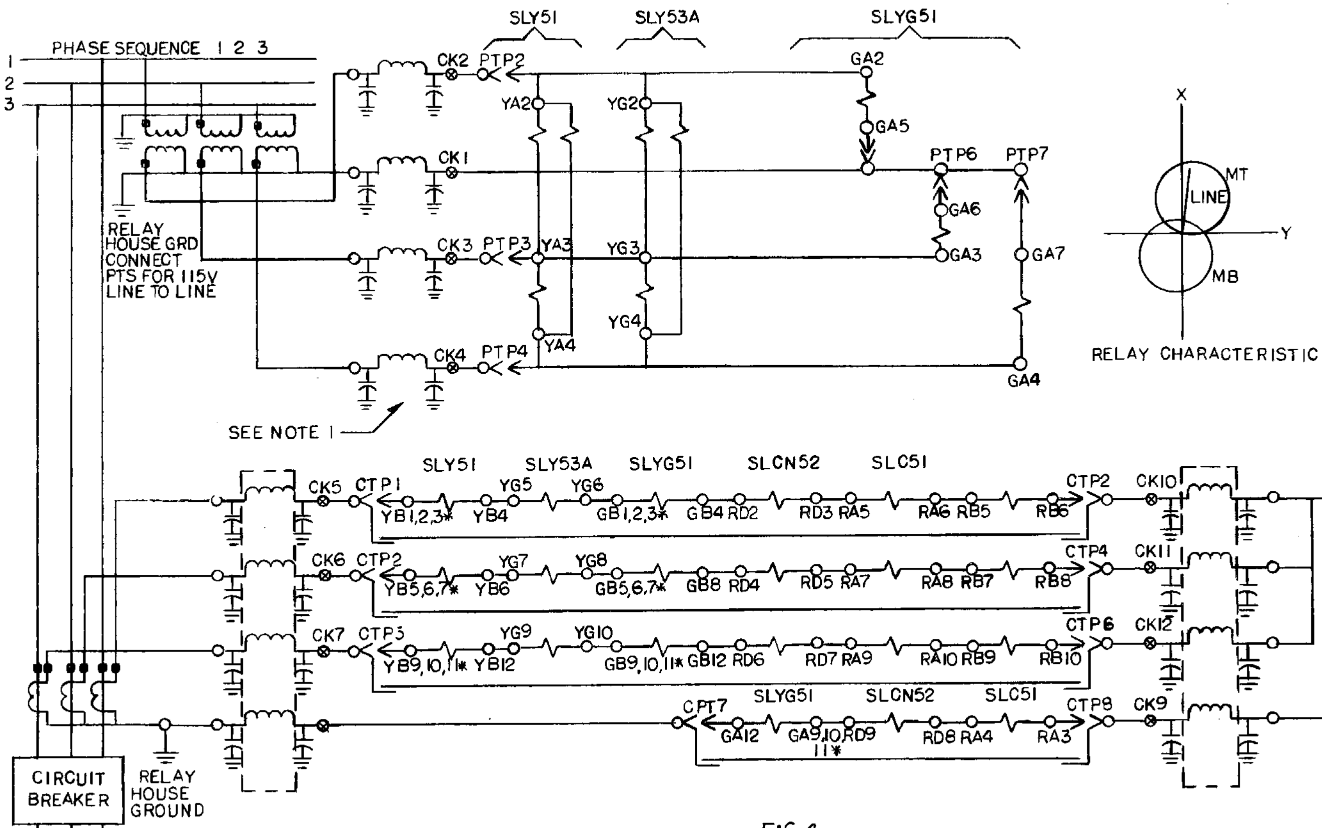



| COMPONENT VALUES | | |
|---|---|---|
| C1 | 5 MFD | 330 VAC |
| C2,C3,C4 | 7.5 MFD | 330 VAC |
| C5 TO C10 | 0.5 MFD | 330 VAC |
| D1 TO D9 | 1N5061 | |
| P1 | 5K | 12 1/2W |
| P2,P3,P4 | 1K | 12 1/2W |
| P5,P6,P7 | 10K | 12 1/2W |

| COMPONENT VALUES | | |
|---|---|---|
| R1 | 300 OHMS | 12 W |
| R2,R12,13,14 | 1K | 12 W |
| R3,R4,R5 | 400 OHMS | 12 W |
| R6,R7,R8 | 25K | 12 W |
| R9,R10,R11 | 20K | 12 W |
| C11,C12,C13 | 0.75 MFD | 330 VAC |
| R15,R16,R17 | 10K | 12 W |

| CABLE | LEADS | DESTINATION |
|---|---|---|
| C071 | 71-80 | SLA |
| C081 | 81-90 | SLA |
| C281 | 281-290 | SLY |
| CG291 | 291-300 | SLYG |
| CP11 | 1-4 | SSA |

FIG. 3 (0126D6201-1) Internal Connections Diagram for the Type SLC51C Relay




| —○— TERMINAL STRIP ON UNIT | —○<<— TEST&CONN RECEPT. ON TEST PANEL | ASSOCIATED RELAY UNIT |
|---|---|---|
| AA, AB, AC, AD | TAA, TAB, TAC, TAD | SLAT53B |
| RD | | SLCN52A |
| AH | | SLA53B |
| GA, GB | PTP, CTP | SLYG51B |
| | | |
| PA | | SSA51A |
| RA | CTP | SLC51C |
| YA, YB | PTP, CTP | SLY51B |
| YG | PTP, CTP | SLY53A |
| CTP | CURRENT TEST PLUG | |
| PTP | POTENTIAL TEST PLUG | |

NOTE 1: ALL INCOMING AC POTENTIAL AND CURRENT CIRCUITS ARE WIRED TO THE CUSTOMER CONNECTION BLOCK, AT CUSTOMER SIDE, THROUGH A SURGE PACKAGE AND OUT THE EQUIPMENT SIDE OF THE CUSTOMER CONNECTION BLOCKS, THEY ARE THEN WIRED TO THE TEST PANEL.

FIG 4

* – SPECIFIED CONNECTION POINT IS DETERMINED BY BASE REACH SETTING AS DESCRIBED IN THE RELAY INSTRUCTION BOOK FOR EACH RELAY.

FIG. 4 (0108B8976-0) Typical External Connections

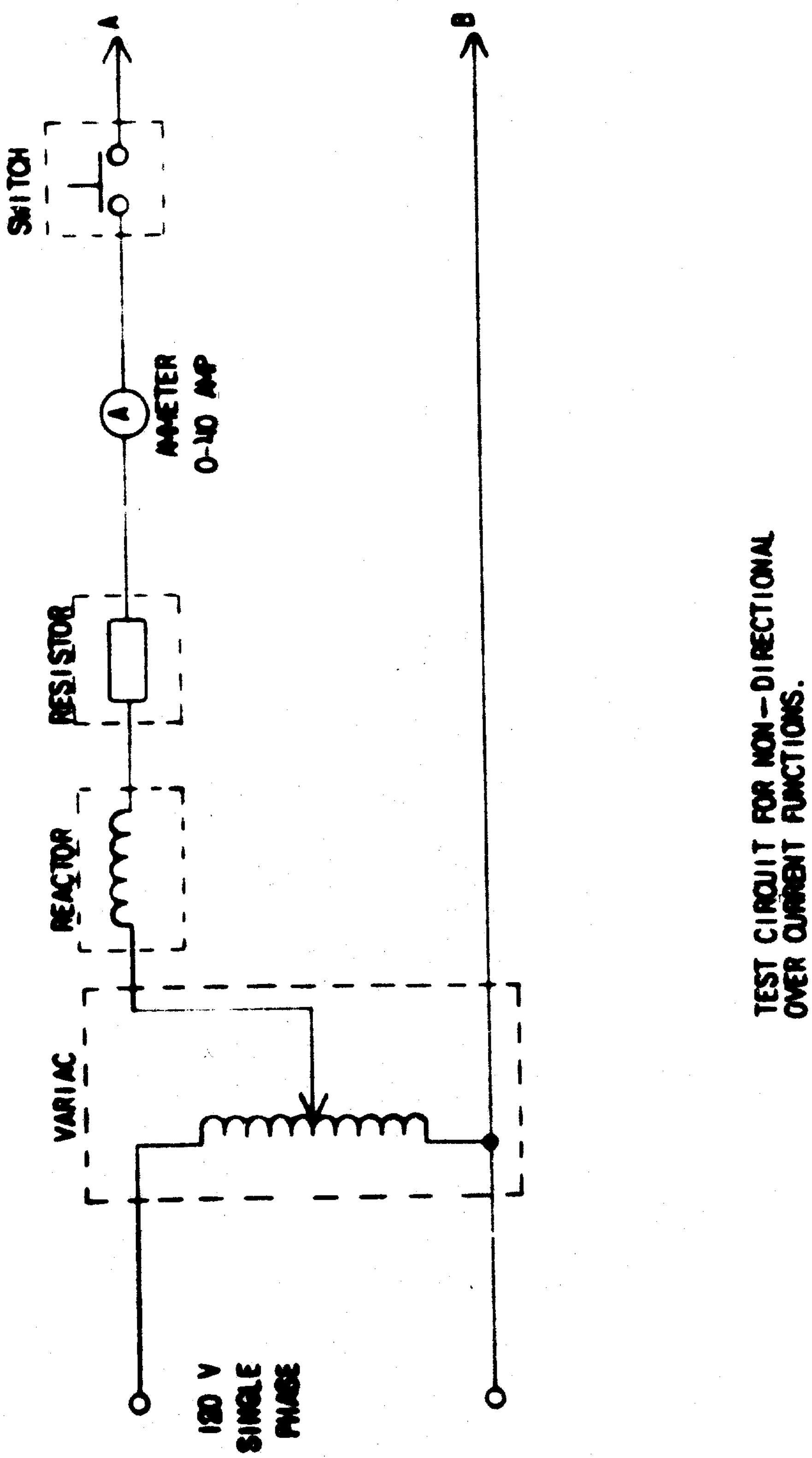



FIG. 5 (0246A3681-1) Overcurrent Function Test Circuit

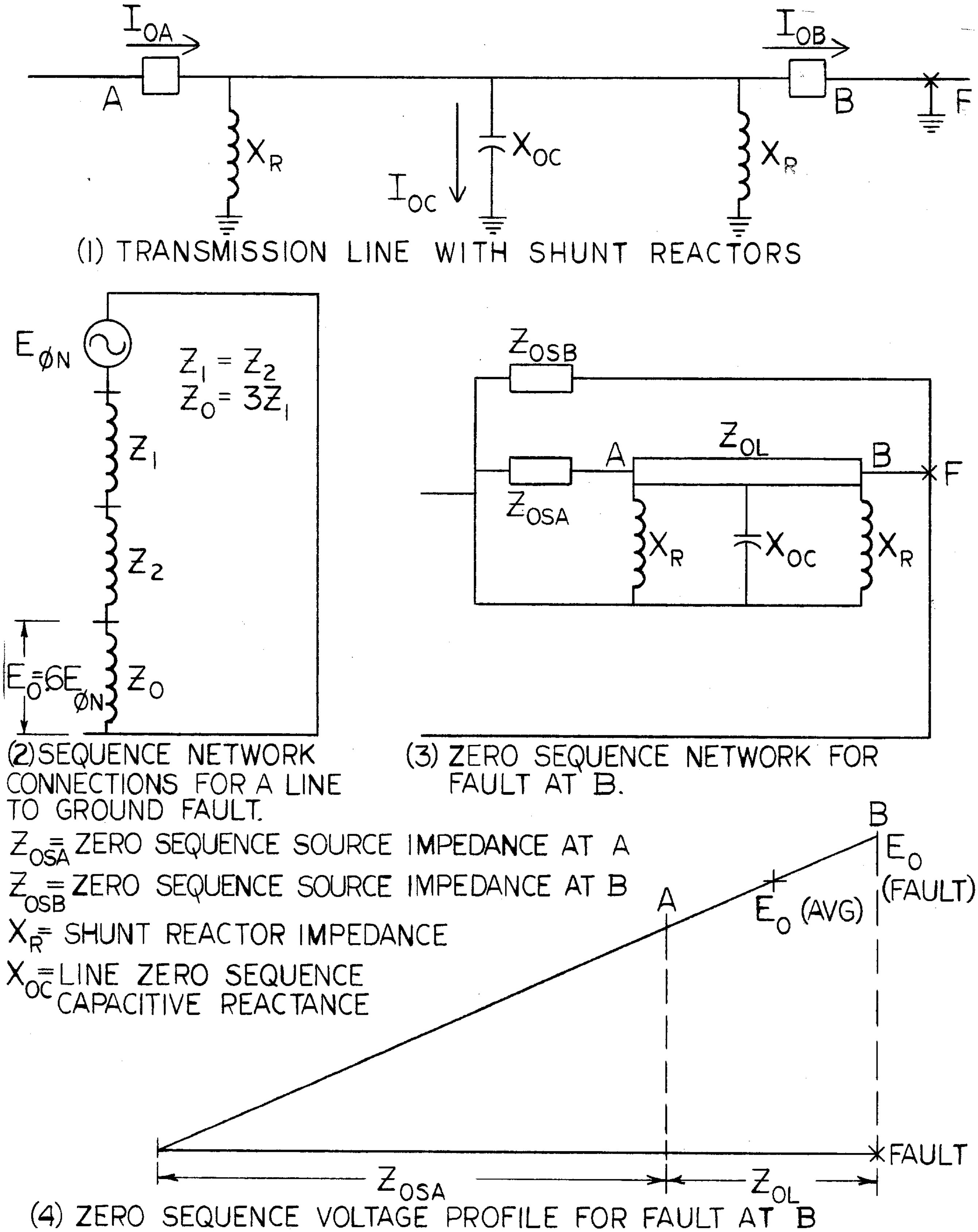



FIG. 6 (0246A6925-0) Determination of Zero Sequence Charging Current