INSTRUCTIONS

GEK- 34018A

SUPERSEDES GEK-34018

OVERCURRENT RELAY

SLC51A

POWER SYSTEMS MANAGEMENT DEPARTMENT

GENERAL ELECTRIC

PHILADELPHIA, PA.

CONTENTS

OVERCURRENT RELAY
TYPE SLC51A

DESCRIPTION

The type SLC51A is a static, three phase, overcurrent relay which provides direct trip functions and supervision of associated phase and ground distance relays in a directional comparison pilot relaying scheme. The SLC51A relay is packaged in one two rack unit case as shown in Figure 1. Component locations are shown in Figure 2.

The SLC51A relay is not intended for use by itself, but rather as part of a complement of equipment that forms a protective relaying scheme. In addition to the SLC51A, a typical directional comparison pilot relaying scheme may be composed of a type SLY phase tripping relay, a type SLY carrier start relay, type SLYG ground relay, a type SLA logic relay, a type SLAT output relay and a type SSA power supply.

The type SLC51A relay outputs are d-c logic signals that are fed into a type SLA logic relay, the circuitry of which depends on the overall protection scheme. The static circuits of the SLC51A require ±15 VDC which is obtained from a type SSA power supply. The internal connections for the SLC51A relay are shown in Figure 3.

The functions included in the SLC51A relay are listed below:

$I_{3\phi}$ - Three phase overcurrent trip supervision

PH4 - Three phase direct trip instantaneous overcurrent

G1 - Ground overcurrent carrier start

G2 - Ground overcurrent trip supervision

G4 - Ground direct trip instantaneous overcurrent

For a complete description of the overall scheme in which this relay is employed, refer to the overall logic diagram and its associated logic description that is supplied with each terminal of equipment.

APPLICATION

The SLC51A static overcurrent relay is designed to provide the overcurrent functions required in directional comparison blocking schemes utilizing suitable phase relays and ground relays.

The SLC51A 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 external connections to the SLC51A when it is used in a typical directional comparison carrier blocking scheme.

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.

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

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

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 current 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:

$$G2 = \frac{8}{3} G1 + 3I_{CO}$$

<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 delta currents $I_1 - I_2$, $I_2 - I_3$ or $I_3 - I_1$. The response of $I_{3Ø}$ will be the same for three phase, phase-to-phase and double phase-to-ground faults at the same location.

<u>PH4</u>

PH4 is a three phase, non-directional, direct trip instantaneous overcurrent function that is intended to provide direct tripping for heavy multi-phase faults. The PH4 function must be set to operate at 125 percent or more of the maximum external three phase fault current. Because PH4 is non-directional, faults at the bus directly behind the relay as well as faults at the remote terminal must be considered. PH4, like I3Ø, responds to the delta currents; therefore, it too will have the same response for all multi-phase faults at the same location.

* In setting I3Ø, the minimum three phase fault current for which each of the functions is to operate should first be determined. Use 86 percent of the value so obtained and follow the instructions given under the section headed DETAILED TESTING INSTRUCTIONS to set the respective functions. With settings

*Indicates Revision

made on this basis, the respective functions will then respond to all multi-phase faults within the area for which the minimum three phase fault current was obtained.

G4

G4 is a zero sequence, non-directional, direct trip instantaneous overcurrent function that is intended to provide direct tripping for heavy ground faults. The G4 function must be set to operate at 125 percent or more of the maximum external ground fault current ($3I_0$). Because G4 is non-directional, it is necessary to consider faults at the bus directly behind the relay as well as at the remote terminal.

RATINGS

The Type SLC51A 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 SLC51A relay are rated at 5 amperes, 60 cycles, for continuous duty and have a one second rating of 300 amperes.

The range of adjustment of the functions in the Type SLC51A relay are listed below:

G1 - 0.2 to 3.2 amperes
G2 - 0.5 to 8.0 amperes
G4 - 2.5 to 40 amperes
$I_{3\phi}$ - 1 to 15 amperes
PH4 - 5 to 80 amperes

BURDENS

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

Phase Current Burden - R = 0.020, X = 0.013, Z = 0.024 $\angle$ 33°

Neutral Burden - R = 0.028, X = 0.018, Z = 0.033 $\angle$ 33°

OPERATING PRINCIPLES AND CHARACTERISTICS

The functions in the SLC51A are adjustable non-directional overcurrent functions of which G1, G2 and G4 operate on residual current and I3Ø and PH4 operate on the highest phase to phase current.

CIRCUIT DESCRIPTION

The internal connection diagram of the SLC51A relay (Figure 3) shows the current inputs on the left side, the small squares denote the specific points on the "RA" terminal board 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 customer adjustable level detector. The detector output pulses are stretched to provide continuous output logic signals routed to the SLA logic unit via cable C071.

CONSTRUCTION

The Type SLC51A relay is packaged in a metal enclosure designed for mounting on a 19 inch rack. The relay is 2 rack units high (one rack unit is 1 3/4 inches) and has a 90° 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 the letter in the small square in the lower right corner is shown on the unit internal Figure 3. One test card is included at the extreme right position "T". Test point #1 at the top of the 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 trouble shooting.

The potentiometers, P1 to P6, located to the left of the printed circuit cards are factory set to provide the range of operation of the associated overcurrent function.

RECEIVING, HANDLING AND STORAGE

This 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 bolt should be removed from each side of all relay units, to facilitate possible future unit removal for maintenance. These shipping support bolts are approximately 8 inches back from the relay unit front panel. Static relay equipment, when supplied in swing rack cabinets, should be securely anchored to the floor or to the shipping pallet to prevent the equipment from tipping over when the swing rack is opened.

INSTALLATION TESTS

The Type SLC51 relay is usually supplied from the factory mounted and wired in a static relay equipment.

All units of a given terminal have been calibrated together at the factory and will have the same summary number on the unit nameplates.

These units must be tested and used together.

NECESSARY ADJUSTMENTS

The following checks and adjustments should be made by the user in accordance with the procedures given below under DETAILED TESTING INSTRUCTIONS, before the relays are put in service. Some of the following items are checks of factory calibrations and settings, or installation connections and hence do not normally require readjustment in the field. Other items cover settings or adjustments which depend on installation conditions and hence must be made on the installed equipment.

1. G4, G2 and G1 Overcurrent operating levels
2. PH4 and I3Ø Overcurrent operating levels

GENERAL TESTING INSTRUCTIONS

INPUT CIRCUITS

The Type SLC51A relay has a terminal block on the rear of the unit identified as "RA". 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 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 voltmeter 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.

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 SLC51A 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 5. The value of the resistance should be equal to the impedance of the AC 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

	CONNECT "RA" TERMINALS TO TEST CKT POINTS				
FUNCTION	A	B	JUMPER	MONITOR OUTPUT AT	ADJ. POT ON CARD
G4	5	6	--	TP5	"P"
G2	5	6	--	TP4	"N"
G1	5	6	--	TP3	"M"
PH4, Ø1-2	7	9	8 TO 10	TP7	"S"
I3Ø, Ø1-2	7	9	8 TO 10	TP6	"R"
PH4, Ø2-3	9	11	10 TO 12	TP7	*
I3Ø, Ø2-3	9	11	10 TO 12	TP6	*
PH4, Ø3-1	11	7	12 TO 8	TP7	*
I3Ø, Ø3-1	11	7	12 TO 8	TP6	*

* PH4 and I3Ø level detectors operate on the highest phase to phase current input; if operating point differences are observed, calibration procedure is described below.

CALIBRATION

The SLC51A relay calibration may be checked by applying a reactance limited single phase current per Figure 5 and Table II. Use of the card adapter will provide access to the required measurement points

TABLE II

	CONNECT "RA" TERMINALS TO TEST CKT. POINTS					MEASURE PIN 3 TO PIN 1	
FUNCTION	A	B	JUMPER	Iin (AMPS)	ADJ.	CARD	VOLTAGE
G4	5	6	--	10.0	P3	P	1.4 Vrms
G2	5	6	--	4.0	P2	N	2.9 Vrms
G1	5	6	--	3.2	P1	M	5.9 Vrms
I3Ø Ø1-2	7	9	8 TO 10	1.0	P4	R	0.58 Vo-p
I3Ø Ø2-3	9	11	10 TO 12	1.0	P5	R	0.58 Vo-p
I3Ø Ø3-1	11	7	12 TO 8	1.0	P6	R	0.58 Vo-p

The PH4 card input voltage (pin 3 to pin 1 of "S" card) with 5 amps applied at any of the above I3Ø connections should be 0.45 to 0.55 volts zero to peak.

*Indicates Revision

MAINTENANCE

PERIODIC CHECKS

For any periodic testing of the Type SLC51 relay the trip coil circuit of the circuit breaker should be opened by opening the disconnect switches or other test switches provided for this purpose.

TROUBLE-SHOOTING

Test points are provided at selected points in the Type SLC51A 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

The number of spare cards to carry in stock would depend on the total number of static relays, using similar cards, at the same location or serviced by the same test group. For each type of card (different code designation) a suggested minimum number of spare cards would be:

1 spare for 1 to 25 cards
2 spares for 26 to 75 cards
3 spares for 76 to 125 cards

CARD DRAWINGS

Details of the circuits of the printed circuit cards can be obtained in the printed circuit card book GEK-34148.

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.

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

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

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

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_o = Zero sequence phase-to-neutral voltage.

E_1 = Positive sequence phase-to-neutral voltage.

E_2 = Negative sequence phase-to-neutral voltage.

Note that when one of these symbols is primed, such as E_a', it 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_o = 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_o'' = 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_o = Zero sequence current distribution ratio.

$$C = \frac{I_1'}{I_1} = \frac{I_2'}{I_2} \qquad C_o = \frac{I_o'}{I_o}$$

Impedance, Reactance

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

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

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

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

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

Z_2' = Negative sequence phase-to-neutral 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 phase-to-neutral reactance of the protected line from the relay to the remote terminal.

X_o' = Zero sequence phase-to-neutral 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 restaint 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_o/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.

θ = Line angle

ϕ = Angle of maximum reach.

α, β or any lower case Greek letter (except π) = 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 that 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_{co}) 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_o applied across it. This requires that the maximum possible source impedance at A (Z_{OSA}) 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.

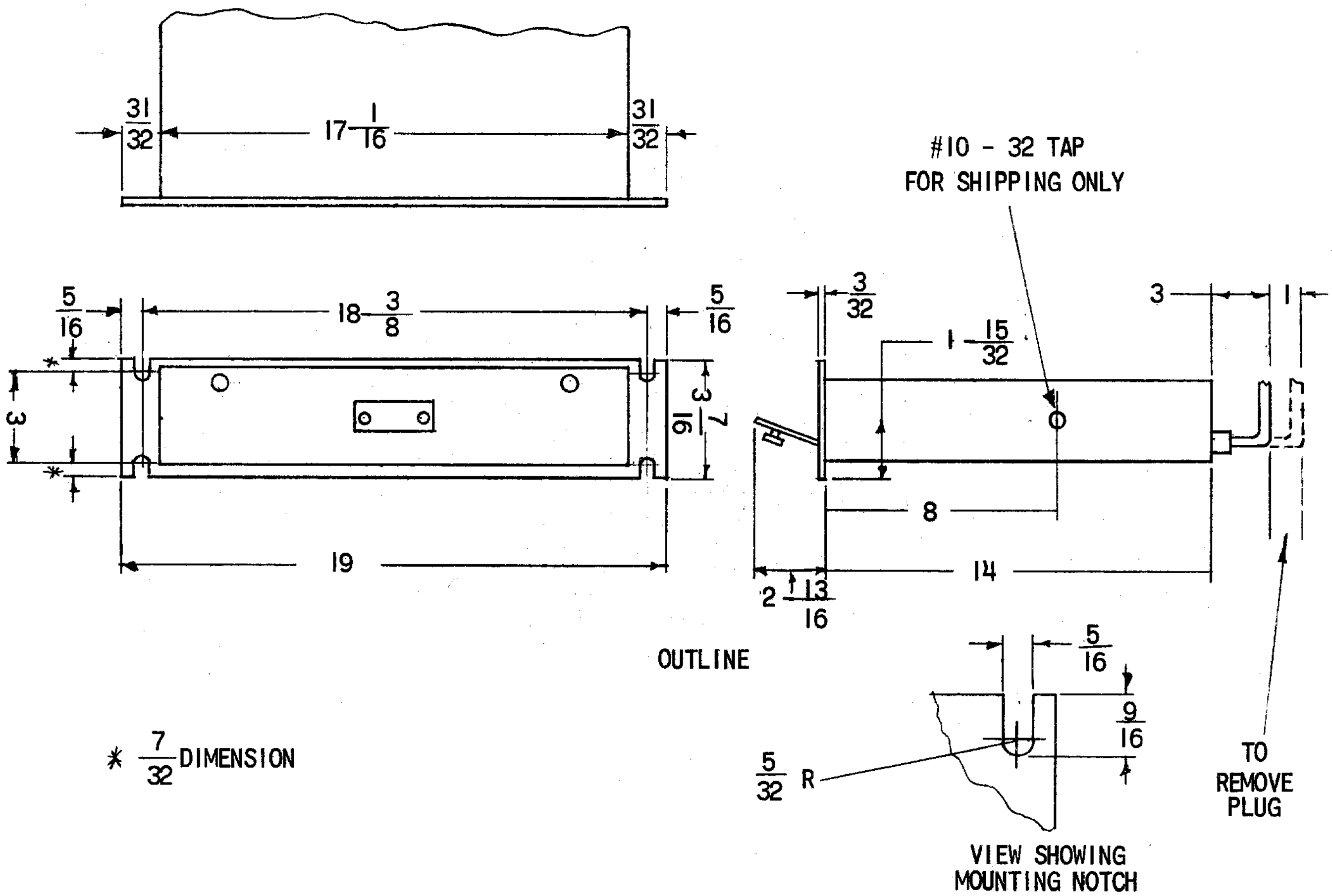


FIG. 1 (0227A2036-0) SLC51A Outline And Mounting Dimensions

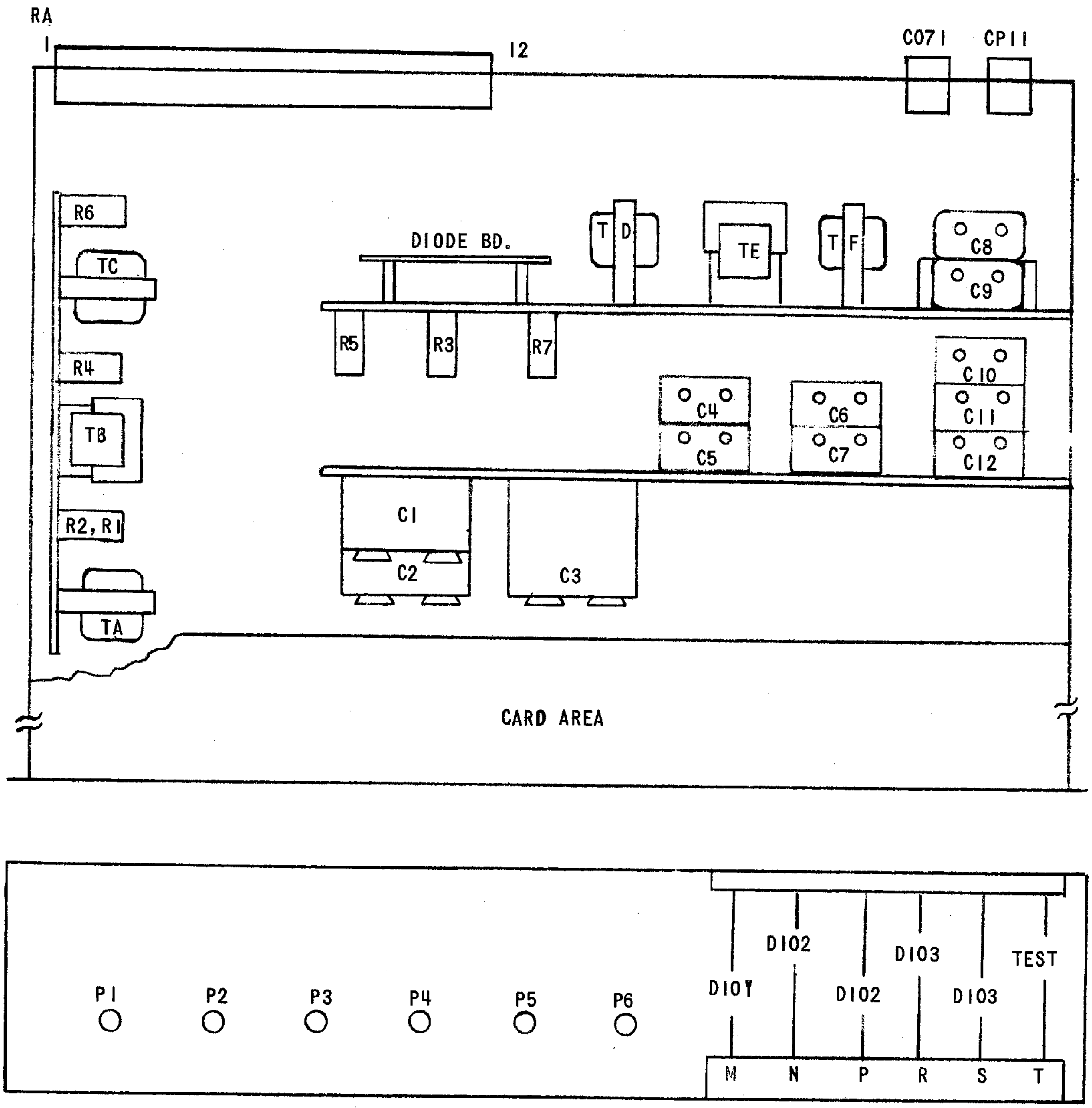


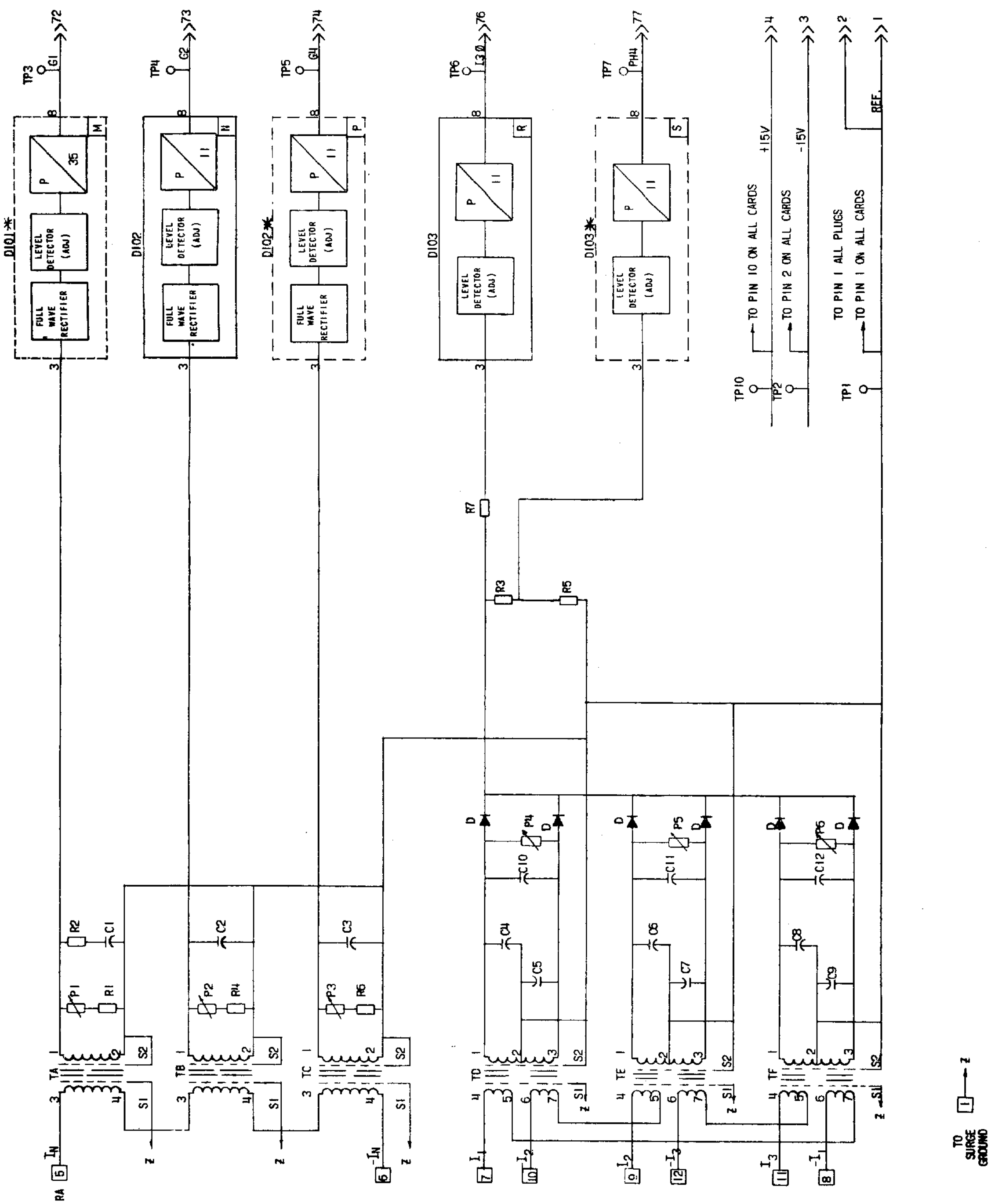
FIG. 2 (0246A6851-0) SLC51A Component Location Diagram

COMPONENT VALUES

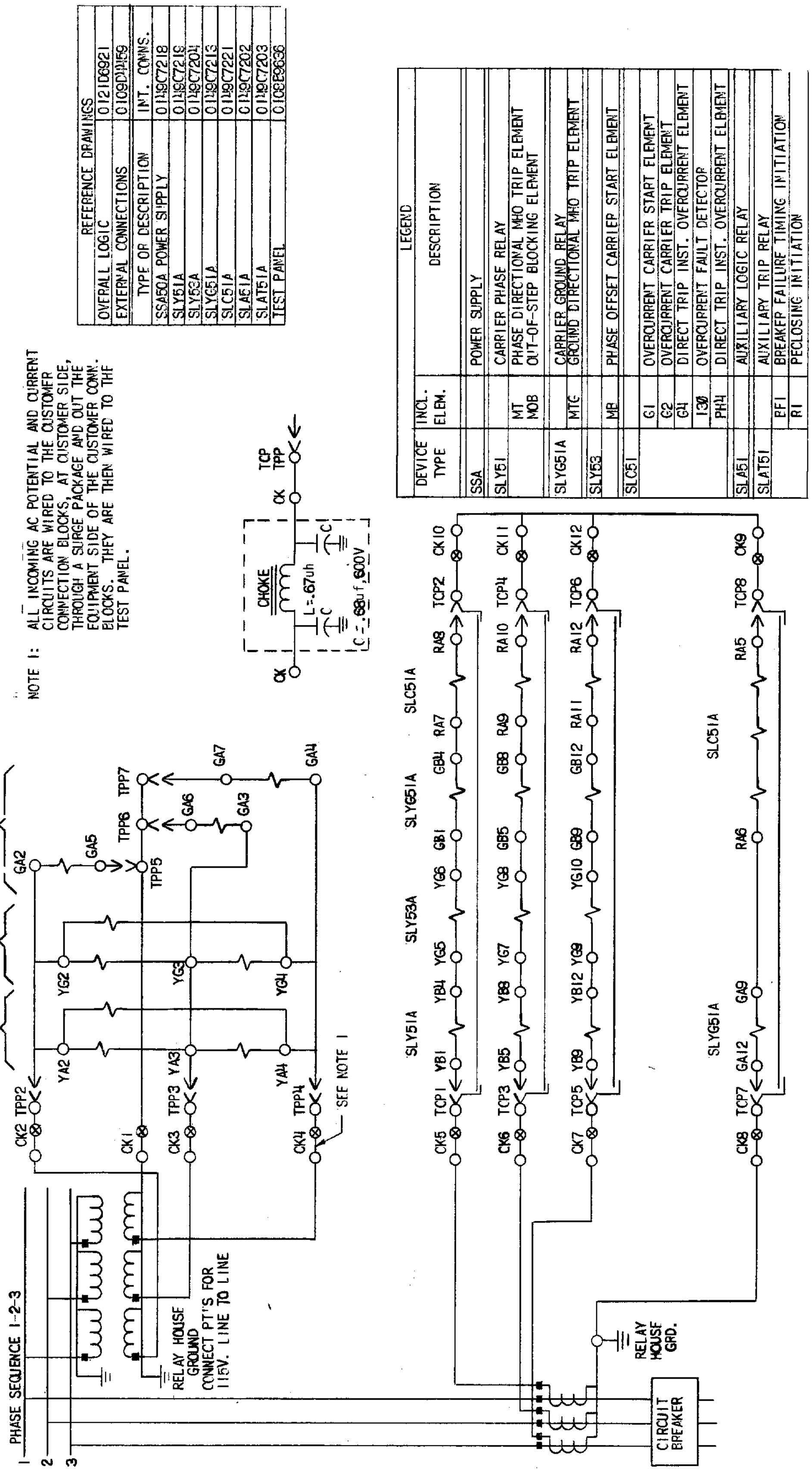
C1	5µF	.330VAC
C2,3	7.5µF	.330VAC
C4 TO C9	0.5µF	.330VAC
C10,11,12	0.75µF	.330VAC
D	1.5A	.600V
P1	5K	.12-1/2W
P2,3	1K	.12-1/2W
R1	1K	.12W
R2	300Ω	.12W
R3	25K	.12W
R4,6	400Ω	.12W
R5	1K	12W
R7	20K	12W
P4,P5,P6	10K	12 1/2W

✱ CARD VARIATIONS

RELAY FORM	CARD LOCATION P	CARD LOCATION S	CARD LOCATION M
SLC51A1	D102	D103	D101
SLC51A2	OMIT	OMIT	D101
SLC51A3	D102	OMIT	D101
SLC51A4	OMIT	OMIT	OMIT
SLC51A5	D102	D103	OMIT



* FIG. 3 (0149C7221-4) Internal Connections Diagram Of SLC51A Relay

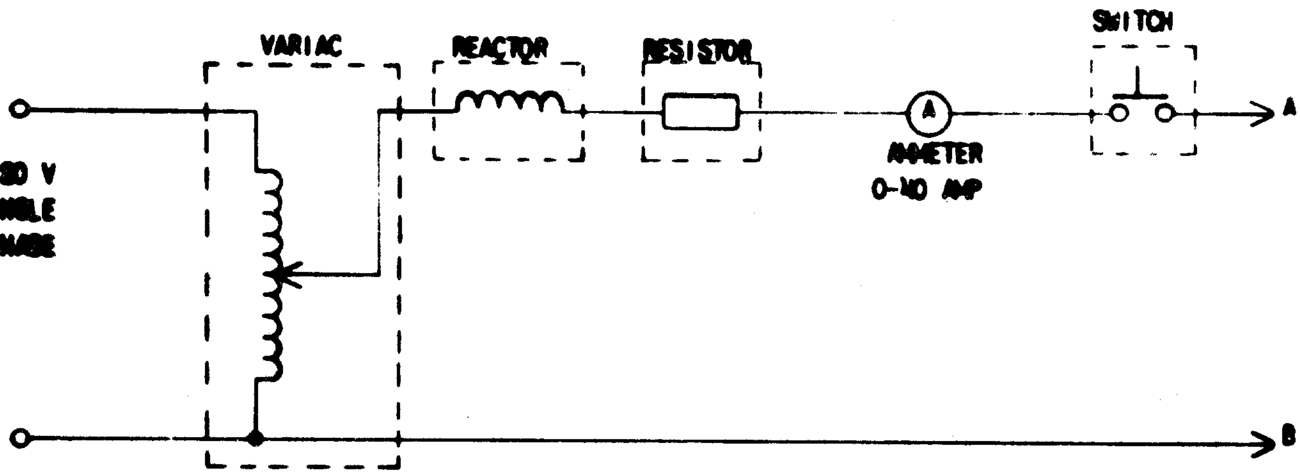


REFERENCE DRAWINGS	
OVERALL LOGIC	0121D6921
EXTERNAL CONNECTIONS	0109D1459
TYPE OR DESCRIPTION	INT. CONNS.
SSA50A POWER SUPPLY	0149C7218
SLY51A	0149C7219
SLY53A	0149C7204
SLYG51A	0149C7213
SLC51A	0149C7221
SLA51A	0149C7202
SLAT51A	0149C7203
TEST PANEL	0108B9636

LEGEND

DEVICE TYPE	INCL. ELEM.	DESCRIPTION
SSA		POWER SUPPLY
SLY51		CARRIER PHASE RELAY
	MT	PHASE DIRECTIONAL MHO TRIP ELEMENT
	MOB	OUT-OF-STEP BLOCKING ELEMENT
SLYG51A		CARRIER GROUND RELAY
	MTG	GROUND DIRECTIONAL MHO TRIP ELEMENT
SLY53		
	MB	PHASE OFFSET CARRIER START ELEMENT
SLC51		
	G1	OVERCURRENT CARRIER START ELEMENT
	G2	OVERCURRENT CARRIER TRIP ELEMENT
	G4	DIRECT TRIP INST. OVERCURRENT ELEMENT
	13Ø	OVERCURRENT FAULT DETECTOR
	PH4	DIRECT TRIP INST. OVERCURRENT ELEMENT
SLA51		AUXILIARY LOGIC RELAY
SLAT51		AUXILIARY TRIP RELAY
	BFI	BREAKER FAILURE TIMING INITIATION
	RI	RECLOSING INITIATION

FIG. 4 (0165B2601-0) Typical External AC Connections



TEST CIRCUIT FOR NON-DIRECTIONAL OVER CURRENT FUNCTIONS.

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

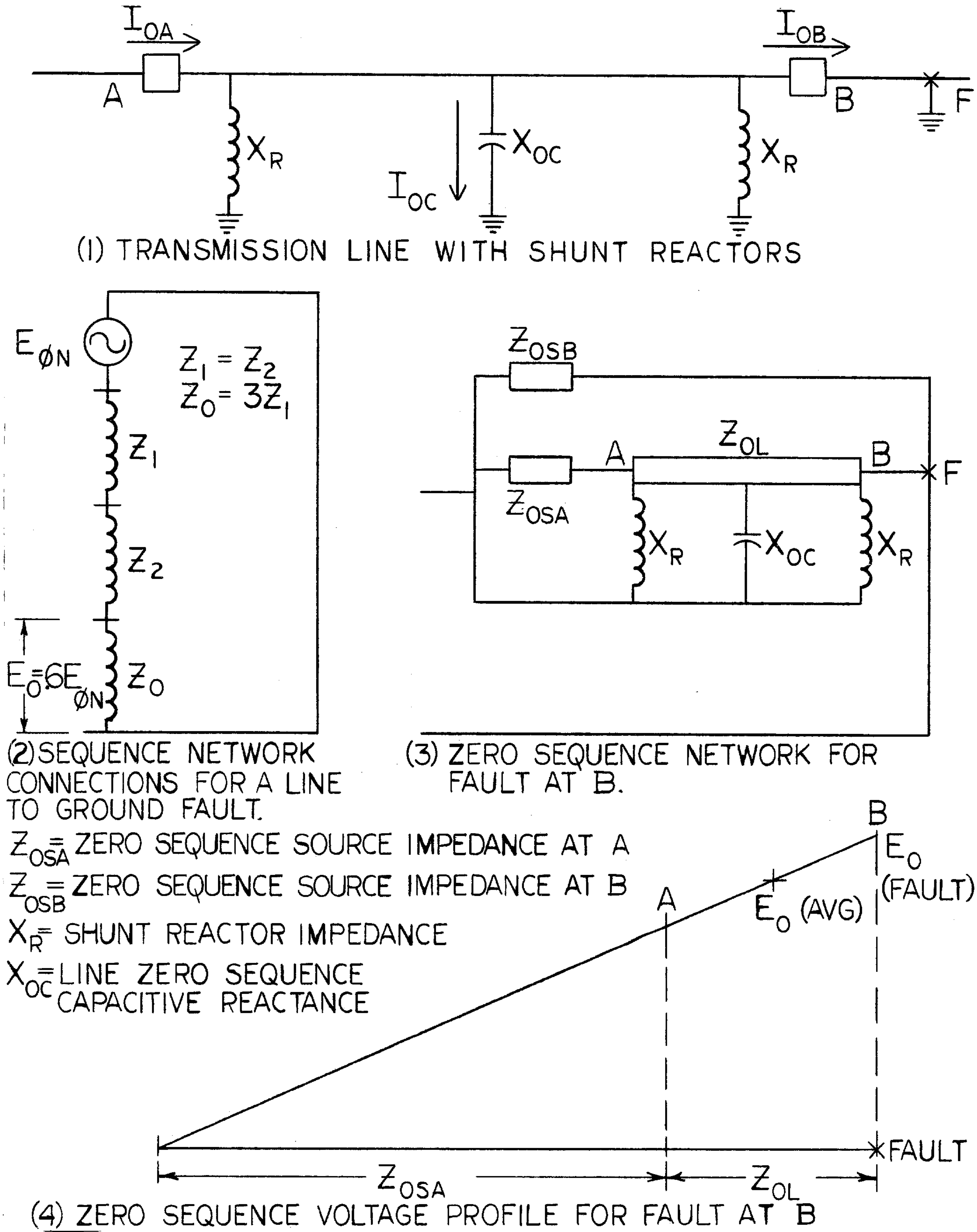


FIG. 6 (0246A6925-0) Determination Of Zero Sequence Charging Current

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