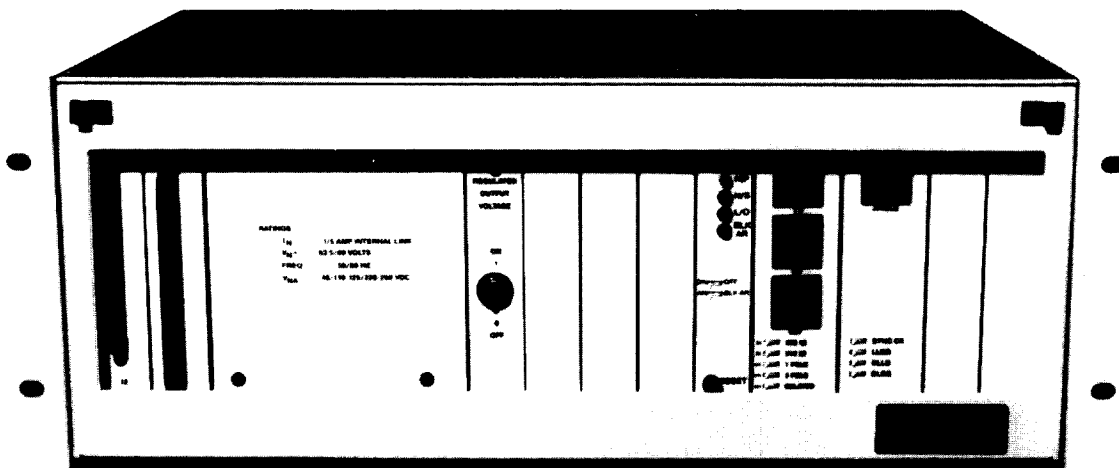




# INSTRUCTIONS

TRS1000

MODULAR RELAY SYSTEM  
FOR  
BREAKER RECLOSING



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(Front Cover Photo 8043775)

**MODULAR RELAY SYSTEM  
FOR  
BREAKER RECLOSING  
TRS1000**

**INTRODUCTION**

The TRS1000 is a relay system containing a basic reclosing function and provision for optional synchronism check and voltage check functions. It may be obtained with either a one breaker or a two breaker reclosing module.

This system is intended for use with protective relay schemes that trip only one breaker pole for single line to ground faults, and all three poles for all multi-phase faults. It has provision for one or two reclose operations, with the ability to choose a different high-speed reclose time for single phase and multi-phase faults. The second reclose operations are always time-delayed.

When two breakers are reclosed, the reclose signal is given to one breaker first and then, after a delay to check that the breaker does not retrip, the second breaker is reclosed.

There is one reclosing output relay per breaker, with this relay having three normally open contacts. This output relay will provide single pole reclosing if only one breaker pole is open, or three pole reclosing if all three poles are open.

There are 12 different reclosing programs that can be selected by switches on the TRS1000. In addition, there is provision for modifying the reclosing program by injecting signals via contact converters in response to changes in system conditions.

The TRS1000 is pre-wired to include an inverse-time overcurrent function, with or without directional control, for ground fault protection. This function is completely separate from the reclosing function and is described in an appendix in this book.

The TRS1000 system is packaged in one four rack unit high modular case containing pluggable printed circuit board modules, plus an isolated power supply module. A photograph of the TRS1000 is shown in Figure 1. This photograph shows a front view of the system, including a one breaker module (RLM111) and the optional synchronism check module (SVM101).

Figure 2, a rear view photograph of the TRS1000, shows terminal boards with double letter identification. Each terminal board has 14 terminals, numbered in left-to-right sequence.

*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.*

## DESCRIPTION OF HARDWARE

### \*CASE ASSEMBLY

#### Construction

The case is fabricated from sheet aluminum. Overall case dimensions are given in the **SPECIFICATIONS** section and Figure 17.

The front cover consists of an aluminum frame with plate glass. It is hinged on the top and opened from the bottom by way of two spring-loaded latches. The cover may be removed by lifting it up and sliding it out from the top. This permits easy access to all modules.

The case is painted with a textured-finish baked enamel.

The modules are mounted vertically. The sockets within the case (towards the rear) serve as mechanical supports as well as the means of electrical connection. They hold the modules firmly in position. In addition, the front cover provides further restraint on the modules. Proper alignment is maintained by slotted guides, one above and one beneath each module (with the exception of the magnetics module which requires two guides above and two beneath).

#### Electrical Connections and Internal Wiring

External connections are made to the case through eight terminal blocks mounted on the rear cover plates. Each block contains 14 terminal points which consist of a Number 6 screw threaded into a flat contact plate.

Connection to the printed circuit board modules is made by means of 60-pin edge connectors. Connection to the MGM module is made by means of two connector sockets; an eight contact current block and a 104-pin signal block. The current block contacts are rated to handle current transformer (CT) secondary currents.

## Identification

The TRS system model number label is located on the inside of the front cover.

A marking strip indicating the name and position of every module in the case is included on the lower inside edge of the front cover. It is placed to be read when the front cover is fully opened.

Figure 3 shows the location of the modules and a diagram of on-board settings for the one-breaker recloser. Figure 4 shows similar information for the two-breaker recloser.

The terminal blocks located on the rear of the modular case are uniquely identified by a two letter code which is found directly beneath the outer most edge of each terminal block. Also, the terminal points (1 through 14) are identified by stamped numbers.

## PRINTED CIRCUIT BOARD MODULES

### Basic Construction

Each module consists of a printed circuit board and front panel. Two knobs are provided on the front panel for removing and inserting the module. Electrical connection is made by contact pads at the back edge of the board. Not all module locations within the case have a printed circuit board. Some locations have a blank board and front panel.

### Identification

Each module has its own identification number consisting of a three letter code followed by a three digit number. These are found at the bottom of each front panel and may be read when the case cover is opened.

## APPLICATION AND CALCULATION OF SETTINGS

RECLOSER MODULES

The Type TRS1000 reclosing system covered by these instructions may be applied to reclose either one breaker, or two breakers in a shared-breaker arrangement, one or two times after a trip by protective relays. The primary application of the TRS1000 system is for use with transmission line protective schemes that trip only the one pole of the circuit breaker(s) corresponding to the faulted phase for single phase faults and all three poles for multiphase faults. These single pole trip protective schemes incorporate reclose initiate (RI) contact outputs that serve as the inputs to the TRS1000 system. The RI contacts may be either phase segregated (i.e., RI-ØA, RI-ØB, RI-ØC) or single pole/three pole segregated (RI-1P, RI-3P). The TRS1000 can be connected to accept either phase segregated or single pole/three pole segregated RI contact inputs as explained in the section on **RECLOSER LOGIC**.

The following general factors should be considered:

1. Interrupting Rating of Circuit Breaker - The derating factor that applies to the interrupting rating of the power circuit breaker must be checked prior to the application of a reclosing relay or the selection of a reclosing cycle.
2. Closing Control Circuits - The current drawn by the closing control circuit must not exceed the contact ratings of the RECLOSE BREAKER contacts of the TRS 1000 system. The ratings are stated in the **SPECIFICATIONS** section under "Trip Outputs."

Choice of Reclosing Program

Twelve different reclosing programs are available as described in the section on RECLOSER LOGIC. The reclosing program is determined by the setting of the 1-POLE, 3-POLE and DELAYED switches on the front panel of the RLM121 module, and by the setting of the SW121A-1 and SW121A-2 switches located on the printed circuit board of the RLM121 module.

The reclosing programs that would result from the use of only the front panel switches with the SW121A-1 and SW121A-2 switches in the OFF position, the BASIC RECLOSING PROGRAMS, are listed in Table 1. In this table, HS1 means high speed reclose with a reclose time determined by the setting of the "1Ø" switch; HS3 means high speed reclose with a reclose time determined by the setting of the "3Ø" switch; and TD means a time delayed reclose with a reclose time determined by the setting of the "DLY" switch. LO means lockout.

**NOTE**

AN IMPORTANT POINT TO CONSIDER IN CHOOSING A PROGRAM IS THAT IF THE 1-POLE SWITCH IS OPEN, A 3-POLE TRIP ENABLE SIGNAL IS SENT TO THE LINE RELAYS TO CAUSE A 3-POLE TRIP FOR ALL SINGLE-PHASE FAULTS. THE RESULTS SHOWN IN TABLE 1 ARE BASED ON THE ASSUMPTION THAT THIS INTERCONNECTION WITH THE LINE RELAYS IS IN-SERVICE.

TABLE 1

Basic Reclosing Programs

RLM 121 FRONT PANEL			TYPE FAULT				COMMENT
			SINGLE-PH		MULTI-PH		
1P	3P	DLY	1st	2nd	1st	2nd	
X	OFF	OFF	HS1	LO	LO	--	High speed, 1 pole only, one shot
OFF	X	OFF	HS3	LO	HS3	LO	*High speed, 3 pole only, one shot
OFF	OFF	X	TD	LO	TD	LO	*Delayed, 3 pole only, one shot
X	X	OFF	HS1	LO	HS3	LO	High speed, 1 pole and 3 pole, one shot
X	OFF	X	HS1	TD	LO	--	Two shot, 1 pole only
OFF	X	X	HS3	TD	HS3	TD	*Two shot, 3 pole only
X	X	X	HS1	TD	HS3	TD	Two shot, 1 pole and 3 pole

\*Single phase faults tripped 3 pole by 3-POLE TRIP ENABLE interconnection with line relays.

X - Switch setting chosen

-- Does not apply

Timing Functions

The following timing functions, identified by the TL designations shown on the logic diagrams, require user selected settings:

TL3 - This "10" high speed reclose time delay is set on the front panel of the RLM121 module. This time delay should be set longer than the estimated total fault extinction time following a single pole trip. If the breaker control circuit includes a time delay, this delay should be subtracted from the total desired delay to arrive at a TL3 setting. TL3 must be set long enough to insure that the RI contacts of the protective relays have reset before it operates in order to prevent the TRS1000 from inadvertently going to lockout under certain conditions.

TL4 - This "30" high speed reclose time delay is set on the front panel of the RLM121 module. This time delay should be set longer than the estimated "de-ionizing" time following a three pole trip. If the breaker control circuit includes a time delay for this purpose, then the TL4 timer may be set to a minimum value established by the reset time of the RI contact inputs.

**NOTE**

TL4 MUST BE SET LONG ENOUGH TO INSURE THAT THE RI CONTACTS OF THE PROTECTIVE RELAYS HAVE RESET BEFORE IT OPERATES IN ORDER TO PREVENT THE TRS1000 FROM INADVERTENTLY GOING TO LOCKOUT UNDER CERTAIN CONDITIONS.

TL5 - This "DLY" time delay is set on the front panel of the RLM121 module. This time delay establishes when the delayed reclose operations occur and may be set between 1-99 seconds.

TL9 - (TL9A and TL9B in two-breaker module.) This "Pole Disagreement" time delay is set internally on the RLM111 (one-breaker) or RLM112 (two-breaker) module. An output from the timer causes a direct 3-pole trip of the associated circuit breaker. For a single pole trip and reclose application, the setting must be greater than the maximum open pole time to avoid a three pole trip and reclose on the first attempt where a single pole trip and reclose is desired. One consideration that may add to the maximum open pole time is the possibility of low air pressure for breakers with pneumatic closing at the time when one pole is tripped. It may be desirable to delay a three pole trip for this scenario for a time interval equal to a "normal recovery time" of the air system.

TL12 - This "OVERALL" time delay is set internally on the RLM111 (one-breaker) or RLM112 (two-breaker) module. A TL12 output will occur if a reclose output is not established at AND24 within its set pickup time once a reclose is called for at TL6. The output of TL12 causes the recloser to go to lockout. TL12 thus establishes the time the TRS1000 relay will wait for an inhibit signal (such as synchronism check) to revert to a permissive state before going to lockout. The minimum permissible setting is established by the TL5 "DLY" timer setting. Settings beyond this value will determine the "wait" time for the inhibit signals on a delayed reclosure.

TL14 - The "RESET" time delay is set internally on the RLM111 (one breaker) or RLM112 (two-breaker) module. A TL14 output resets the recloser following a successful reclosure. The setting is based on the breaker "reclaim time" which is the minimum time required between successive reclose sequences as set on the TRS1000.

TL15 - The "TRANSFER" timer is used only on the RLM112 (two-breaker) module and is set internally on that module. TL15 is initiated by an OR42 output (close signal to either breaker). TL15 output transfers the reclose signal (OR44 output) from the breaker selected via the flip-flop FF-12 output to the second breaker. The time delay setting is based on the maximum time interval between a TRS relay close signal and an external RI contact closure assuming a permanent fault (unsuccessful reclose). Therefore, the minimum setting is equal to the maximum breaker closing time plus the maximum line protection relay time (including RI operate time) plus a suitable margin. A setting based on the above criteria will prevent the TRS relay from transferring to the second breaker unless a successful reclose of the first breaker occurs.

#### SYNCHRONISM CHECK MODULES

The SVM101 module is used with the one-breaker recloser and the SVM102 module is used with the two-breaker recloser. The synchronism-check function is normally used at only one end of a transmission line, with the other end being closed first to energize the line.



## NOTE

WHEN THE SVM101 OR SVM102 MODULE IS INCLUDED AS PART OF THE TRS1000 RECLOSER, THE **SYNC CK** SWITCH ON THIS MODULE MUST BE IN THE **SYNC CK** POSITION EXCEPT FOR THE SPECIAL CASE WHERE THIS RECLOSER IS EXPECTED TO OPERATE ONLY FOR THE **LLDB**, **DLDB** OR **DLDB** CONDITION. IF IT IS DESIRED TO TAKE THE SYNCH CHECK FUNCTION OUT OF SERVICE, THIS SHOULD BE DONE BY ENERGIZING CC7, AND NOT BY PLACING THE UPPER SWITCH IN THE **OFF** (LEFT SIDE) POSITION.

The synchronism check function is intended primarily for application where the two parts of a system to be joined by the closure of a circuit breaker are interconnected at least at one other point in the system. Even though the voltages on either side of the open breaker are in synchronism, there may be an angular difference between them as a result of load flow throughout the interconnected system. It is usually desirable to close the breaker even though an angular difference exists, provided that this difference is not great enough to be detrimental to the system or to connected equipment. Each application should be checked to determine the maximum angular difference for which closing can be tolerated.

Once an acceptable angular difference has been determined, the closing angle can be set accordingly. The closing angle setting is made directly in degrees via switches located on the front of the SVM101 or SVM102 module. It is important to note that this function is not intended to initiate the closure of a breaker, but rather to check that the angle between the voltages across the open breaker is within the predetermined value, and then permit the breaker to be closed.

It is also necessary to check that the angle between the voltages stays within the closing angle setting for a fixed amount of time. In the SVM101 and SVM102 modules, this time of measurement is determined by the setting of the low set slip cutoff frequency and/or the high set slip cutoff frequency, depending on the mode of operation selected. The amount of time required for measurement is given by the expression  $T_{LS}$  or  $T_{HS}$ . This is also the operating time of the synchronism check measurement when the two voltages are in phase and there is no slip frequency.

Usually, in conventional synchronism check relaying, a relatively long time measurement is used to insure that the voltages are in synchronism. However, this long delay, which may be 10 or 20 seconds, is undesirable if both ends of the line are being reclosed at high speed. If the time of measurement is shortened, a faster synchronism check measurement can be made, but this may result in reclosing for a non-synchronous condition with slip frequencies that are higher than desired for satisfactory reclosing.

The SVM101 and SVM102 modules use a combination of the low set and high set cutoff frequency settings plus some special circuitry to provide a high speed synchronism check determination when voltages are in synchronism without running the risk of reclosing if high slip frequencies are actually present. These modules also provide a choice of two modes of operation, one using only the low set slip cutoff frequency setting, and the other using the high set/low set combination of settings. These are described separately below.

### Low Set Slip Cutoff Setting Mode

This mode of operation may be selected by closing an internal switch marked LOW SET SLIP ONLY on the SVM101 or SVM102 module.

The low set slip frequency circuit determines the slip rate by comparing the time that  $V_L$  remains in any quadrant (see Figure 5) against a reference time established by the low set slip cutoff setting. This reference time is the time it would take the voltage phasor  $V_L$  to traverse  $90^\circ$  (one quadrant) at a frequency equal to the low set slip cutoff frequency. This reference time is expressed by

$$T_{LS} = \frac{1}{4 \times F_{LS}}$$

where:  $F_{LS}$  is the low set slip cutoff frequency in slip cycles per second.  $T_{LS}$  is the time required to traverse  $90^\circ$ , in seconds.

#### NOTE

$T_{LS}$  IS NOT A SETTING IN ITSELF. IT IS AN OPERATING TIME THAT RESULTS FROM THE CHOICE OF  $F_{LS}$ .

The time  $T_{LS}$  is the operating time of the low-slip measurement for any condition where the slip frequency is less than  $F_{LS}$ , including the condition of no slip frequency. As an example, if the setting of  $F_{LS}$  is 0.1 Hz, the operating time  $T_{LS}$  is 2.5 seconds. The range of adjustment for  $F_{LS}$  is 0.01 to 0.9 Hz.

In this mode of operation, after the slip frequency is determined to be less than the low slip cutoff setting, the voltage  $V_L$  must still remain within the closing angle for a time established by the high set slip cutoff setting. A minimum delay will be obtained by placing the high slip cutoff setting at its maximum value.

The choice of a setting for  $F_{LS}$  is a matter of judgment depending on the location of the transmission line in the total power system, and should take into account the possibility of attempting to synchronize the system through this particular line.

### High Set/Low Set Operating Mode

The high set slip cutoff setting is based on the closing angle as set on the front of the SVM101 or SVM102 module and the dead time of the transmission line before a high speed reclosure. This dead time is actually the time it takes the remote breaker to establish line voltage (i.e., breaker closure) following simultaneous clearing of both ends of the line for an internal fault. The setting can be calculated as follows:

$$F_{HS} = (270^\circ - \theta)/(360)(T)$$

where:  $F_{HS}$  = high set slip cutoff setting (hertz)  
 $T$  = dead time (seconds)  
 $\theta$  = closing angle setting (degrees)

The high set slip cutoff frequency,  $F_{HS}$ , is based on  $(270^\circ - \theta)$  to insure that, if the slip rate is equal to or less than  $F_{HS}$ ,  $V_L$  will have traversed less than three quadrants (see Figure 5) during the time when both breakers are open. If  $V_L$  returns in the second or third quadrant, the low slip cutoff frequency measurement is initiated and the actual slip must be less than the low slip cutoff setting to permit reclosing.

There are three possible conditions that could cause  $V_L$  to appear in quadrants I or IV when the line is re-energized. One condition is a slip frequency that is higher than  $F_{HS}$ . In this case the high set slip cutoff measurement will prevent reclosing. A second condition is a very low or zero slip frequency. For this condition, reclosing will be permitted provided that  $V_L$  remains within the set closing angle,  $\theta$ , with respect to  $V_B$  for the time associated with the high set slip cutoff setting. This time delay is:

$$T_{HS} = \theta / (F_{HS})(180^\circ)$$

where:  $T_{HS}$  = time in seconds that the voltage must be within the closing angle setting  
 $\theta$  = closing angle setting  
 $F_{HS}$  = high set slip cutoff setting (hertz)

**NOTE**

$T_{HS}$  IS NOT A SETTING IN ITSELF. IT IS AN OPERATING TIME THAT RESULTS FROM THE CHOICE OF  $F_{HS}$  AND  $\theta$ .

The time  $T_{HS}$  is the operating time for any condition where the high set slip cutoff setting controls the synchronism check measurement, including the condition of no slip frequency. For example, if the closing angle setting is  $20^\circ$  and the setting of  $F_{HS}$  is 1.5 Hz, the operating time  $T_{HS}$  is 0.074 seconds. The range of adjustment for  $F_{HS}$  is 0.25 to 2.25 Hz.

The third condition that could cause  $V_L$  to appear in quadrants I or IV is a delayed reclosing attempt that produces a transmission line dead time greater than the value  $T_{HS}$  used in calculating  $F_{HS}$ . Any delayed reclosing operation, or a manual reclosing operation, will not allow quadrant discrimination of  $V_L$  relative to  $V_B$  after the line is reenergized. Consequently, the SVM101 or SVM102 module includes a timer whose output initiates the low slip cut-off measurement preventing the angle check measurement from permitting a reclose until the low set slip cut off measurement has produced a permissive output. The input to this timer is energized when the line voltage  $V_L$  is less than the "dead line" voltage setting. The pickup delay of the timer is set for the transmission line dead time corresponding to a successful high speed reclosure, plus a suitable margin.

$$T_D = 1.1 [ (\text{line dead time}) + (25 \text{ milliseconds}) ]$$

The 25 milliseconds is included to account for possible differences in clearing time of the two line terminals. If the channel time exceeds 25 milliseconds, then the 25 millisecond value should be increased to be equal to the channel time.

In order for the synchronism check function to provide an output, there must be a voltage present on both sides of the breaker and the phase angle between these voltages must be within the closing angle setting of the relay. This means that the synchronism check function alone will not permit picking up a dead line. For applications where dead line and/or dead bus operation is required, the undervoltage detecting functions can be used. Selection switches are provided on the front of the SVM module to provide an output for one or more of the following conditions:

1. Live line and dead bus
2. Dead line and live bus
3. Dead line and dead bus

The voltage level settings are made via switches located on the SVM101 or SVM102 module.

## RECLOSER FUNCTION DESCRIPTION

The recloser portion of the TRS1000 system provides both single pole and three pole reclosing for one or two breakers. The reclosing sequence can be set to any one of 12 programs. The selected program can be modified remotely via the remote control contact converters. A description of the reclosing programs can be found in the **RECLOSER LOGIC** section of this book.

The reclosing sequence is begun by the receipt of a reclose initiation signal. After the set time delay, a reclose output is produced. If only one shot has been chosen, the recloser will go to lockout if a second initiation input is received prior to the expiration of the reset time. If two shots have been chosen, a second delayed shot will precede the lockout state. The recloser can be reset from lockout manually or via a manual close input. For manual closing, two options are available: external, via the close switch, in which case the recloser will be disabled for the reset time; or, internal, where the closing of the breaker is done via the reclose output. Synchronism check can be used to supervise an internal manual close.

For a more detailed discussion of the recloser, refer to the **RECLOSER LOGIC** section of this book.

### SYNCHRONISM CHECK

The SVM101 and SVM102 modules provide the voltage and synchronism check functions to supervise the closing of a breaker. The synchronism check portion determines the angle and frequency difference between the bus and line voltages. It will only permit closing if both the angle and frequency differential are within preset limits. The voltage check function supervises the synchronism check function by enabling it only if both the line and bus voltages are greater than preset limits. Further, the voltage check unit can in itself permit closing for dead line-dead bus, dead line-live bus or live line-dead bus conditions. The line and bus voltage dead and live thresholds are separately adjustable.

## MODULE DESCRIPTIONS

### IOM101

The IOM101 module contains the contact converters which provide an isolated input of remote signals into the relay logic. The contact converters consist of a dropping resistor and a sensitive reed relay. Each contact converter has a voltage selection link which must be set to the DC voltage that will be energizing that contact converter.

### IOM201, IOM202

The IOM201 module contains auxiliary relays whose contacts are used for such functions as breaker three pole trip, reclose in progress, reset second recloser, etc. See SPECIFICATIONS section for ratings.

The IOM202 module contains reed relay contacts for DLA (data logging) functions. When used, this module is located in the far right-hand position.

RLM111

(see Figure 6)

The RLM111 single breaker recloser module provides the closing output logic, overall timer, reset timer and pole disagreement timer. The front panel provides target outputs, function control switches and local reset push-button (reset from lockout). The switch positions are as marked.

Front Panel Indications and Settings

- RDY** When on, a green light emitting diode indicates the recloser is ready for automatic or manual closing.
- RIP** Reclose-in-progress is indicated by an amber light emitting diode. When on, it indicates the recloser has been initiated and is timing. This light remains on for the duration of the reclose cycle.
- N/S** The red light emitting diode labeled **N/S** indicates the reclose action was blocked by the synchronism check module.
- L/O** Lockout is indicated by a red light emitting diode.
- BLK AR** Block Automatic Reclosing, a red light emitting diode, lights to indicate that automatic reclosing has been blocked. It can be blocked either by actuation of the **BLK AR** switch on the front panel of this module, or by not selecting a reclose program.
- ON/OFF** When this switch is positioned to the right the recloser is turned off and the ready lamp (**RDY**) will go out. When the recloser is off, no reclose operations can occur.
- AR/BLK AR** When this switch is positioned to the right, automatic reclosing is blocked. The recloser can still be used for manual closing in this mode.
- RESET** Pushbutton switch that turns off the red lockout (**L/O**) light emitting diode and starts the restore timer to take the relay out of lockout and restore it to the reset or normal state.

On-Board Settings

- Overall Time** The overall time is settable from 10 to 1650 seconds in ten second steps. The time is the sum of the closed switches.
- Reset Time** The reset time is settable from 4 to 165 seconds in one second steps. The time is the sum of the closed switches.

RLM111 continued

NOTE

THE MINIMUM RESET TIME IS 4 SECONDS. IF LESS THAN 4 SECONDS IS SELECTED, THE TIME BECOMES 4 SECONDS PLUS THE SELECTED TIME. FOR EXAMPLE, SELECT ONE SECOND; ACTUAL TIME IS  $1 + 4 = 5$  SECONDS. AT 4 SECONDS AND HIGHER TIME SELECTIONS, THE RESET TIME IS THE SUM OF THE CLOSED SWITCHES.

**Pole Disagreement** Time is adjustable from 0.1 to 25.5 seconds in 0.1 second steps. The time is the sum of the closed switches.

Logic Selection

**SW111A-1** Should be left in closed position.

**SW111A-2** Closing this switch causes the reclose output circuit to wait the overall time for the removal of the signal blocking reclosing, which could be the synchronism check, inhibit via contact converter 5, or block via contact converter 7. If the blocking signal is not removed, the recloser will lock out. If it is removed prior to the end of the overall time, reclosing will occur. When the switch is open, if any blocking signal is present at the end of the reclose delay time, lockout will occur.

**SW111A-3** When closed, a three pole trip enable signal will be produced when the recloser is off. The switch would be open where redundant reclosers are used, and it is desirable to retain single pole operation when one recloser is off.

\* **SW111A-4** Dwell Time Setting is used to keep output contacts closed for 200 or 800 milliseconds, selectable.

**SW111B-1** Chooses internal or external manual closing. In the external position, the recloser is blocked from automatic operating for the reset time. In the internal position, the manual close signal uses the recloser output section and blocking signals to provide breaker closing.

RLM112

(See Figure 7)

The RLM112 two-breaker recloser module provides the closing output logic, overall timer, reset timer, transfer timer, and pole disagreement timers. The front panel provides target outputs, function control switches, breaker closing sequence switch and local reset push-button (reset from lockout). The switch positions are as marked.

Front Panel Indications and Settings

**RDY** When on, a green light emitting diode indicates the recloser is ready for automatic or manual closing.

\* Indicates revision

RLM112, continued

- RIP** Reclose-in-progress is indicated by an amber light emitting diode. When on, it indicates the recloser has been initiated and is timing. This light remains on for the duration of the reclose cycle.
- N/S** The red light emitting diode labeled **N/S** indicates the reclose action was blocked by the synchronism check module.
- L/O** Lockout is indicated by a red light emitting diode.
- BLK AR** Block Automatic Reclosing, a red light emitting diode, lights to indicate that automatic reclosing has been blocked. It can be blocked either by actuation of the **BLK AR** switch on the front panel of this module, or by not selecting a reclose program.
- BLK A** Red light emitting diode indicating breaker A reclosing is blocked.
- BLK B** Red light emitting diode indicating breaker B reclosing is blocked.
- ON/OFF** When this switch is positioned to the right the recloser is turned off and the ready lamp (**RDY**) will go out. When the recloser is off, no reclose operations can occur.
- NORMAL/BLK AR** When this switch is positioned to the right, automatic reclosing is blocked. The recloser can still be used for manual closing in this mode.
- NORMAL/BLK A** When this switch is positioned to the right, reclosing of breaker A is blocked.
- NORMAL/BLK B** When this switch is positioned to the right, reclosing of breaker B is blocked.
- 1-2/2-1** This switch determines the sequence of breaker closing. When the switch is positioned to the left, breaker 1 is reclosed before breaker 2.
- RESET** Pushbutton switch that turns off the red lockout light emitting diode, takes the relay out of lockout, and restores it to the reset or normal state.

On Board Settings

- Overall Time** The overall time is settable from 10 to 1650 seconds in ten second steps. The time is the sum of the closed switches.



RLM112, continued

- \* **Reset Time**      The reset time is settable from 4 to 99 seconds in one second steps. The time is the sum of the closed switches.
- Trip A:**            This pole disagreement time is adjustable from 0.1 to 16.5 seconds in 0.1 second steps. The time is the sum of the closed switches.
- Trip B:**            This pole disagreement time is adjustable from 0.1 to 16.5 seconds in 0.1 second steps. The time is the sum of the closed switches.
- Delay:**            The transfer delay time is adjustable from 0.1 to 16.5 seconds in 0.1 second steps. The time is the sum of the closed switches.
- \* **Dwell Time:**     The Dwell Time is used to keep the output contacts closed for either 200 or 800 milliseconds, selectable.

Logic Selection

- SW112A-1**            In open position initiates three pole trip of breaker A for any RI output at FF4. In closed position, initiates three pole trip of breaker A for CC10 input plus RI output at FF4.
- SW112A-2**            Closing this switch causes the breaker A reclose output circuit to wait the overall time for inhibit signal to become permissive.
- SW112A-3**            In open position initiates three pole trip of breaker B for any RI output at FF4. In closed position, initiates three pole trip of breaker B for CC11 input plus RI output at FF4.
- SW112A-4**            Closing this switch causes the breaker B reclose output circuit to wait the overall time for inhibit signal to become permissive.
- SW112A-5**            When closed, a three pole trip signal will be produced when the recloser ON-OFF switch is in the OFF position. The SW112A-5 switch would be left in the open position if redundant reclosers are used and it is desired to retain single pole operation with one recloser out of service.
- SW112A-6**            Works in conjunction with CC3 for manual closing operations. In the external position, the TRS can be reset from lockout without reclosing the breaker. In the internal position, the breaker is reclosed through the TRS.
- SW112A-7**            Selects synchronism check of second breaker
- SW112A-8**            Selects synchronism check of first breaker

\* Indicates revision

RLM121

(see Figure 8 and Table 2)

The RLM121 recloser module provides the reclose delay timers and the reclosing sequence selection and control logic. Unless marked otherwise, when the switch toggle is in the right position, the switch is closed; in the left position, it is open.

Front Panel Settings

- 1Ø** This switch sets the one pole high speed reclose delay time. Its range is 0.01 to 0.99 seconds in 0.01 second steps. The range can be increased to 0.1 to 9.9 seconds in 0.1 second steps by positioning the **X1-X10 1-POLE** switch to the right.
- 3Ø** This switch sets the three pole high speed delay time. Its range is 0.01 to 0.99 seconds in 0.01 second steps. The range can be increased to 0.1 to 9.9 seconds in 0.1 second steps by positioning the **X1-X10 3-POLE** switch to the right.
- DLY** This switch sets the operating time for the delayed reclosing operation. The time range is 1 to 99 seconds in one second steps.
- 1-POLE** Chooses single pole high speed reclosing logic.
- 3-POLE** Chooses three pole high speed reclosing logic.
- DLY** Chooses delayed reclosing.
- X1-X10 1-POLE** Multiplies the **1Ø** time by a factor of ten
- X1-X10 3-POLE** Multiplies the **3Ø** time by a factor of ten

On-Board Switches

SW121A Scheme Selection

- SW121A-1** Only one three pole reclose attempt. Valid only when single pole, three pole and delayed switches on the front panel are in the right side position. (Schemes 9-12 in Table 2).
- SW121A-2** Changes the high speed three pole time to the delay time (schemes 4, 9 and 11 in Table 2).
- SW121B-1** Chooses type of reclose initiation signal. When open, initiation is on an individual phase basis. When closed, a single pole and a three pole initiation signal is required.
- SW121B-2** Chooses synchronism check logic. When open, only delayed reclose operations will have synchronism check. When closed, all three pole close operations will have synchronism check.
- SW121B-3** Chooses synchronism check of manual closing when switch is closed.

SVM101, SVM102  
(Optional Feature)

(See Figure 9)

The SVM modules provide angle check, frequency differential and voltage check supervision for breaker closing. SVM101 is used with one-breaker reclosers, and SVM102 with two-breaker reclosers. Unless marked otherwise, when the switch toggle is in the right position, the switch is closed; in the left position, it is open.

Front Panel

<b>ANGLE</b>	Sets the closing angle in degrees. Normal operating range is 5 to 75 degrees in one degree steps.
<b>SYN CK</b>	Selects synchronism check supervision when both the bus and line voltages are greater than the live setting.
<b>LLDB</b>	Selects live line-dead bus supervision.
<b>DLLB</b>	Selects dead line-live bus supervision.
<b>DLDB</b>	Selects dead line-dead bus supervision.

The LLDB, DLDB AND DLDB switches are active when to the right; any combination can be selected.

On-Board Switches

Voltage Selection

<b>PT Voltage</b>	Sets the rated input voltage. Only one switch should be closed. Potential transformer rated operating voltage can be set to any one of the following:  69 volts phase-to-neutral 66.4 volts phase-to-neutral 63.5 volts phase-to-neutral 57.7 volts phase-to-neutral
<b>BUS DEAD</b>	Sets the percent of rated voltage below which the bus is considered dead. The setting is additive, with a base of ten percent. It can be set in five percent steps between 10 and 70 percent.
<b>BUS LIVE</b>	Sets the percent of rated voltage above which the bus is considered live. The setting is additive, with a base of 70 percent. It can be set in five percent steps between 70 and 110 percent.
<b>LINE DEAD</b>	Sets the percent of rated voltage below which the line is considered dead. The setting is additive, with a base of ten percent. It can be set in five percent steps between 10 and 70 percent.

SVM101, SVM102, continued

**LINE LIVE** Sets the percent of rated voltage above which the line is considered live. The setting is additive, with a base of 70 percent. It can be set in five percent steps between 70 and 110 percent.

Slip Cut-off Selection

**HIGH SET SLIP** Sets the high set slip cut-off frequency. The range is 0.25 to 2.25 hertz in steps of 0.25 hertz.

**NOTE**

AT LEAST ONE SWITCH MUST BE CLOSED FOR PROPER OPERATION. SETTINGS IN EXCESS OF 2.25 HERTZ RESULT IN AN EFFECTIVE SETTING OF 2 OR 2.25 HERTZ. IF THE .25 SWITCH IS CLOSED, THE SETTING IS 2.25, IF NOT IT IS 2.

**LOW SET SLIP** Sets the low set slip cut-off frequency. The range is 0.01 to 0.09 hertz in steps of 0.01 hertz. A multiplier is provided to increase the range to 0.1 to 0.9 hertz in 0.1 steps.

**NOTE**

AT LEAST ONE SWITCH MUST BE CLOSED FOR PROPER OPERATION. SETTINGS IN EXCESS OF 0.9 HERTZ RESULT IN AN EFFECTIVE SETTING OF 0.8 HERTZ IF THE LEAST SIGNIFICANT DIGIT SWITCH IS OPEN AND 0.9 HERTZ IF THE LEAST SIGNIFICANT DIGIT SWITCH IS CLOSED.

Logic

**SW9-1** Sets the rated frequency. 60 HZ to the left, 50 HZ to the right.

**SW9-2** Multiplies the low-set slip setting by one or ten.

**SW9-3** Eliminates second breaker synchronism check.

**SW9-4** Requires the low-set slip supervision of the synchronism output.

Timer

**Dead Time** Sets the line dead time after which the slip frequency must be below the low-set cut-off for an output to occur. The setting is equal to the sum of the closed switches in seconds.

Indication

**TL1** Output is blocked by angle check when lit (on-board red LED).

**TL2** Output is blocked by low-set slip when lit (on-board red LED).

**TL3** Conditions are within settings and reclosing permitted (on-board red LED).

PSM

(See Figure 10)

This module provides power to operate the TRS system. The input voltage must match the DC rating listed on the front panel of the PSM module. The power supply is self-protecting and will not be damaged by a continuous short circuit. The output voltage will recover when the fault is removed. An output alarm is provided to indicate voltage outside the desired limits. A green light-emitting diode on the front panel indicates normal output voltage. A switch mounted on the front panel removes the internal module voltages from the relay. A fuse is provided on the board to protect the printed-circuit-board runs.

**WARNING:**

**DC BATTERY VOLTAGE IS STILL PRESENT ON THIS MODULE AFTER THE SWITCH HAS BEEN TURNED OFF**

MGM

The magnetics module contains the potential transformers to couple the TRS1000 measuring elements to the system. The potential circuits can be continuously operated at twice rated voltage without damage.

Some of the output relays are also mounted in this module, together with their drive interface. The output relays are telephone type relays, which pass the ANSI trip duty contact test. The relays are used for closing breaker A, breaker B and for enabling 3-pole trip. The ground time overcurrent tripping relay (optional) is also included in the MGM module.

## RECLOSER LOGIC

A functional logic diagram of the one breaker TRS1000 is shown in Figure 11, and a functional logic diagram of the two breaker TRS1000 is shown in Figure 13. These diagrams are not intended to accurately depict the actual circuit components, but are intended to assist in understanding the operation of the reclosing circuits. Some of the timing functions in the TRS1000 produce pulse outputs rather than continuous outputs. This is depicted by a P in the dropout time position of the timer symbol. The numbers in the timer symbols are in milliseconds unless otherwise noted.

The logic description below applies to both the one breaker and two breaker logic diagrams, where the operation is the same in both. The description is separated into two parts where there are significant differences.

### BASIC RECLOSING OPERATION

The reclosing program is determined primarily by the three front panel switches 1-POLE, 3-POLE and DELAYED. These determine the inputs to logic array LA2, shown at the lower left of the diagram. This logic array operates in such a way that only one output can be a logic one for any combination of input signals. For example, if inputs X and Y are present, then the XY output is a logic one, while all others are a logic zero. If inputs X, Y and Z are present, the output XYZ is a logic one and all others are logic zero. Two internal switches, 121A-1 and 121A-2 complete the programming. The 12 different programs determined by these switches are shown in Table 2.

Reclosing sequences are started by RI (reclose initiate) contacts in the associated line relaying systems. Contact converters CC1, CC2 and CC21 provide inputs to logic array LA1 at the upper left corner of the diagram. These contact converters can be arranged to respond to either phase segregated RI contacts or single pole/three pole segregated RI contacts. If phase-segregated RI is used, RI-ØA is connected to CC1, RI-ØB is connected to CC2, RI-ØC is connected to CC21, and switch SW121B-1 is placed in the ØRI position. If single pole/three pole segregated RI is utilized, then RI-3Ø is connected to CC1, RI-1Ø is connected to CC21 and switch 121B-1 is placed in the PRI position.

The time delay for the initial reclose operation will be determined by either TL3 (1P), TL4 (3P), or TL5 (DLY) depending on the program selected by the inputs to LA2, the positions of the SW121A switches, and by the inputs to LA1. The outputs of TL3, TL4 or TL5 pass through OR6 to timers TL6A and TL6B and ultimately to TS3 via AND24, if there is no inhibit signal present at the input to NOR8. For the two breaker module, there are two output circuits, AND24A and AND24B, and two inhibit circuits, NOR8A and NOR8B.

One of the TL6 outputs, TL6B, operates FF2, which provides an OR12 input to AND7/8/9 via AND12. This input inhibits AND7 and AND8 (high speed time delays) and enables AND9, the delay timer. Therefore the second reclose will be delayed by the setting of TL5 unless the programming calls for a lockout.

The four contact converters, CC15-16-17-18, permit modifying the reclosing program in response to external signals. Their effect is shown in Table 2. In the description below it is assumed that these contact converters are not operated and therefore the signal is a logic zero where the CC number is shown on the diagram.

To explain the reclosing sequence in more detail, note that the  $\overline{XYZ}$  (not X AND not Y AND not Z) output of LA2 inhibits AND1/2/3 if all of the input switches to LA2 are open (connected to REF). If one or more of these switches is closed, the  $\overline{XYZ}$  output is a logic zero, NOT1 output is a logic one, and the CC1/2/21 inputs are passed to LA1 inputs U, V or W.

When an RI signal appears at any input to LA1, the  $\overline{UVW}$  output becomes a logic zero, NOT2 output becomes a logic one and FF4 is switched to the ON position, with a logic one at output Q. Functionally, FF4 is known as the RI SEAL-IN. It provides a permissive input to AND7/8/9 to start the reclose timing measurement.

The output of FF4 also operates through AND5 OR3, AND6, TL1 and OR4 to produce an OR5 output. This causes the 3-POLE TRIP ENABLE relay, which is normally picked up, to drop out and enable three pole tripping of the line relay system. This means that if a fault is still present after reclosing single pole, the breaker will be tripped three pole.

#### SAMPLE RECLOSING PROGRAM SEQUENCE

To illustrate how the programming switches produce the programs shown in Table 2, consider program 11 which calls for HS1 (1P setting selected on RLM121 front panel), and HS3 (3P setting selected on RLM121 front panel), time delays for the first reclosure, TD (DELAYED setting selected on RLM121 front panel) for second single phase fault, and LO (lockout) (SW121A or RLM121 module) for second multi-phase fault.

For the first single phase fault, the XYZ output of LA2 via OR9 provides the lower input to AND10. However there is no upper input to AND10. OR11 has no inputs, so OR12 has no output, which means that AND7 and AND8 are not inhibited and AND9 is not enabled. There are no inputs to OR13, so the middle input of AND7 is not inhibited and the middle input of AND8 is not present. Therefore, only TL3 is energized, and the time delay of the first reclosure is TL3 time, or HS1.

For the first multi-phase fault, operation is similar to that described above, except that LA1 causes OR1 to have an output, which operates FF5, providing an input to OR13. The output of OR13 inhibits TL3 and enables TL4, producing a TL4, or HS3, time delay.

For the second single phase fault, which would be tripped three pole, FF2 output via OR11, AND12 and OR12 inhibits AND7 and AND8, and enables AND9 causing a delay equal to the setting of TL5, the delayed reclosure timer.

The second multi-phase reclose attempt results in a lockout by the following sequence. On the first multi-phase fault, FF5 output plus the XYZ signal from LA2

via 121A-1 closed, produces an output from AND13 which is the D input to FF3. In this flip-flop, D input must be present before CK input to produce Q output. When the first fault occurred, TL6B output provided CK input to FF3, and this permitted XYZ signal to pass through AND16 to OR20 and to AND18. On the second fault, NOT2 output (RI signal) provides upper input to AND18 and this passes through OR21 and OR36 to FF7 to cause lockout.

### TWO BREAKER RECLOSING SEQUENCE

This description refers only to Figure 13, the two breaker logic diagram.

The sequence of reclosing two breakers is best explained by referring to Figure 12, which shows a portion of the two breaker logic diagram. For this description, assume there are no inhibit signals at NOR8A or NOR8B and that there are no reset signals at AND25A and AND25B.

The manual and auto-reclose signals from AND37 or TL6A are present at OR44 output. The output of FF12 is zero for the 1-2 sequence and a logic one for the 2-1 sequence. Assuming the 1-2 choice (breaker A before breaker B), FF12 output permits OR44 output to pass through gate 33A to initiate reclosing of breaker A and blocks the OR44 output from passing through gate 34B to initiate reclosing of breaker B. After TL15 (transfer timer) operates, the TL15 output passes through gate 33B to initiate reclosing of breaker B.

If the 2-1 sequence had been chosen, FF12 output would be a logic one, and this would pass the OR44 reclose signal through gate 34B and initiate reclosing of breaker B. When transfer timer TL15 operates, FF12 output passes through gate 34A to initiate reclosing of breaker A.

If the reclose of the first breaker is not successful, an RI pulse at AND4 output (see Figure 13) will operate through OR30 and OR35 to reset FF14 and stop the transfer timer, blocking the reclose of the second breaker.

The reclose outputs at AND24A and AND24B are only momentary, with their duration determined by the setting of dwell timers TL11A and TL11B. These timers reset AND25A and AND25B after the dwell time has expired.

### RESET AFTER SUCCESSFUL RECLOSURE

When a reclose output signal appears at AND24 in the one breaker module, or at either AND24A or AND24B in the two breaker module, this operates through FF9 to start the reset timer TL14. If the reclosure is not successful, an RI pulse from AND4 via OR30 will reset FF9 to stop the reset timer TL14. If the reclosure is successful, TL14 will remain energized and when it times out, will reset all of the flip-flops critical to reclosing (FF2, FF3, FF4, FF5, etc.).

### OVERALL SEAL-IN AND LOCKOUT

When a reclose sequence is started by the operation of FF4, the RI seal-in, the output of FF4 operates through AND5 (after RI from the line relays resets), OR3, AND6 and TL1 to produce an OVERALL SEAL-IN signal. The feedback from TL1 output to OR3 input maintains this OVERALL SEAL-IN signal until a reset or a lockout signal resets AND6.



The OVERALL SEAL-IN operates TS4 to produce a RECLOSE IN PROGRESS output signal. It also operates through AND28 to start the OVERALL TIMER, TL12. The setting of TL12 determines how long the recloser will wait for an inhibit signal, such as SYNC CK, to revert to a permissive state before going to lockout. If a reclose output appears at AND24 in the one breaker module, or at OR42 in the two breaker module, this inhibits AND28 and stops the OVERALL TIMER, preventing lockout (in the two breaker module, this path involves FF9). If there is no reclose output before TL12 times out, TL12 operates through OR36 to cause lockout.

There are three other conditions that can cause lockout via OR36. The first is CC6, which provides for an external contact closure to put the TRS1000 into a lockout state. The second is the reclosing program circuitry that operates through AND18 and AND19. The third is an output from AND35, indicating that a manual circuit breaker closing resulted in an RI output at AND4, caused by reclosing onto a faulted line.

The output of OR36 sets flip-flop FF7. The output of FF7 is used to (1) cause TS1 to drop out, sending a 3-POLE TRIP ENABLE signal to the line relays; (2) energize TS7 to close the RECLOSER LOCKED OUT contacts, and (3) reset all the flip-flops critical to reclosing (FF2, FF3, FF4, FF5, etc.).

Once FF7 is set, it maintains the lockout state until it is reset by an output from OR32. Resetting FF7 restores the recloser to its normal state. The reset signal for FF7 can come from (1) a manual close of the breaker as indicated by CC3 output; (2) pushing the RESET button on the front panel of the RLM111 or RLM112 module, or (3) closing an external contact wired to CC4.

### 3-POLE TRIP ENABLE CIRCUIT

The TRS1000 reclosing system is designed to work with a protective relay system that will accept a 3-POLE TRIP ENABLE signal and use that signal to issue a three pole rather than a single pole trip output for all single phase faults. Table 2 shows the reclosing programs and is based on the assumption that this interconnection with the line relaying is in service and performs this function.

-POLE TRIP ENABLE relay in the TRS1000 can be activated by any of the inputs to OR6. With the TRS1000 in its normal reset state, the output of OR6 is a logic zero, and therefore the relay is normally picked up because of NOT3. This relay drops out to enable a three pole trip in the line relays.

There are five inputs to OR6. One of these is from OR4, which has two inputs. One of the inputs to OR4 is from FF4 via AND5, OR3, AND6 and TL1. The purpose of this input is to cause any retrip to be a three pole tripping operation when reclosing onto a permanent single phase fault.

The second input to OR4 is from OR12 or OR13 via OR15. Any reclosing program (except number 1) that does not have the 1P switch closed will operate through this path to cause the line relays to trip three pole for single phase faults.

There are four other inputs to OR6. These are:

1.  $\overline{XYZ}$  output of LA2. This is the condition of the recloser being out of service because no reclosing program was selected.

2. FF7 output. This is the LOCKOUT condition.
3. If the TRS1000 ON-OFF switch is in the OFF position, and switch SW11A-3 (SW112A-5 in the two-breaker module) is closed, a three-pole trip is enabled. The switch gives the user the option of removing this path if desired.
4. FF6 output. The input signal comes from CC3, indicating a manual reclose operation.

#### POLE DISAGREEMENT AND DIRECT 3-POLE TRIPPING

##### One Breaker Logic Diagram (Figure 11)

Contact converter CC9 is energized by a pole disagreement signal, and this causes a direct three pole trip of the breaker after TL9 has timed out.

There is an additional path through SW11A-1 for a direct three pole trip. Although this path does not serve any useful purpose in the one breaker version of the TRS1000, it is useful in the two breaker version. With SW11A-1 in the OFF (dotted) position, any RI signal appearing at the FF4 output will cause a three pole trip, which is undesirable. Therefore, this switch should be left in the ON position (solid line) with no input connection to CC10.

##### Two Breaker Logic Diagram (Figure 13)

Contact converter CC9 is energized by a pole disagreement signal from breaker A, and this causes a direct three pole trip of breaker A after TIMER TL9 has timed out. Contact converter CC13 is energized by a pole disagreement signal from breaker B, and this causes a direct three pole trip of breaker B after timer TL9B times out.

There is another path for direct tripping of breaker A through the lower input to OR40A, or direct tripping of breaker B through the lower input to OR40B. This path may be used for either of the purposes described below:

First, this tripping path may be used in a breaker and a half arrangement to trip the middle breaker three pole and the other breaker single pole for any single phase fault. Assuming the middle breaker is breaker A, leave SW112A-1 in the open (dotted) position, and place SW112A-3 in the closed (solid) position with no input connection to CC10.

The second use of this tripping path is to trip the middle breaker three pole only for the special case of simultaneous single phase faults above and below the middle breaker (breaker A in Figure 14). Assume in Figure 14 that one TRS1000 is applied on line X and another on line Y. Assume that an A-g fault occurs on line X, and that breakers A and B1 are tripped single pole. Assume that a B-g fault occurs on line Y within a few cycles. This would normally trip a second pole of breaker A, leaving only one pole carrying current. For this condition, breaker A can be tripped three pole by the following path:

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A reclose in progress signal from the recloser on line X can be connected to CC10 of the recloser on line Y. If SW112A-1 is closed (solid line) this will trip breaker A three pole. A CC10 signal via OR41 also causes a transfer of reclosing to the second breaker (B2), and initiates a single pole reclose of that breaker. The TRANSFER timer, TL15 times out and the TRS1000 transfers back to breaker A for a three pole reclose. This reclosing is supervised by synchronism check. Synchronism check is selected at AND39 following a flip-flop FF-11A change of state (Q=1) via OR46-AND38-OR22-AND20. If SW112A-8 is closed, 3-pole reclose is supervised by the synchronism check function at NOR8A.

The sequence of events is to have the second recloser operate, initiating the three pole tripping of the middle circuit breaker. Since either recloser may be the second one to operate, there should also be an interconnection from the RECLOSER IN PROGRESS output of the recloser on line Y to CC10 of the recloser on line X.

SYNCHRONISM CHECK SUPERVISIONOne Breaker Logic Diagram (Figure 11)

The output of the synchronism check module (SVM101) is a logic one when the two voltages being checked are in synchronism. This signal is inverted at NOT3 so that the upper input to AND20 is a logic one when the voltages are not in synchronism. FF1 supplies the lower input to AND20 via OR22. If SW121B-2 is in the SYNC-3P position, synchronism check is effective for all three pole reclosures. If SW121B-2 is in the SYNC-DLY position, it is effective only for the delayed reclosures.

The output of AND20 via OR23 and NOR8 causes a logic zero at the lower input to AND24 for a non-synchronous condition and inhibits reclosing. On the other hand, if voltages are in synchronism, NOT3 and AND20 outputs will be zero, the lower input to AND24 will be a logic one, and reclosing will not be inhibited.

If manual reclosing is being done through the TRS1000 with the INT-EXT switch in the INT position, reclosing may be supervised by synchronism check if SW121B-3 is closed. FF6 provides the lower input to AND20 to pass the synchronism check signal to OR23, NOR8, OR28 and AND24.

Switch SW111A-2 provides a choice as to how the TRS1000 responds to synchronism check and other inhibit signals. With SW111A-2 open (dotted), the synchronism inhibit signal must be absent when the TL6 output resets. With SW111A-2 in the closed (solid) position, AND25 output is sealed in until reclose occurs or until the overall timer TL12 times out. This provides additional time, if desired, for the synchronism check signal to become permissive.

Two Breaker Logic Diagram (Figure 13)

The output of the synchronism check module (SVM102) is a logic one when the two voltages being checked are in synchronism. This signal is inverted at OR54 so that the lower input to AND20 is a logic one when the voltages are not in synchronism. FF1 supplies the upper input to AND20 via OR22. If SW121B-2 is in the SYNC-3P position, synchronism check is effective for all three pole reclosures. If SW121B-2 is in the SYNC-DLY position, it is effective only for the delayed reclosures.

Switches SW112A-7 and SW112A-8 with OR49 and AND39, determine which breaker reclosing will be supervised by synchronism check. This is done by monitoring the position of FF9, which is reset before the first breaker reclosure and changes state after that first reclosure. With SW112A-8 closed and SW112A-7 open (REF), synchronism check will supervise the reclosing of the first breaker in the reclosing sequence. With SW112A-7 closed and SW112A-8 open (REF), synchronism check will supervise the reclosing of the second breaker in the reclosing sequence. With both switches closed, synchronism check will supervise the closing of both breakers. With both switches open, synchronism check is disabled.

The output of OR49 (either SW112A-7 or SW112A-8 closed) enables AND39 and allows the synchronism check signal at AND20 to pass via OR23 to NOR8A and NOR8B. For a non-synchronous condition, this produces a logic zero at the lower input of AND24A and AND24. The reclose-attempt signal (TL5A and OR44) is routed to either OR29A or OR29B by the AND33A, AND34A, AND33B, AND34B logic. For a synchronous condition, NOR8A and NOR8B outputs are a logic one and the appropriate output, AND24A or AND24B, is enabled.

The function of FF12 and OR48 is to provide the proper bus voltage to the synchronism check module for the first reclosure and then to switch to the other bus voltage for the second reclosure. OR48 is an exclusive OR, which means there is no output if both inputs are present. The OR48 output is fed back to the synchronism check module and operates analog switches in that module to select the proper bus voltage.

#### OPTIONAL RECLOSE INHIBIT SIGNALS

Contact converter signals can be used to inhibit reclosing for various breaker and system conditions. These inhibit signals operate through NOR8 in the one breaker recloser to remove the lower input to AND24. In the two breaker recloser, they operate through either NOR8A to block reclosing of breaker A, or NOR8B to block reclosing of breaker B. The logic diagram description is given below.

#### General Purpose Inhibit (via CC5)

Contact converter CC5 permits a user-selected function to inhibit all reclosing. This operates via OR23 in the two breaker recloser to inhibit reclosing of both breakers. A manual reclose will cancel this inhibit signal at AND21, since the  $\bar{Q}$  output of FF6 becomes a logic zero after CC3 operates.

#### Breaker Out of Service (via CC7 and CC14)

In the one breaker recloser, CC7 provides an indication that the breaker associated with the recloser is out of service and inhibits reclosing via OR24 and NOR8.

In the two breaker recloser, CC7 provides for an indication that breaker A is out of service and inhibits reclosing of breaker A via OR41A and OR24A. Similarly, CC14 provides for an indication that breaker B is out of service and inhibits reclosing of breaker B via OR41B and OR24B. CC7 is functional with the NORMAL/BLK-A switch in the NORMAL position, and CC14 is functional when the NORMAL/BLK-B switch is in the NORMAL position. For the BLK-A or BLK-B position of these switches, reclosing of that particular breaker is inhibited regardless of the CC7 or CC14 indication. An OR24A output causes transfer of reclosing from breaker A to breaker B and an output from OR24B causes transfer of reclosing from breaker B to breaker A.

Breaker Open Before Fault (via CC8 and CC12)

In the one breaker recloser, CC8 provides an indication that any pole of the associated breaker is open. In the two breaker recloser, CC8 is used for breaker A and CC12 for breaker B. If a reclose initiate indication is not present as an input to OR25 (OR25A and OR25B in the two breaker recloser) within 30 milliseconds of the contact converter output, reclosing is inhibited. This feature is intended to prevent reclosing if one of the breakers was open in advance of an RI input to the recloser. A manual reclose (FF6 output) will reset the OR27-TL10 seal-in by supplying a logic one to the NOT input of AND23 (AND23A and AND23B in two breaker recloser). This reset is necessary in order to permit a manual close via the recloser output contacts.

MANUAL RECLOSING

The TRS1000 may be used in either of two modes of operation for manual closing. Switch 111B-1 on the RLM111 one breaker module and SW112A-6 on the RLM112 two breaker module, marked EXT-INT, determine how the recloser responds to a CC3 manual reclose input signal.

With this switch in the EXT position, the actual reclosing of the breaker must be accomplished by circuits external to the TRS1000. The CC3 input signal in this mode of operation resets FF7 to take the recloser out of the locked-out state if it was locked out, and sets FF9 to start the reset timer. If reclosing is successful (no RI output) the recloser is reset and is ready for an automatic reclosing operation when the next fault occurs.

With this switch in the INT position, breaker closing is accomplished through the same output circuits used for automatic reclosing. In the one breaker recloser, the closing path is from CC3 and FF11 through OR29, AND25 and AND24. In the two breaker recloser, the closing path is from CC3 and FF13 through AND37 and OR44 to the same breaker selection and output circuits used for automatic reclosing. The CC3 signal resets FF7, the lockout flip-flop, if the recloser was in lockout. A reclosing output signal at AND24 in the one breaker recloser or at OR42 in the two breaker recloser will operate FF9 to start the reset timer. If reclosing is successful (no RI input) the recloser is reset and is ready for automatic operation when the next fault occurs.

For either the INT or EXT position, if the breaker closes into a permanent fault, FF6 output plus an output from FF4, operates through AND35 to cause lockout of the recloser.

PROGRAM MODIFICATONS BY EXTERNAL CONTACT CONVERTERS

The pre-set reclosing programs shown in Table 2 can be modified by operating one or more of the external contact converters, CC15, CC16, CC18 and CC19. This may be done as a result of a change in system conditions, such as having a parallel line open, or having a tie-line to a strong source open.

Each of the contact converters has an intended effect; however, the actual effect is different for some reclosing programs because of the interaction of the various switches. Before using the contact converters, check Table 2 for the actual effect.

If more than one contact converter is used, the combined effect follows the priority order of the sequence in which they are listed in Table 2, i.e., CC15, CC18, CC16 and CC19. For example, if CC15, CC16 and CC18 are used with program 4, and all three are closed, CC15 transfers the program to program 2, CC18 has no effect on program 2 and CC19 transfers from program 2 to program 14, which is lockout for all fault types.

The intended functions and the exceptions for these four contact converters are:

- CC15: Reclose on single pole trip only. (See Table 2 for effect on programs 3, 6 and 8.)
- CC18: Change three pole reclose from high speed to delayed. (See Table 2 for effect on programs 3 and 8.)
- CC16: Trip three pole for all fault types. (This energizes three pole trip enable before first breaker trip, therefore it eliminates all HS1 time delays.)
- CC19: Block delayed three pole reclose. (This blocks delayed second reclosure, but does not block initial time-delayed reclosure of programs 6, 10, and 12. In program 6, CC19 permits HS1 reclose for single phase faults and HS3 reclose for multi-phase faults.)

#### RECLOSE IN PROGRESS

The reclose in progress signal operates from OR38. It starts when FF4 operates and lasts until the overall seal-in at TL1 output is reset after the reset timer (TL14) times out for a successful reclosure, or until the recloser goes to lockout after an unsuccessful reclosure.

#### ZONE 1 EXTENSION

The zone 1 extension relay operates from OR37. It operates after the first recloser output from AND24 (one breaker recloser) or OR42 (two breaker recloser). It also operates if the recloser ON-OFF switch is in the OFF position.

TABLE 2

RECLOSE PROGRAM	TYPE FAULT				RLM121 FRONT PANEL			SW121A*		CONTACT CONVERTER			
	SINGLE PHASE		MULTI-PHASE		1P	3P	DLY	1	2	CC15	CC18	CC16	CC19
	1st	2nd	1st	2nd									
1	NR	NR	NR	NR	OFF	OFF	OFF	--	--	--	--	--	--
2	HS1	LO	LO	--	X	OFF	OFF	--	--	--	--	14	--
3	HS3	LO	HS3	LO	OFF	X	OFF	--	--	1	--	--	--
4	HS1	LO	HS3	LO	X	X	OFF	--	0	2	5	3	--
5	HS1	LO	TD	LO	X	X	OFF	--	C	2	--	6	--
6	TD	LO	TD	LO	OFF	OFF	X	--	--	--	--	--	4
7	HS1	TD	LO	--	X	OFF	X	--	--	--	--	14	2
8	HS3	TD	HS3	TD	OFF	X	X	--	--	6	--	--	3
9	HS1	TD	HS3	TD	X	X	X	0	0	7	10	8	4
10	HS1	TD	TD	TD	X	X	X	0	C	7	--	13	5
11	HS1	TD	HS3	LO	X	X	X	C	0	7	12	3	4
12	HS1	TD	TD	LO	X	X	X	C	C	7	--	6	5
13#	TD	TD	TD	TD									6
14#	LO	--	LO	--									

NOTES TO TABLE 2

1. NR - no recloser operation.
2. HS1 - high speed reclose with time equal to setting of "10" switch on front panel of RLM121 module.
3. HS3 - high speed reclose with time equal to setting of "30" switch on front panel of RLM121 module.
4. LO - lockout.
5. TD - time delayed recloser with time equal to setting of "DLY" switch on front panel of RLM121 module.
6. OFF - function not selected.
7. X - function selected.
8. 0 - switch position OPEN
9. C - switch position CLOSED
10. -- - no effect.
11. \* - see Figure 8 for switch information.
12. # - only via remote.
13. If external contact converters are used to modify program, the numbers in the chart above shown how each one changes the original program to a different program. If more than one contact converter is used, follow the sequence in which contact converters are listed to determine the combined effect. For example, if the original program is No. 5, and CC15 and CC16 are used, CC15 shifts to program No. 2, and CC16 shifts from No. 2 to No. 14. Therefore, program number 14 will be followed.



**TESTING**DIELECTRIC TESTS

Dielectric testing may be performed 1) between all terminals (tied together) and the case, and 2) between independent circuit groups (refer to elementary diagram, Figure 9). The recommended voltage is 2000 volts rms for initial testing and 1500 volts rms for subsequent periodic testing. The test voltage should be applied for one minute.

**CAUTION**

**When hipot testing, it is necessary to remove the jumper between terminals BD13 and BD14. This removes the grounding connection between the surge capacitors and case ground. Failure to do so could result in damage to the noise filter capacitors on the PSM module when the DC supply terminals are tested.**

**NOTE**

ALL OTHER STUDS CAN BE TESTED WITH THE JUMPER IN PLACE WITHOUT DAMAGE; HOWEVER, LEAKAGE WILL BE INDICATED DUE TO CURRENT FLOWING THROUGH THE SURGE CAPACITORS.

ACCEPTANCE TESTS

The operational tests described in this section should be conducted prior to the installation of the TRS1000 system. These may be done on a "bench-top" basis.

**CAUTION**

**Remove all power from the TRS1000 before removing or inserting any of the printed circuit board modules. Failure to observe this caution may result in damage to the relay.**

One method of removing power is to turn off the power switch on the PSM power supply module and then remove both of the connection plugs located in the TPM position on the left side of the case.

Recloser

The recloser operation can be tested by applying input signals to the input contact converters and by monitoring the output contacts as well as observing the LED indicating lights on the front panel of the RLM111 or RLM112 module. The operating time for high speed and delayed reclosures may also be checked.

The test circuit shown in Figure 15 shows the connections that should be made to test the basic two-shot reclosing sequence, including the effect of contact converters CC15-CC16-CC18-CC19.

The recloser can be checked for the reclosing program to be used and with the settings that will be used in service, if that information is available. If the information is not available, the recloser may be checked for program 11 with the following settings:

1Ø delay	-	1 second
3Ø delay	-	0.5 second
DLY delay	-	5 seconds
Transfer delay	-	2 seconds
Reset time	-	10 seconds
Overall time	-	15 seconds

RECLOSER TESTS

1. Close SW1 momentarily and note that the RECL A contacts close in 1 second. If the two-breaker operation is being checked, note that RECL B contacts close 2 seconds later. The RIP front panel light should go out after the reset time of 10 seconds. Note also that the 3-POLE TRIP ENABLE LIGHT comes on at beginning of the sequence.
2. Close SW2 momentarily and note that the RECL A contacts close in 0.5 seconds. If the two-breaker operation is being checked, note that RECL B contacts close 2 seconds later. The RIP front panel light should go out after the reset time of 10 seconds.
3. Close SW1 momentarily to simulate the first breaker operation. After approximately 2 seconds, close SW2 to simulate a 3 pole trip for the second breaker operation. Observe that the first RECL A output occurs in 1 second and the second RECL A output occurs after the DLY setting of 5 seconds. RECL B operation should occur 2 seconds after RECL A in both cases. Recloser should reset 10 seconds after the second RECL A output.
4. Close SW2 momentarily to simulate the first breaker operation. After approximately 2 seconds, close SW2 momentarily again. Observe that RECL A and RECL B outputs occur after the first SW2 closure, and that the recloser goes to LOCKOUT after the second SW2 closure.

5. Close SW3 to check the effect of CC15. This should block the high speed reclosure for multiphase faults. Close SW2 momentarily and observe that the recloser goes to LOCKOUT.
6. Open SW3 and close SW4 to check the effect of CC18. This should make the reclosure for multiphase faults time delayed instead of high speed. Close SW2 momentarily and observe that RECL A output occurs in 5 seconds rather than 0.5 seconds.
7. Open SW4 and close SW5 to check the effect of CC16. This should cause a 3 pole trip for single phase faults. Observe that 3 POLE TRIP ENABLE contacts close when SW5 is closed.
8. Open SW5 and close SW6 to check the effect of CC16. This should block the delayed reclosure on the second shot after a single phase fault. Close SW1 momentarily and observe that RECL A time is 1.0 second. After approximately 2 seconds, close SW1 momentarily again and observe that recloser goes to LOCKOUT. Open SW6 and reset recloser from LOCKOUT.

Synchronism Check Functions - SVM Module

Testing the SVM module requires two AC voltage sources which can be phase-shifted. If the slip cut-off circuits are to be tested, the frequency of one source must be variable.

The following voltage and synchronizing tests require the SVM module to be removed from the case and be placed on a card extender (0138B7406G1).

Voltage Check

The voltage check units can be verified by selecting the front panel switches for the units being checked and watching the board mounted light emitting diode, TL3 (see Figure 9 for LED location).

## a) Dead Line Unit:

Set the front panel switches to DLDB. Short the bus voltage input to avoid extraneous pickup. Lower the line voltages from ten percent above the set point until TL3 lights. The line voltage should be within  $\pm 2.5$  percent of setting.

## b) Dead Bus Unit: Repeat test a), except interchange the bus and line inputs.

## c) Live Line Unit:

Set the front panel switch to LLDB. Apply bus voltage ten percent below setting, and starting with the line voltage ten percent below setting, increase the voltage until TL3 lights. The voltage should be within  $\pm 2.5$  percent of setting. Raise the bus voltage, and the light should go out within  $\pm 2.5$  percent of the dead bus setting.

## d) Live Bus Unit: Set the front panel switch to DLLB and repeat test c) except interchange the bus and line inputs.

Angle

Place the SVM module in the **SYNC CK** mode. Set  $V_{bus}$  and  $V_{line}$  to 69 volts. Wait approximately 20 seconds for the circuit to stabilize, then vary the angle between the two voltages. When the angle is less than the setting, TL3 should be lit and TL1 should be out. When the angle exceeds the setting, TL3 should go out and TL1 should be on. TL1 and TL3 will change state within  $\pm 2$  degrees of the ANGLE setting. To avoid activating the low slip detector, do not exceed a test angle in excess of  $\pm 90^\circ$ .

High-Set Slip Cut-off

Connect TP3 to plus 12 volts, which is available at pin 2 of the card extender. This disables the low-slip measurement circuit. With no frequency difference, and the line and bus sources set greater than the line setting, TL3 should be lit.

Increase the frequency of one source until TL3 no longer flashes on. This is the cut-off frequency and should be within five percent of setting.

As an alternative to watching TL3, the output can be monitored at TP4. Zero volts at TP4 means the output is blocked. 12 volts means OK to close. Use card extender pin 1 (ground) as the reference for this test.

#### Low-Set Slip Cut-off

Watch LED TL2 or monitor TP3 when both of the voltage sources are synchronized. TL2 should be out. Next, vary the frequency of one of the voltage sources. When TL2 lights, it indicates the low set slip unit is blocking. The frequency at which this occurs should be within  $\pm 15$  percent of the setting.

#### PERIODIC TESTS

A periodic test program should be developed which checks all of the TRS1000 functions employed in the scheme under consideration. It is left to the user's discretion to choose from among the Acceptance Tests given in the previous section, for those tests which may be applicable as Periodic Tests for a particular installation.

#### XTM TEST PLUGS

##### Description

The XTM test plugs are designed specifically for post-installation testing of the TRS1000 system. There are two plugs; XTM28L1 (left-hand plug) and XTM28R1 (right-hand plug), each providing access to fourteen relay and fourteen system points. The system points are located on the outer edge. The plugs are keyed by the contact finger arrangement so that there may be no accidental interchange between the left-hand and right-hand plugs.

The plugs are fitted with a sliding handle which swings out to facilitate wiring to the terminals. The terminals consist of number 8 screws threaded into flat contact plates. The handles each have a tab on the outside edge to guide the wire dress of the test leads.

#### **CAUTION**

**Not all of the external connections to the TRS are wired through the test receptacle.**

#### Terminal Designation

The test receptacle and connection plugs are located to the left of the magnetics module. Their terminals are labelled 1 through 28 with 1 through 14 corresponding to the left-hand side and 15 through 28 corresponding to the right-hand side. These points are designated on the elementary diagram (Figure 16) as TP1 through TP28.

The left-hand test plug (XTM28L1) terminals are labelled 1R through 14R and 1S through 14S for the relay side and system side, respectively, with the system side labelled in red. Similarly, the right hand test plug (XTM28R1) terminals are labelled 15R through 28R and 15S through 28S.

### XTM Test Circuit Connections

Test circuit connections, designated as TP points in the elementary diagrams, should be made to the relay side of the test plug. Where it is desired to use available system quantities for testing, e.g., DC control power, jumpers may be inserted between the corresponding system side and relay side test plug terminals. Appropriate precautions should be taken when working with station battery DC.

Connections should be made to the test plugs prior to insertion into the TRS1000.

### Test Plug Insertion

To insert the test plugs, the two connection plugs must first be removed. In so doing, electrical continuity is broken between the power system and the TRS for those signals which are wired through the test receptacle (refer to TP points on elementary diagram, Figure 16). For the terminals connected to the current transformer secondaries, shorting bars are included on the system side of the test receptacle. These are clearly visible through the transparent plastic face plate on the receptacle. The shorting bars make contact before the connection plug contacts break during removal, so that the CT secondaries are never open-circuited.

Both test plugs may be inserted at the same time. Otherwise, if using only one test plug, the connection plug may remain in the other half of the receptacle.

When the test plugs are inserted into the receptacle, part of the power system becomes isolated from the TRS1000. Refer to the elementary diagram (Figure 16) for the TP points associated with each of the test plugs.

### **WARNING**

**IT IS CRITICAL THAT JUMPERS BE INSERTED ON THE SYSTEM SIDE TEST PLUG TERMINALS WHICH ARE CONNECTED TO THE CT SECONDARIES. IF THESE JUMPERS ARE LEFT OUT, THE RESULTING HIGH VOLTAGES DEVELOPED PRESENT A SERIOUS HAZARD TO PERSONNEL AND MAY SEVERELY DAMAGE EQUIPMENT.**

### CARD EXTENDER

The card extender (GE #0138B7406G1) is used to obtain information about the operation of an individual module. The extender may be inserted in the place of any of the printed circuit board modules. The module can then be inserted into the connector on the extender.

The extender has 60 test points which are identified by numbers 1 through 60.

**CAUTION**

Remove all power from the TRS1000 before removing or inserting any of the printed circuit board modules. Failure to observe this caution may result in damage to the relay.

One method of removing power is to turn off the power switch on the PSM power supply module and then remove both of the connection plugs located in the TPM position on the left side of the case.

**WARNING**

**CAUTION MUST BE EXERCISED WHENEVER A CARD EXTENDER IS INSERTED INTO AN IOM OR PSM POSITION SINCE STATION BATTERY POTENTIAL WILL BE PRESENT AT SOME POINTS. TURNING OFF THE POWER SWITCH ON THE PSM MODULE AND REMOVING BOTH CONNECTION PLUGS DOES NOT REMOVE ALL EXTERNAL POWER TO THE RELAY. FAILURE TO OBSERVE THIS WARNING MAY RESULT IN PERSONAL INJURY AND DAMAGE TO EQUIPMENT.**

RECEIVING, HANDLING AND STORAGE

CAUTION

This relay contains electronic components which could be damaged by electrostatic discharge currents if those currents flow through certain terminals of the components. The main source of electrostatic discharge currents is the human body, and the conditions of low humidity, carpeted floors and insulating shoes are conducive to the generation of electrostatic discharge currents. Where these conditions exist, care should be exercised when removing and handling the modules to make settings on the internal switches. The persons handling the module should make sure that their body has been discharged by touching some surface at ground potential before touching any of the components on the modules.

Immediately upon receipt, the equipment should be unpacked and examined for any damage sustained in transit. If damage resulting from rough handling is evident, file a damage claim at once with the transportation company and promptly notify the nearest General Electric Sales Office.

If the equipment is not to be installed immediately, it should be stored indoors in a location that is dry and protected from dust, metallic chips, and severe atmospheric conditions.



## INSTALLATION

### ENVIRONMENT

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

### MOUNTING

The TRS1000 case has been designed for standard rack mounting. The case measures four rack units in height. The units may also be flush mounted on a panel. Refer to Figure 17 for the outline and mounting dimensions.

Provision has been made for surface panel mounting as well. This is accomplished by removing and reversing the side brackets so that the mounting wings are in the rear. For surface mounting, cutouts must be made in the panel to allow for the terminal blocks.

### EXTERNAL CONNECTIONS

External connections are made according to the elementary diagram given in Figure 16. This is a general diagram incorporating all of the available options. Connection need not be made to those terminals associated with options that will not be used.

The terminal block points are shown in Figure 2.

SPECIFICATIONS

GENERAL

- Rated Frequency ● 50 or 60 hertz
- Rated Voltage ● 57.7/69 V phase-to-neutral
- DC Control Voltage ● 48 VDC - Operating range 34-60 VDC  
 110/125 VDC - Operating range 88-150 VDC  
 220/250 VDC - Operating range 176-300 VDC
- Maximum Permissible AC Voltage  
 Continuous ● 2.0 x rated  
 One Minute ● 3.5 x rated
- Ambient Temperature Range  
 For Storage ● -40 to +65 degrees Celsius  
 For Operation ● The TRS has been designed for continuous operation between -20°C and +55°C per ANSI Standard C37.90. In addition, the TRS will not malfunction nor be damaged by operation at temperatures up to +65°C.
- Insulation Test Voltage ● 2 kV 50/60 hertz, one minute
- Impulse Voltage Withstand ● 5 kV peak, 1.2/50 milliseconds, 0.5 joule
- Interference Test Withstand ● In accordance with applicable IEC and ANSI Standards

Burdens

- Voltage Circuits ● 0.2 VA / 49 degrees, 60 hertz  
 ● 0.24 VA / 48 degrees, 50 hertz
- DC Battery
 

	Normal	Tripped
All voltage ratings	7W	12 W
- DC Battery (for Contact Converters) ● 1.4 milliamperes each

Contact Data

Heavy Duty Outputs

1. Reclose A, Reclose B
2. 3 Pole Trip Enable
3. Ground Overcurrent Trip  
(if used)

- o Continuous rating = 3 amperes
- o Make and carry for tripping duty (per ANSI C37.90) 30 amps
- o Break 180 VA resistive at 125/250 VDC
- o Break 60 VA inductive at 125/250 VDC

Auxiliary Outputs  
(including Alarms)  
(All contacts marked with "A" on logic diagram)

- o Continuous rating = 3 amperes
- o Make and carry for 30 seconds 5 amperes
- o Break 25 watts inductive at 125/250 VDC
- o Make and Carry continuously 50 watts
- o Maximum of 250 volts or 0.5 amp

Data Logging Contacts  
(when used)

- o 10 watts
- o 250 VDC maximum
- o 0.5 amp maximum

RECLOSER

Reclosing Timers

Single and Three Pole Reclose  
Timers (independently  
adjustable)

- o 0.01 to 0.99 second in 0.01 second steps
- o 0.1 to 9.9 seconds in 0.1 second steps

Delayed Second Reclosure

- o 1 to 99 seconds in 1.0 second steps  
(may be disabled)

Dwell Time of Reclosing Contacts

- o 0.8 second or 0.2 second

\* Reset Time

- o 4 to 99 seconds in one second steps

Overall Time

- o 10 to 1650 seconds in ten second steps

\* Indicates revision

SYNCHRONISM CHECK

- |                           |  |
|---------------------------|--|
| Line and Bus Voltage Live | o 70 to 110 percent of rated in five percent steps.  |
| Line and Bus Voltage Dead | o 10 to 70 percent of rated in five percent steps.   |
| Rated Voltage             | o 57.7, 63.5, 66.4, 69 volts phase-to neutral  |
| Synchronism Angle         | o 5-75 degrees in one degree steps   |
| Slip Cut-off Frequency    | o High 0.25-2.25 hertz in 0.25 steps<br>Low 0.01 to 0.09 hertz in 0.01 steps 0.1 to 0.9 hertz in 0.1 steps |

DIMENSIONS

- |                             |   |
|-----------------------------|---|
| Standard rack mounted unit: | o 6-15/16 inches (176 millimeters) high                         |
|                             | o 19-1/16 inches (484 millimeters) wide (standard 19-inch rack) |
|                             | o 14 inches (356 millimeters) deep (including terminal blocks)  |

WEIGHT

Standard rack mounted unit weighs approximately 33 pounds (15 kilograms) net.

Since the last edition, Figures 7 and 10 have been changed.

Appendix A

Type CTM102 or CDM102  
Time Overcurrent Modules

INTRODUCTION

As an option, the TRS1000 recloser system may include either a CTM102 non-directional ground overcurrent function, or a CDM102 directional ground overcurrent function. Both of these are completely separate from the TRS1000. They are intended to provide sensitive backing protection for another modular protective relay system.

The time overcurrent function in these modules produces an inverse time characteristic curve as shown in Figure 18. This curve is based on curve A of IEC standard 255-4. The operating current is  $3I_0$  (the current transformer neutral current). In the CDM102 module, the characteristic angle can be set to either 15, 30, 45 or 60 degrees.

The characteristic of the CDM102 module directional unit with voltage polarizing is shown in Figure 19.

The location of the front panel and on-board adjustments for the CDM102 module are shown on Figure 23.

MODULE DESCRIPTION

Front Panel Indications

- IS** Amber light emitting diode lights to indicate that the input current exceeds the pickup level.
- IN** Red light emitting diode indicates trip. It is a latching type target which will remain latched until reset.

Switches

- IS** Pickup current setting. Additive setting with a base of 0.1. The sum of the switches positioned to the right, multiplied by the rated input current, gives the pickup value.
- TM** Time dial selects which time curve will be followed (see Time-Current Curve, Figure 18). It is adjustable from 0.05 to 1. Two toggle switches provide intermediate settings of 0.025 and 0.05, and with both positioned to the right, 0.075.
- RESET** Push button to reset **IN** target.

On-Board Settings - CDM Module Only (See Figure 23)

- ANGLE** Selects angle of maximum torque, settable to 15°, 30°, 45° or 60°. Separate position for 50 and 60 hertz.
- FREQUENCY** Selects rated frequency for directional unit.

TESTING

TIME OVERCURRENT UNIT (CTM101)

Pickup Current Check

Connect the TRS according to the test circuit given in Figure 20. It is not necessary to connect the timer at this point. Close SW1 and increase the current slowly from zero until the yellow **IS** LED on the CTM102 module just lights. The current should be within five percent of 0.5 amperes (five amp relay) or 0.1 amperes (one amp relay) because the **IS** tap setting is 0.1 X  $I_N$ . The current pickup may be checked at other tap values.

Timer Checks

Adjust the variable auto-transformer so that  $I_{op}$  will be twice the pickup current when SW1 is closed. Connect the timer and close SW1. Verify a trip output after a delay of approximately ten seconds (refer to the time curves in Figure 18). The normally open contact between terminals should close, and the normally closed

contact between terminals should open at the time of the trip, and remain open so long as current is still applied. The red  $I_N$  LED on the CTM102 module should light and latch in.

Remove current and reset the trip target. Repeat the time tests for varying multiples of pickup current and different  $TM$  time dial settings, as desired, to verify the time curves given in Figure 18.

### DIRECTIONAL GROUND TIME OVERCURRENT TESTS

#### Pickup Current Check (with Current Polarization)

Connect the TRS according to the test circuit given in Figure 21. It is not necessary to connect the timer at this point. Adjust  $I_{POL}$  to 1.0 amperes (five amp relay) or 0.2 amperes (one amp relay). Close SW1 and adjust the phase shifter so that  $I_{POL}$  and  $I_{OP}$  are in phase. Increase  $I_{OP}$  slowly from zero until the yellow  $I_S$  LED on the CDM102 module just lights. The current ( $I_{OP}$ ) should be within five percent of 0.5 amperes (five amp relay), or 0.1 amperes (one amp relay) because the  $I_S$  tap setting is  $0.1 \times I_N$ . The current pickup may be checked at other tap values.

#### Time Checks (with Current Polarization)

Maintain  $I_{POL}$  as above to enable the pickup level detector. Connect the timer and conduct the time checks, as described in the previous section (Non-Directional Ground Time Overcurrent Tests).

#### Current Polarization Test

Leave the TRS connected according to Figure 21. The timer may be disconnected. Apply  $I_{OP} = I_{POL} = 5$  amperes (five amp relay), or 1 ampere (one amp relay), in phase. The unit should trip (yellow  $I_S$  and red  $I_N$  LEDs on CDM102 both light). Adjust the phase shifter and verify that the yellow  $I_S$  LED goes out when the angle between the two currents reaches 90 degrees (plus or minus four degrees). The directional unit is now blocking operation of the pickup level detector in the ground time overcurrent unit. Repeat to cover both a leading and lagging phase shift. The red  $I_N$  LED will remain lit, because it is latched-in.

#### Voltage Polarization Test

Connect the TRS according to the test circuit given in Figure 22. Apply  $V_{POL}$  of 69 volts, and  $I_{OP}$  of 5 amperes (five amp relay) or 1 ampere (one amp relay) lagging  $V_{POL}$  by 15 degrees. This is the setting on the voltage polarization link within the CDM102 module. Verify a trip. Increase the phase shift and verify that the yellow  $I_S$  LED goes out when the angle reaches  $90 + 15 = 105$  degrees lagging (plus or minus four degrees).

Repeat with  $I_{pOL}$  leading  $V_{pOL}$ . The cut-off point should now be  $90 - 15 = 75$  degrees leading (plus or minus four degrees). This test may also be conducted using the other three angle settings (30, 45, 60) of the voltage polarization link in the CDM102 module.

SPECIFICATIONS

Pickup Current

- 10 to 80 percent of nominal in 2 percent steps

Time "Dial"

- 0.05 to 1.0 in 0.025 steps.  
IEC 255-4 Type A Curve: See Figure 18 (BS 142 Normal Inverse Curve)  
NOTE: This curve is similar to the GE Type IAC relay inverse curve.



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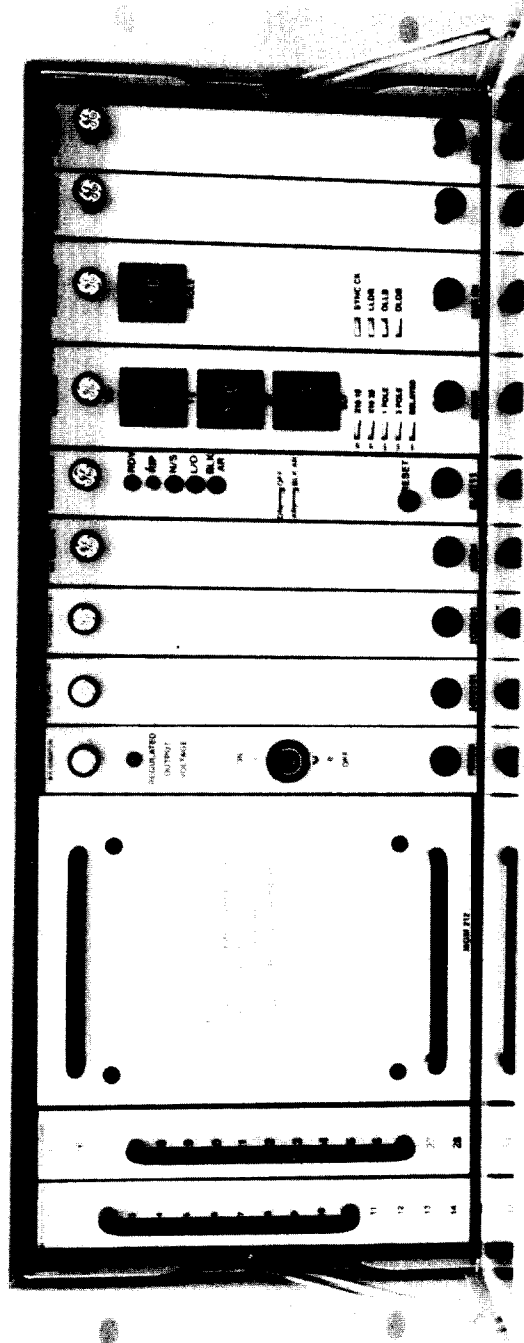


Figure 1 (8043774) Photograph of TRS1000, Front View

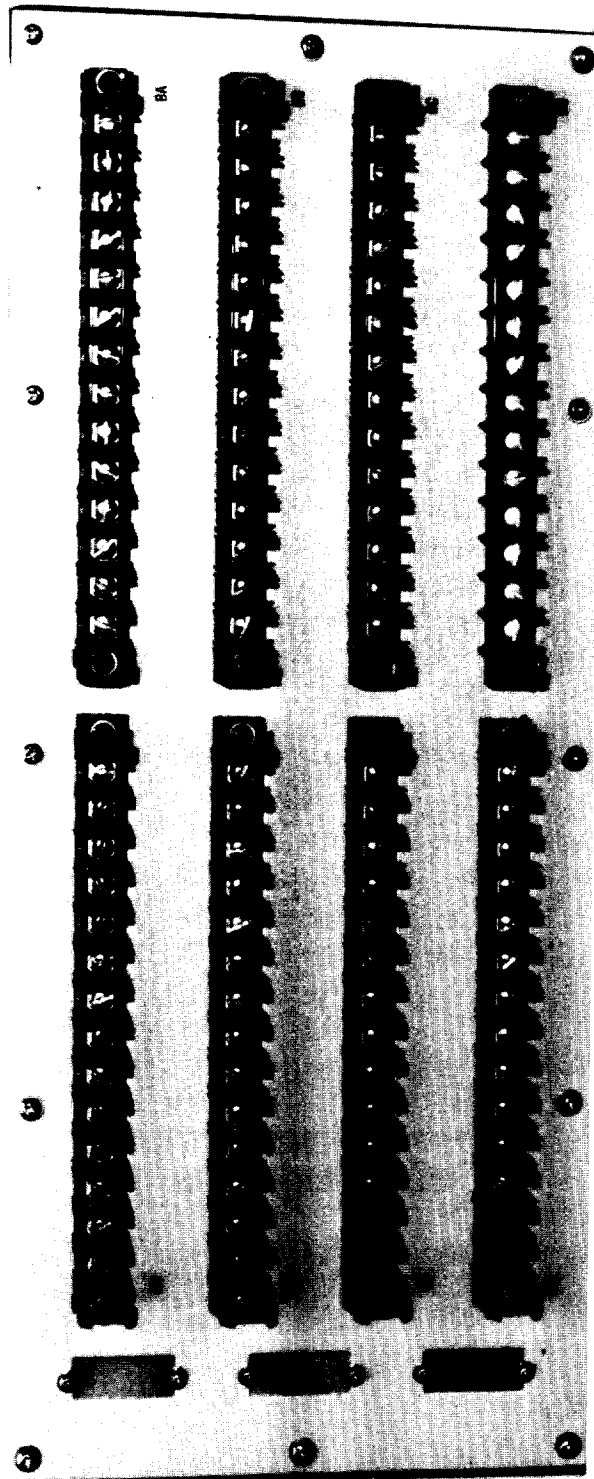


Figure 2 (8043776) Photograph of TRS1000, Rear View

	MAGNETICS OUTPUT RELAYS	POWER SUPPLY	CONTACT CONVERTERS	CONTACT CONVERTERS	AUXILIARY OUTPUT RELAYS	RECLOSER	RECLOSER	SYNCHRONISM CHECK	TIME OVERCURRENT	OPTIONAL LOGIC
TEST PLUG	LINK TO SET RATED CURRENT	SET RATED VOLTAGE	SET RATED VOLTAGE	SET RATED VOLTAGE		LOGIC SWITCHES 111A 111B OVERALL TIMER RESET TIMER POLE DISAGREE TIMER	LOGIC SWITCHES 121A 121B	LINE & BUS LIVE & DEAD THRESHOLDS RATED VOLTAGE SLIP CUTOFF FREQUENCY DEAD TIME RATED FREQUENCY	CTM-TOC CDM-DIRECTIONAL TOC RATED FREQUENCY CHARACTERISTIC ANGLE	MONITORING RELAYS
TPM	MGM212	PSM201	IOM101	IOM101	IOM201	RLM111	RLM121	SVM101	CTM102 OR CDM102	IOM202

Figure 3 (0183B8086 SH 1 [1]) Module Location & On-Board Settings, One-Breaker Recloser

	MAGNETICS OUTPUT RELAYS	POWER SUPPLY	CONTACT CONVERTERS	CONTACT CONVERTERS	AUXILIARY OUTPUT RELAYS	RECLOSER	RECLOSER	SYNCHRONISM CHECK	TIME CURRENT	OPTIONAL LOGIC
TEST FLUG	LINK TO SET RATED CURRENT	SET RATED VOLTAGE	SET RATED VOLTAGE	SET RATED VOLTAGE		LOGIC SWITCHES 111A 111B OVERALL TIMER RESET TIMER POLE DISAGREE TIMER TRANSFER TIMER	LOGIC SWITCHES 121A 121B	LINE & BUS LIVE & DEAD THRESHOLDS RATED VOLTAGE SLIP CUTOFF FREQUENCY DEAD TIME RATED FREQUENCY	CTM-TOC CDM-DIRECTIONAL TOC RATED FREQUENCY CHARACTERISTIC ANGLE	MONITORING RELAYS
TPM	M3M212	PSM201	ICM101	ICM101	ICM201	RLM112	RLM12	SVM102	CTM102 OR CDM102	IOM202

Figure 4 (0183B8086 SH 2) Module Location & On-Board Settings  
Two-Breaker Recloser

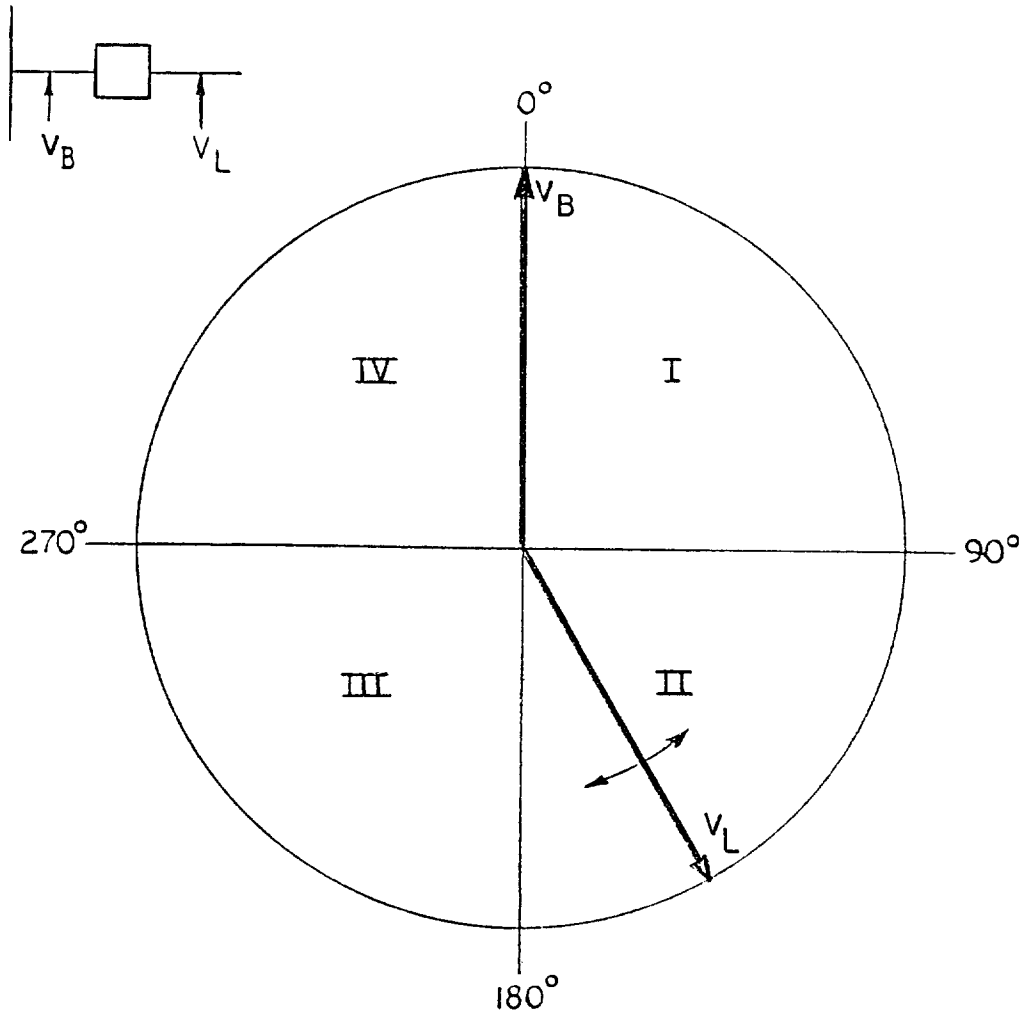


Figure 5 (0285A9179) Synchronism Check Voltages

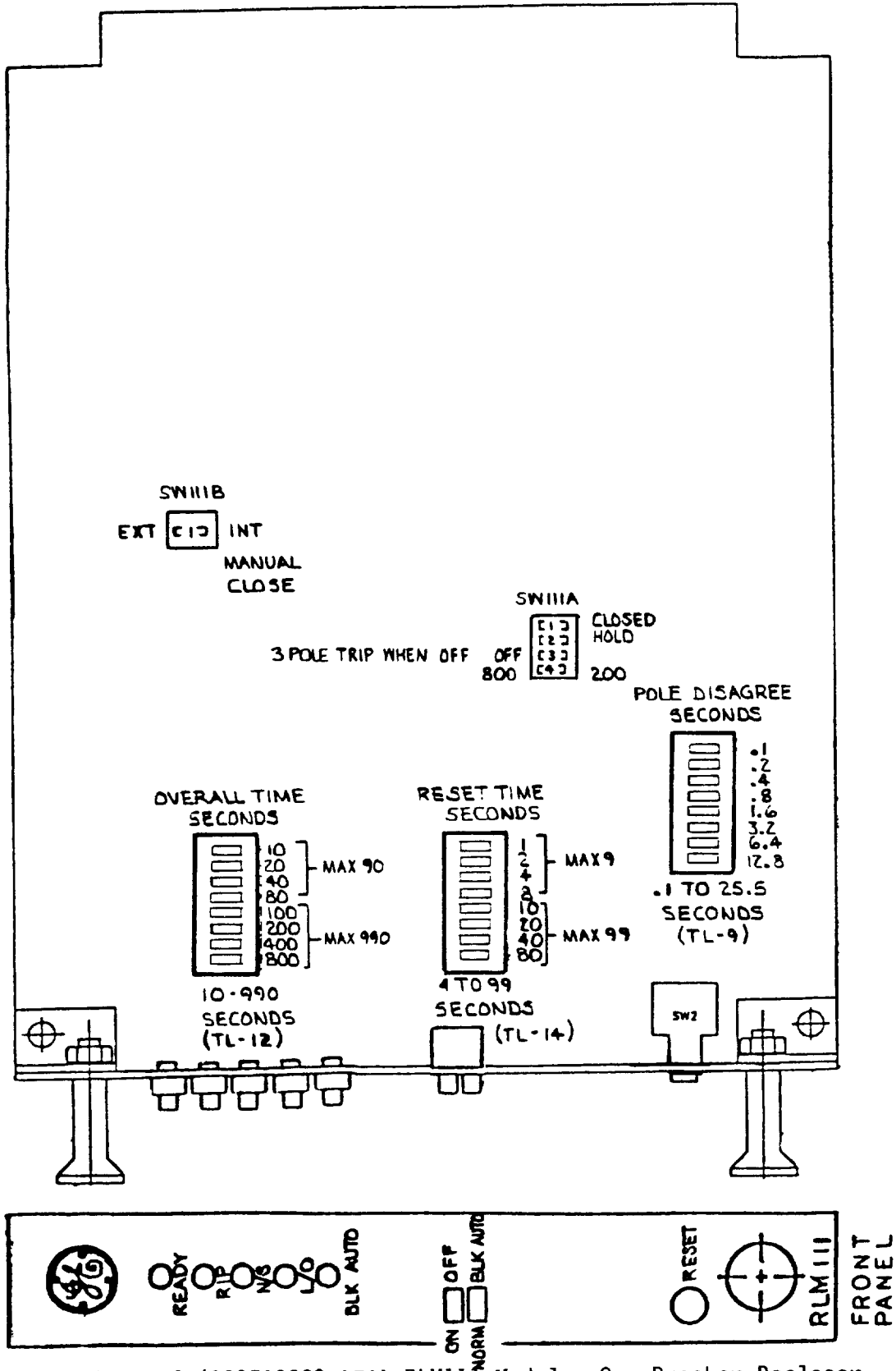


Figure 6 (0285A8239 [2]) RLM111 Module, One-Breaker Recloser



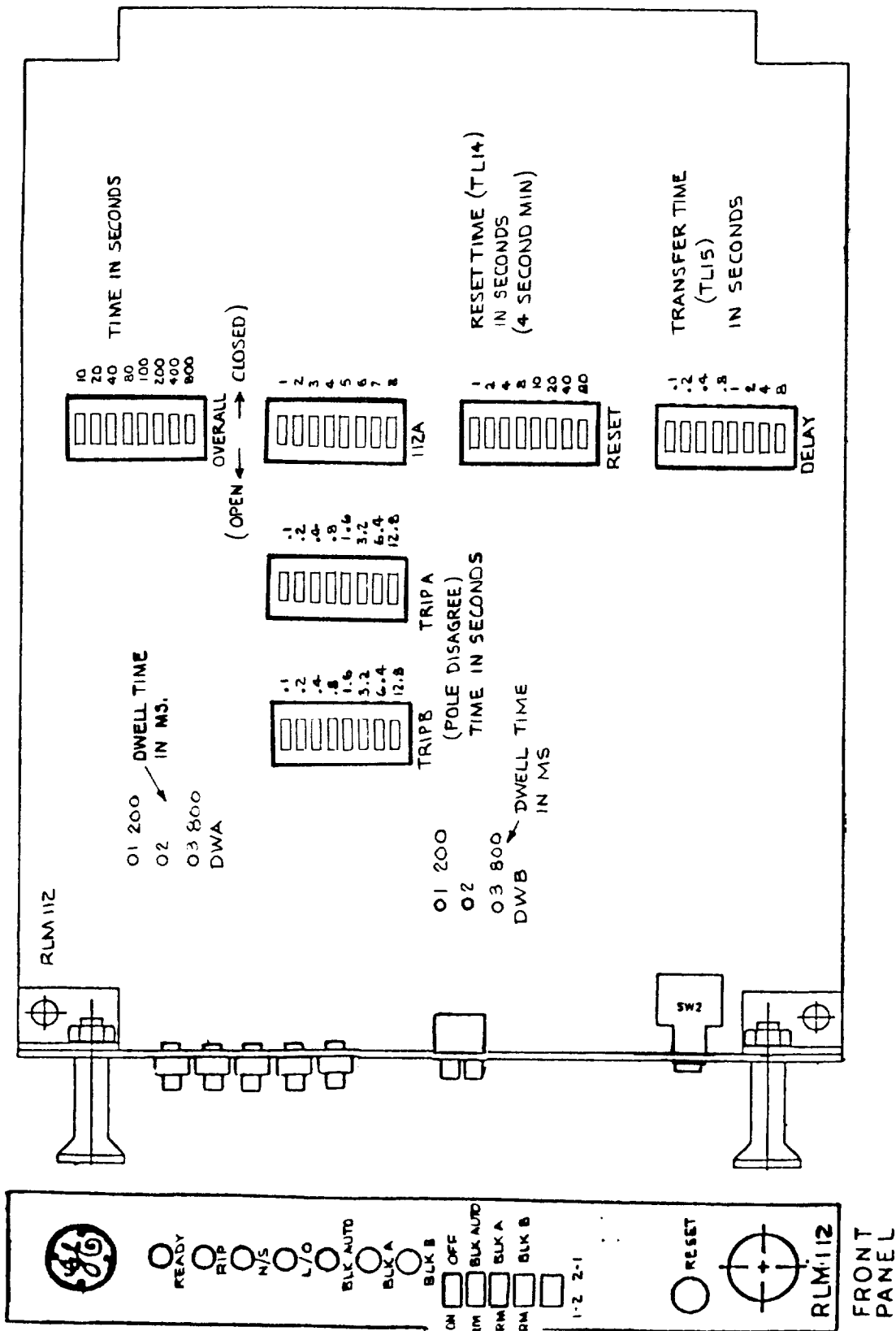


Figure 7 (0285A9184 [1]) RLM112 Module, Two-Breaker Recloser



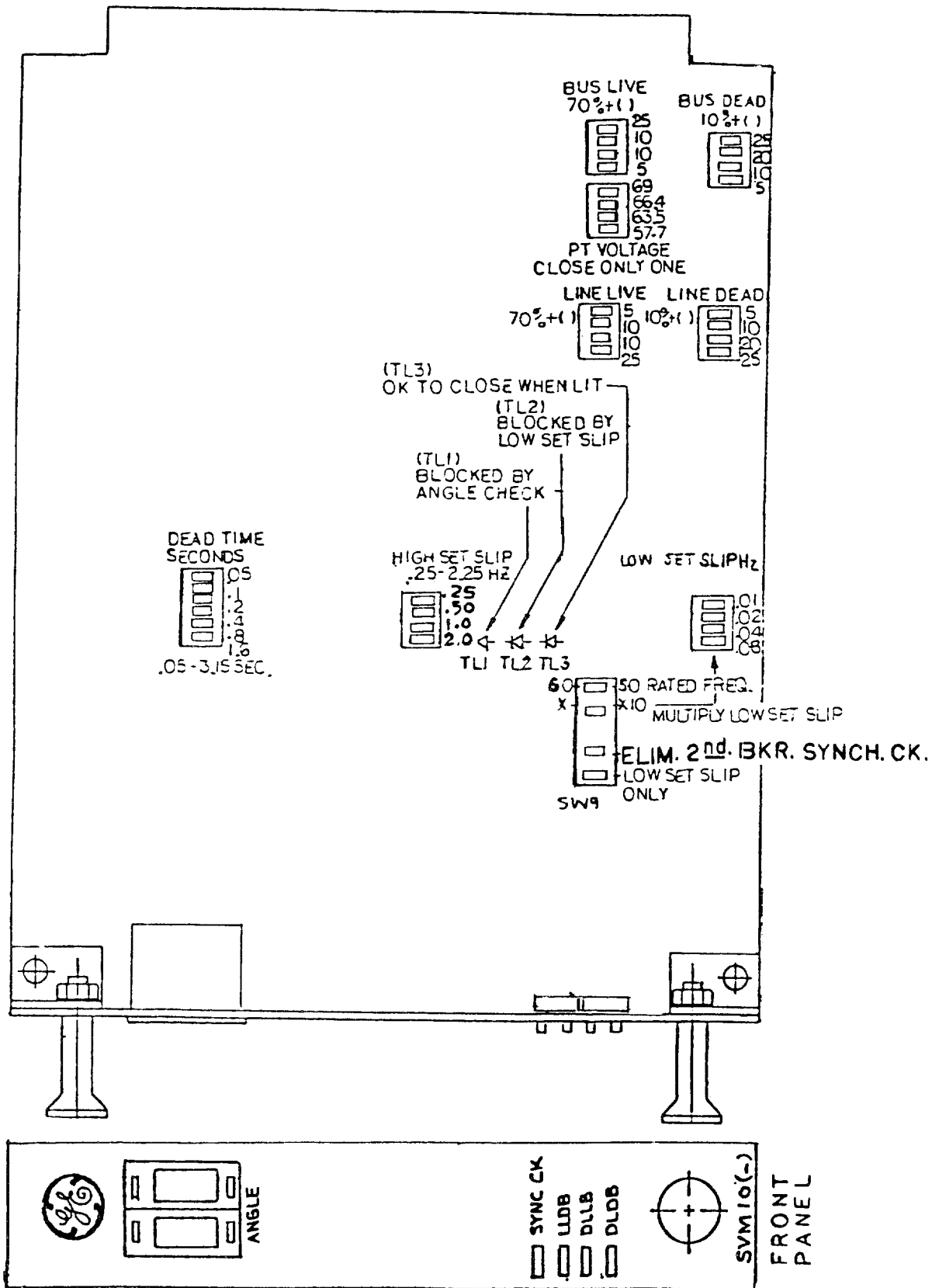


Figure 9 (0285A8238 [3]) SVM 101, 102 Modules

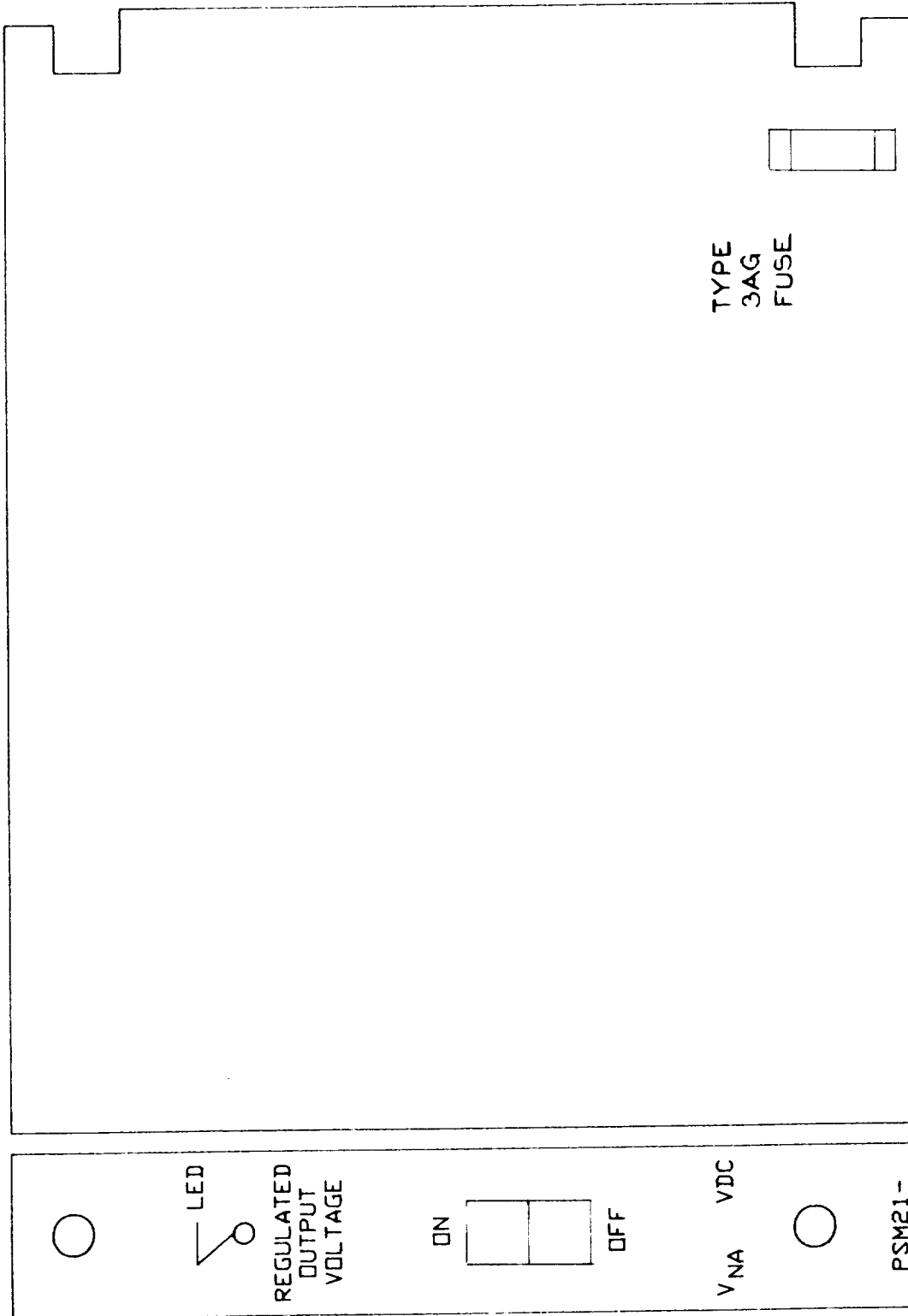


Figure 10 (0286A2547 [1]) PSM 201 Module

GER-86116

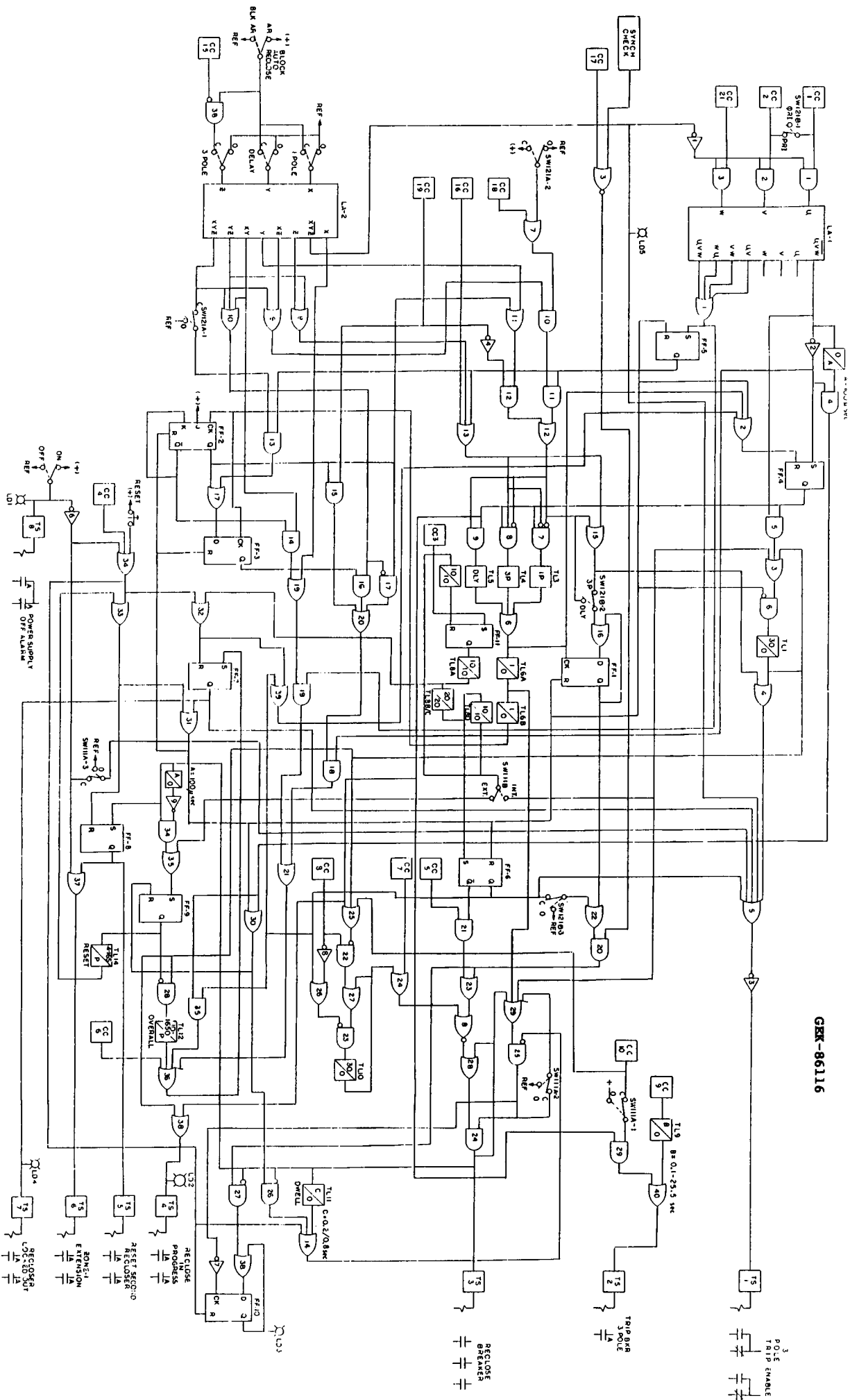


Figure 11 (01AD9066 SH1 [2]) One-Breaker Logic Diagram

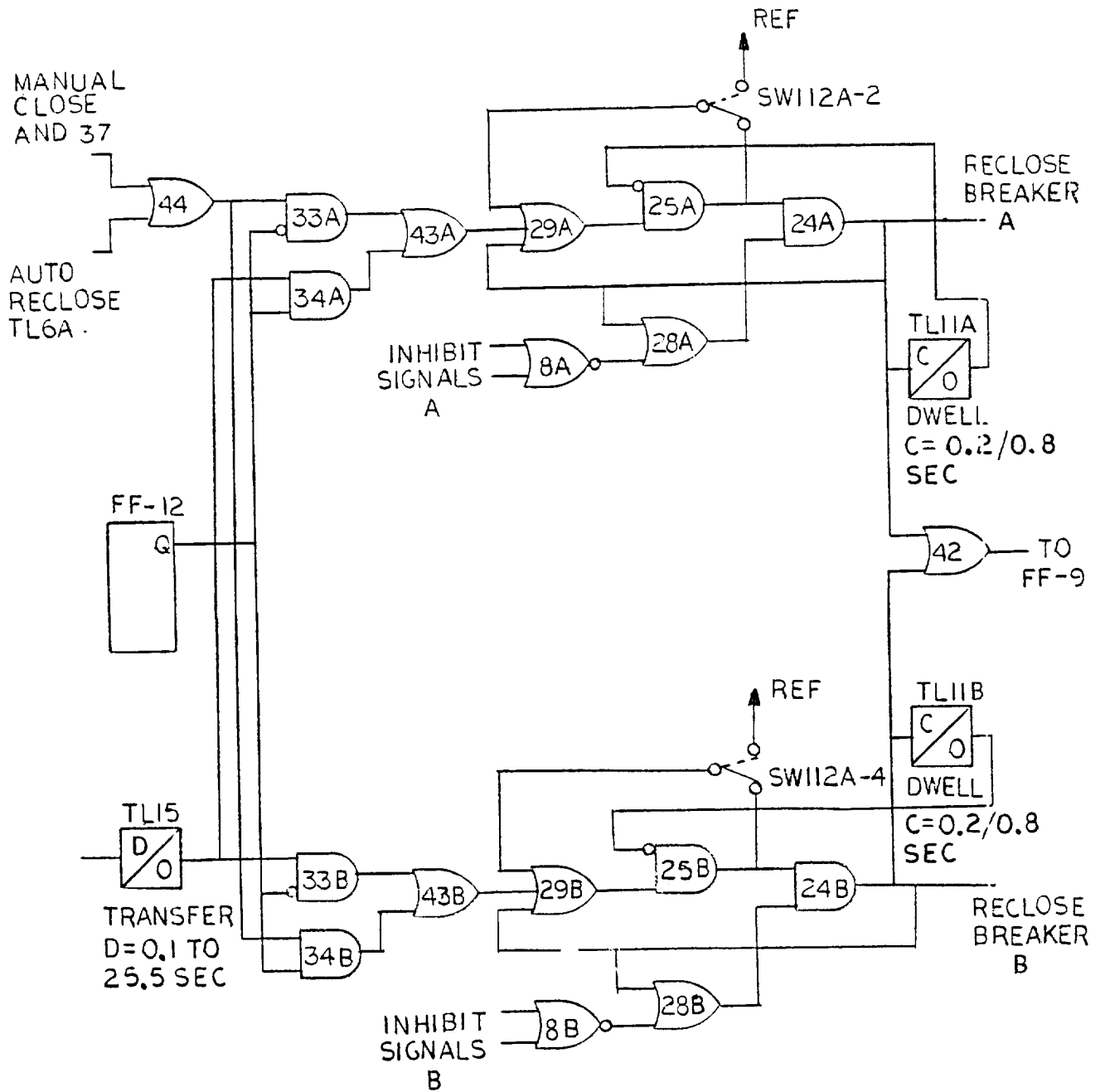


Figure 12 (0285A9176) Two-Breaker Steering Circuit



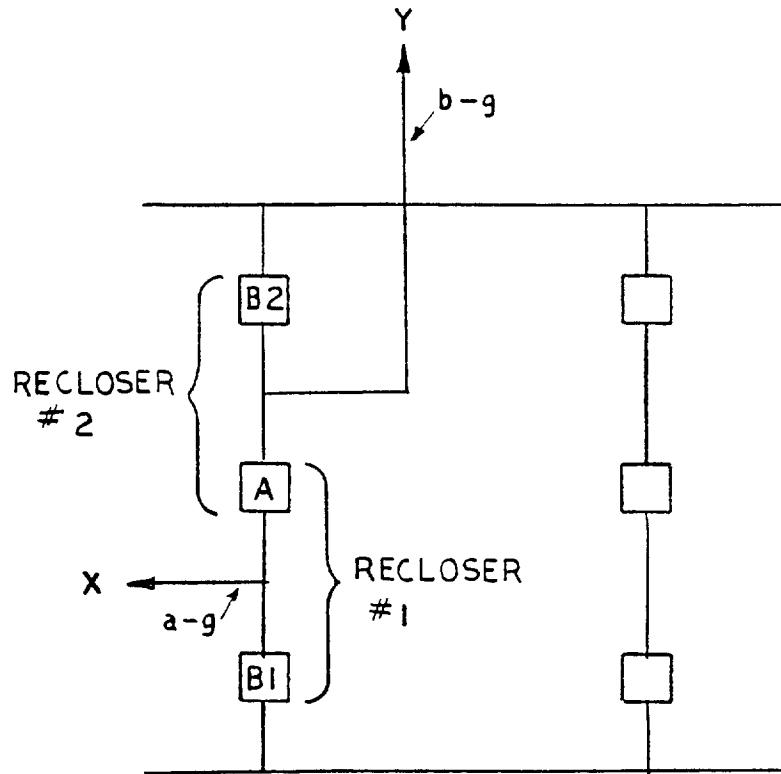
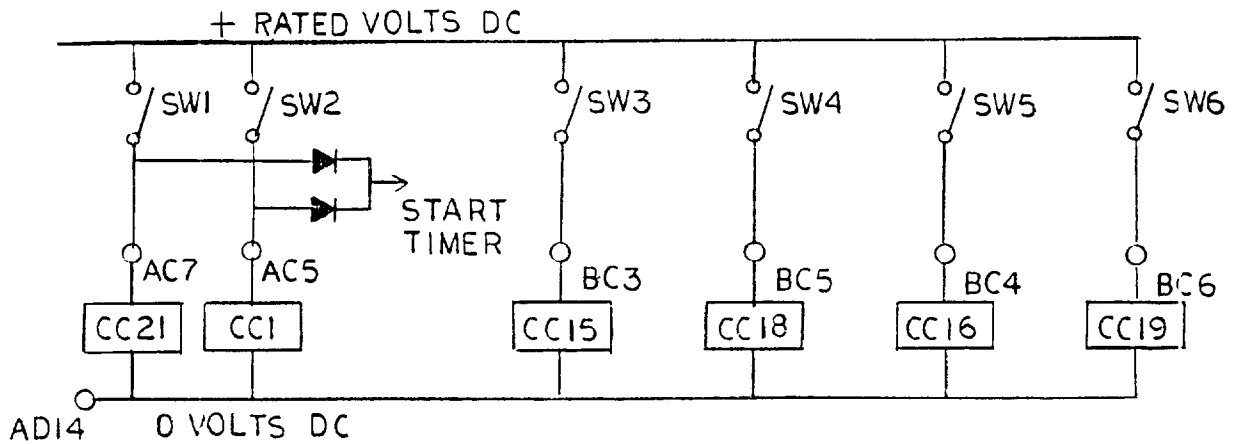


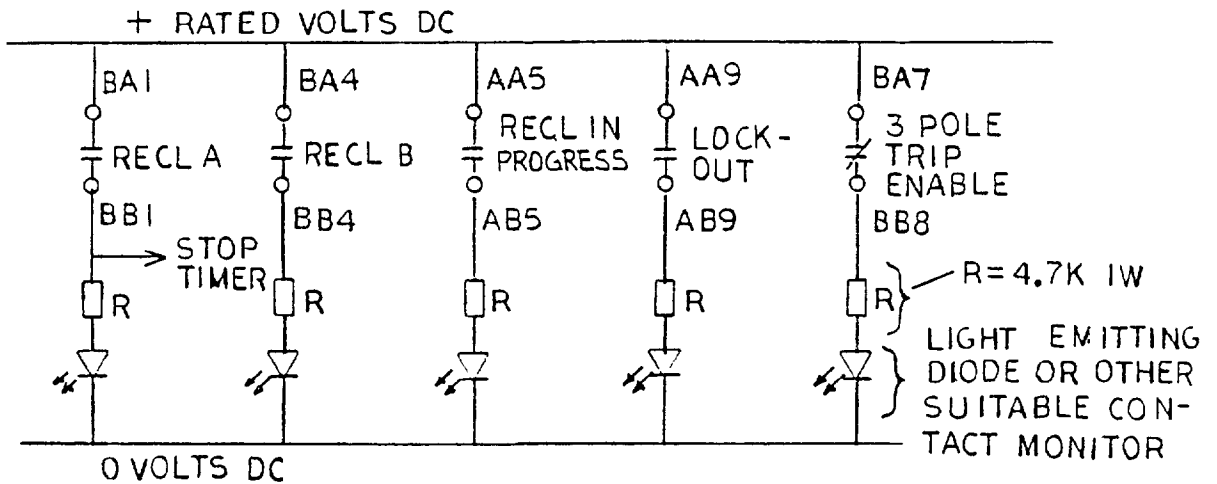
Figure 14 (0285A9178) Breaker and One-Half Arrangement



FIRST MADE FOR TRS1000



(a) INPUT CIRCUIT



(b) OUTPUT CIRCUIT

- CC1 RECLOSE INITIATION- 3 POLE
- CC15 RECLOSE ON SINGLE POLE TRIP ONLY
- CC16 TRIP 3P FOR ALL FAULT TYPES : 3 POLE RECLOSE
- CC18 DELAYED 3P RECLOSE ONLY: BLOCKS HIGH SPEED 3P RECLOSE
- CC19 BLOCKS DELAYED 3P RECLOSE
- CC21 RI 1 POLE

Figure 15 (0285A9177) Test Circuit, TRS1000

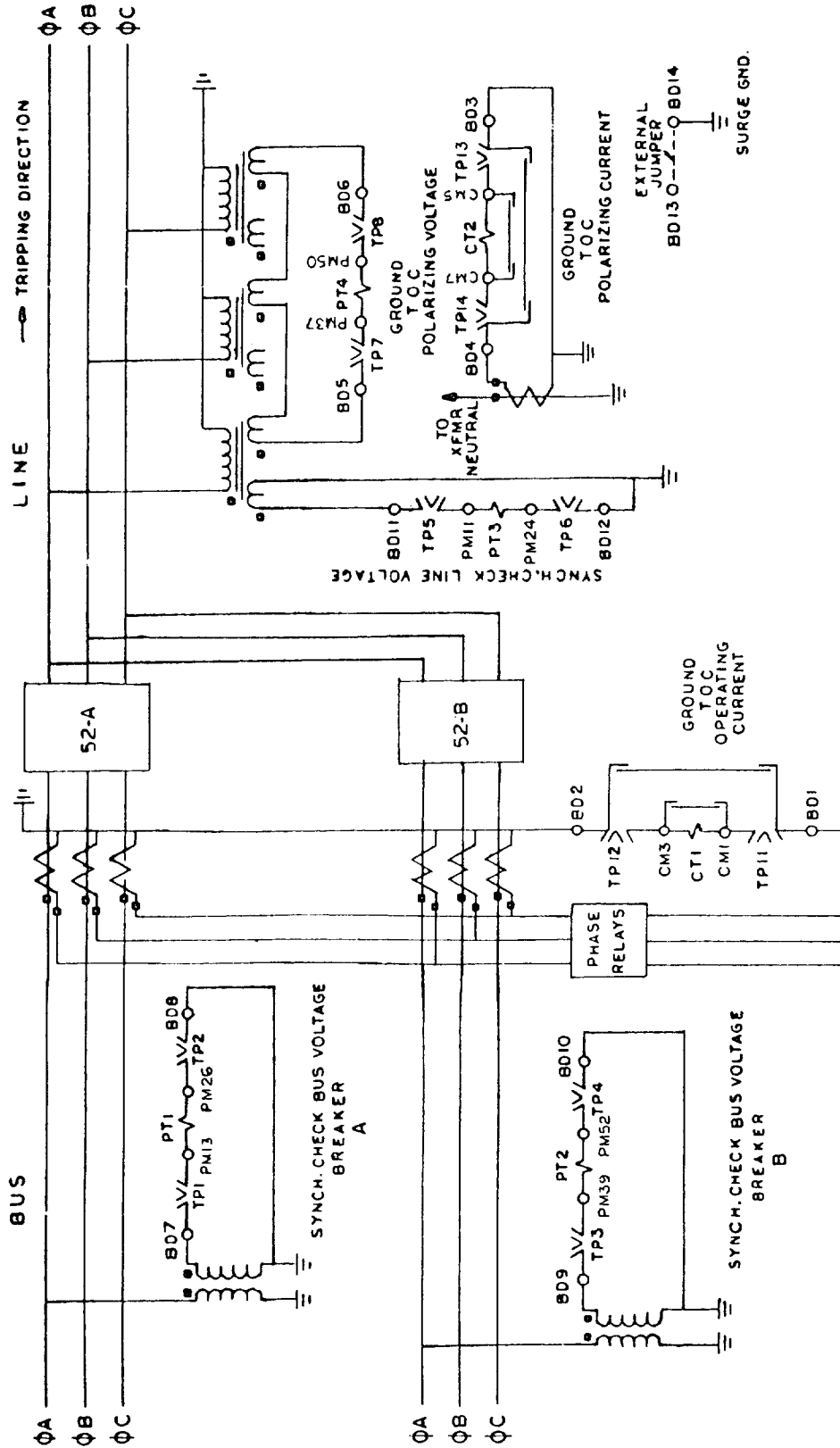
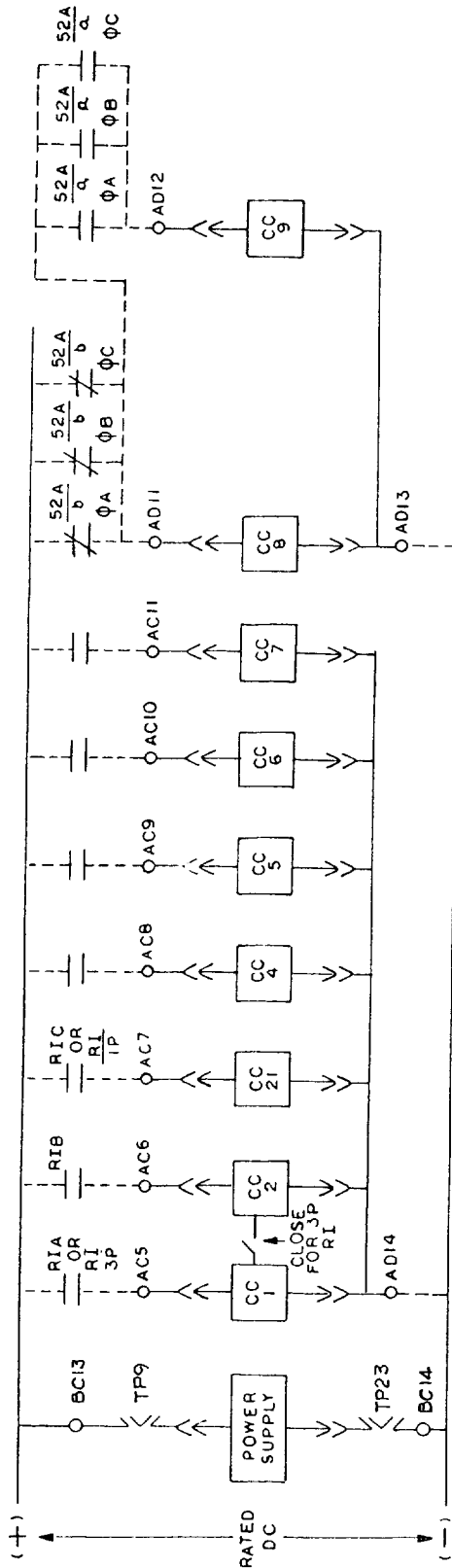


Figure 16A (0138B7777 Sh.1 [3]) Elementary Diagram, TRS1000



- LEGEND:
- CC1 : } RECLOSE INITIATION
  - CC2 : } CC1+CC2 LINKED INTERNALLY FOR 3 POLE RECLOSE
  - CC4 : REMOTE RESET FROM LOCKOUT
  - CC5 : INHIBIT RECLOSING INPUT
  - CC6 : LOCKOUT RECLOSING INPUT
  - CC7 : BREAKER-A-OUT OF SERVICE
  - CC8 : BREAKER-A-ANY POLE OPEN
  - CC9 : BREAKER-A-POLE DISAGREEMENT
  - CC21: RI I POLE OR RI ΦC

Figure 16B (0138B7777 Sh.2 [2]) Elementary Diagram, TRS1000

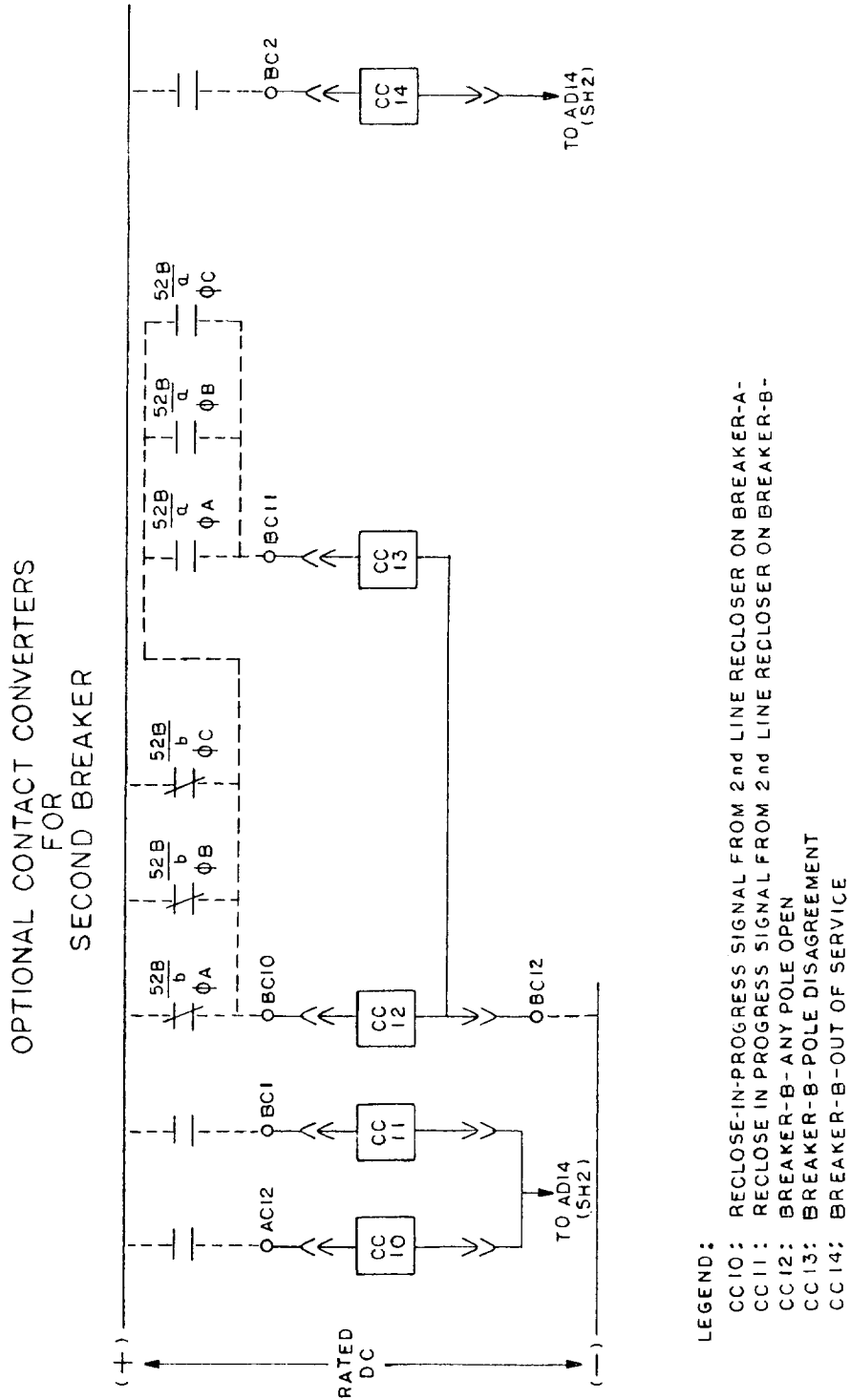


Figure 16C (0138B7777 Sh.3 [1]) Elementary Diagram, TRS1000

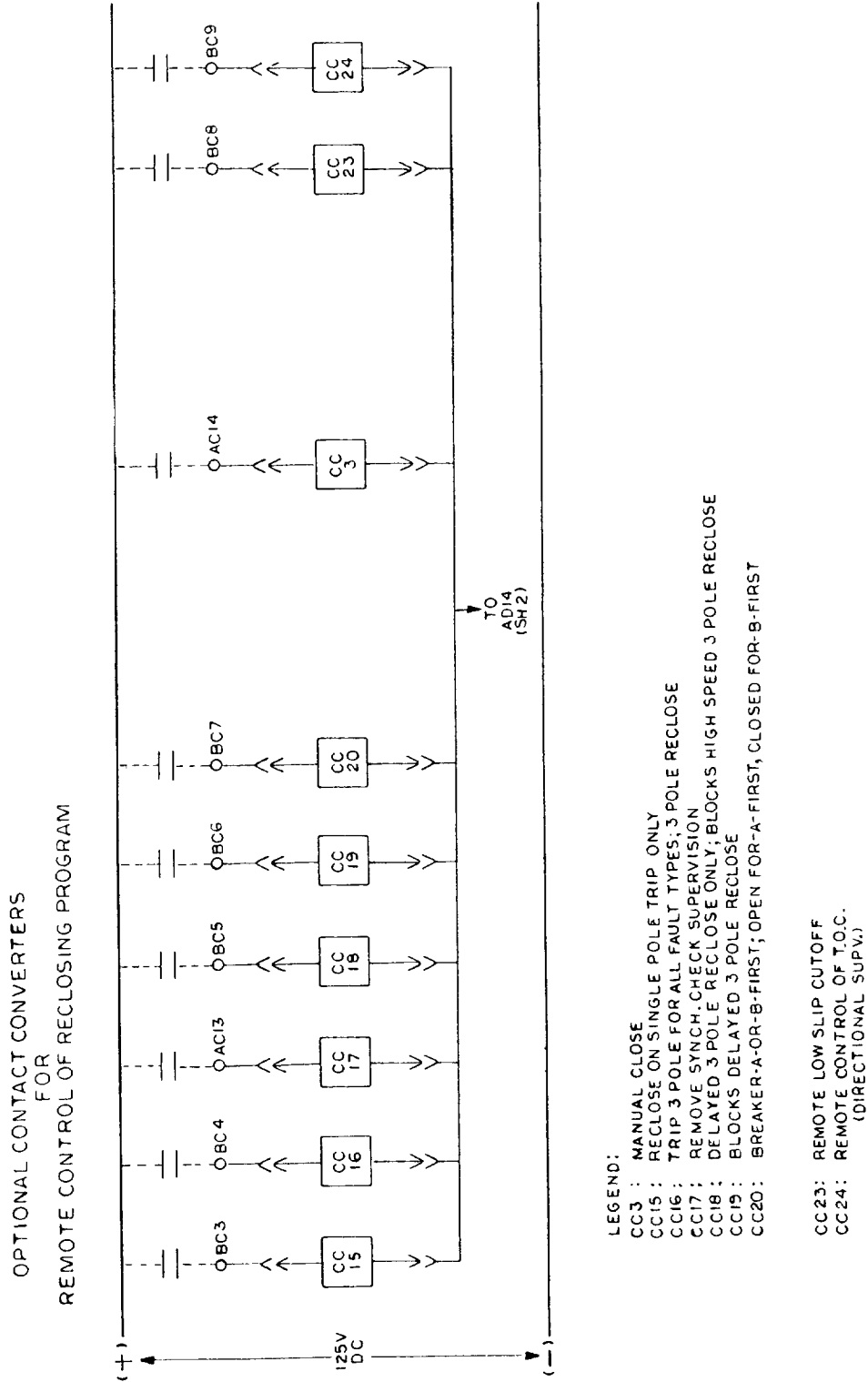
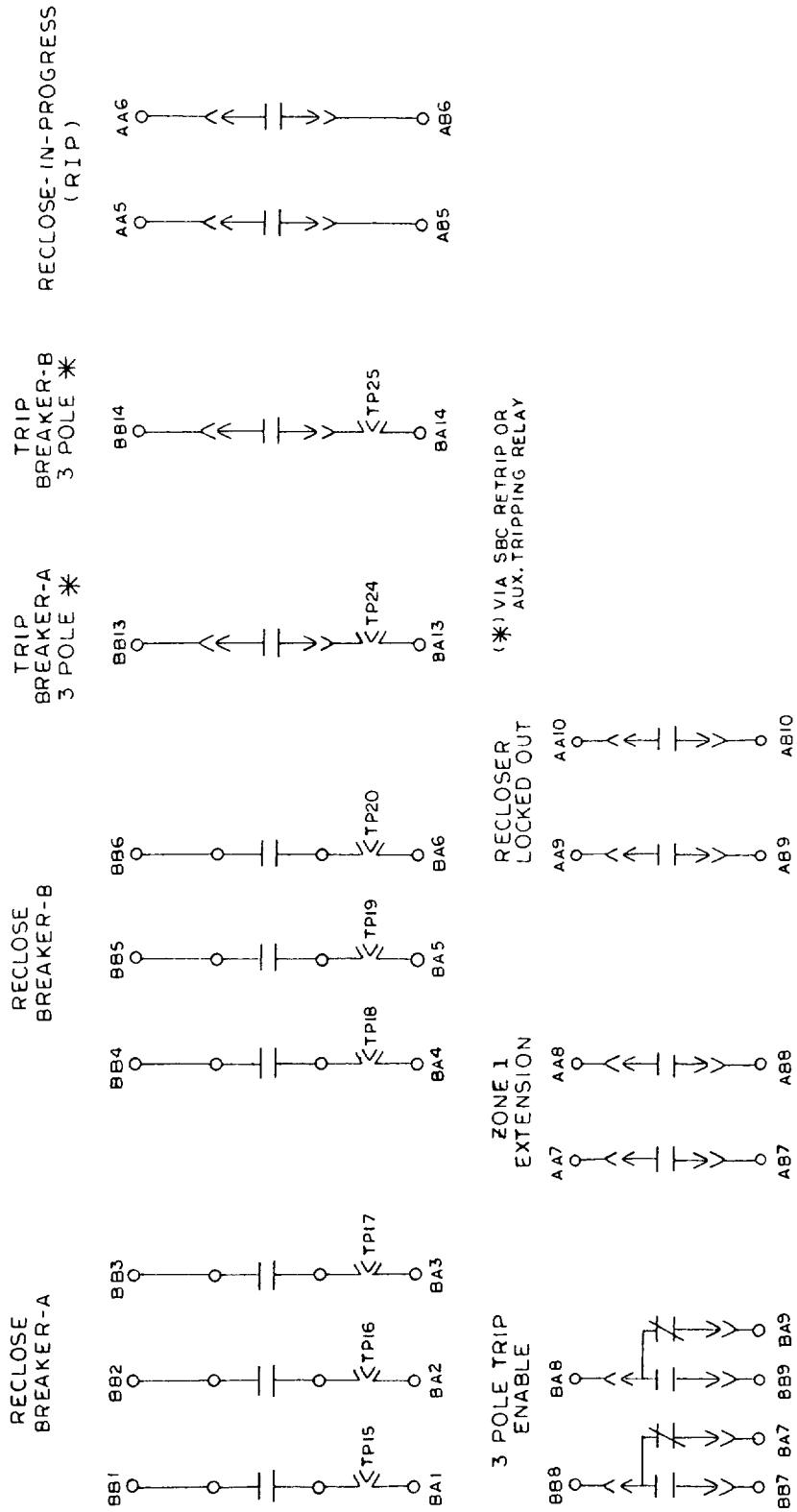


Figure 16D (0138B7777 Sh.4 [1]) Elementary Diagram, TRS1000



(\* ) VIA SBC RETRIP OR AUX. TRIPPING RELAY

Figure 16E (0138B7777 Sh.5 [1]) Elementary Diagram, TRS1000

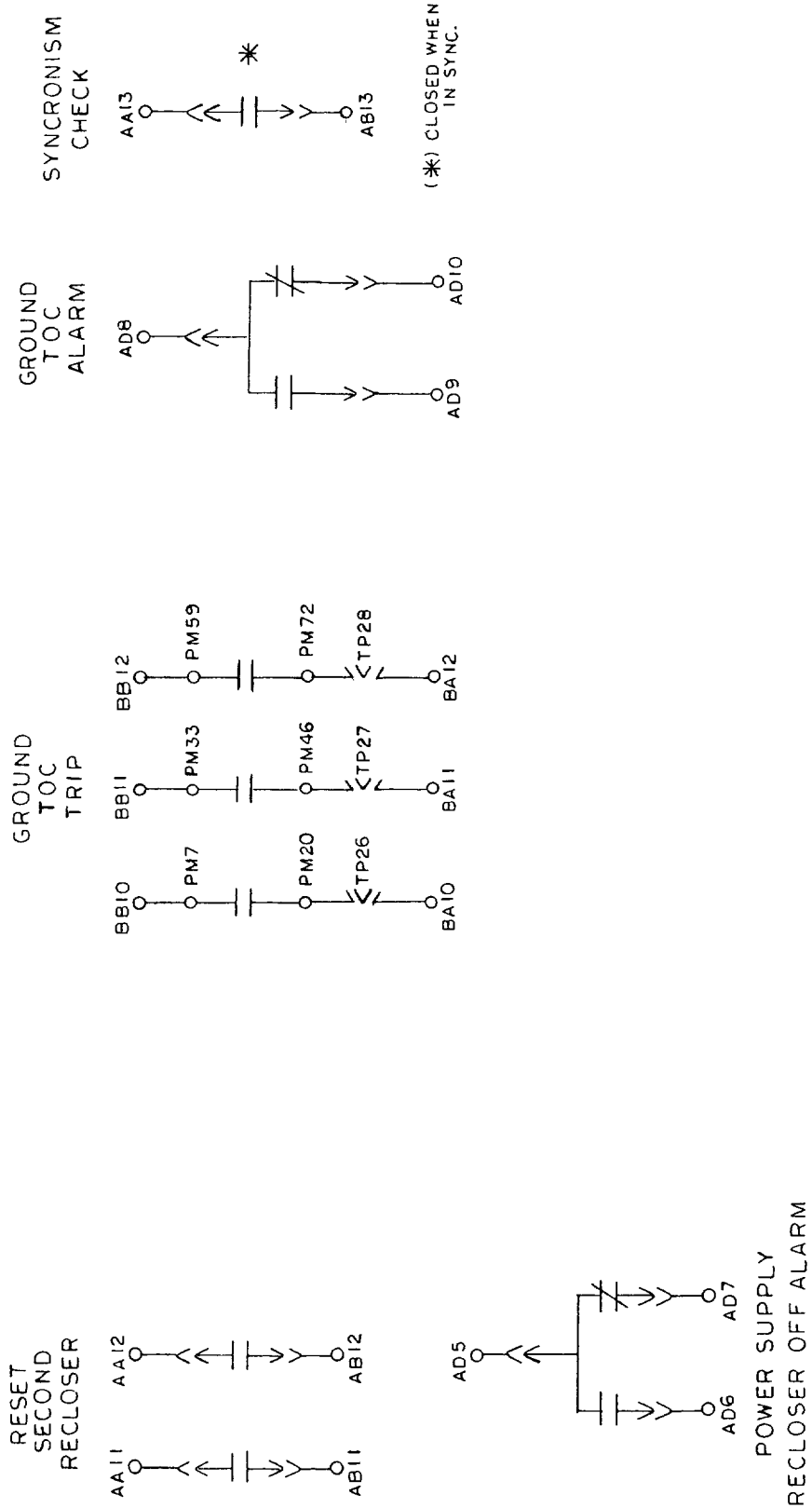
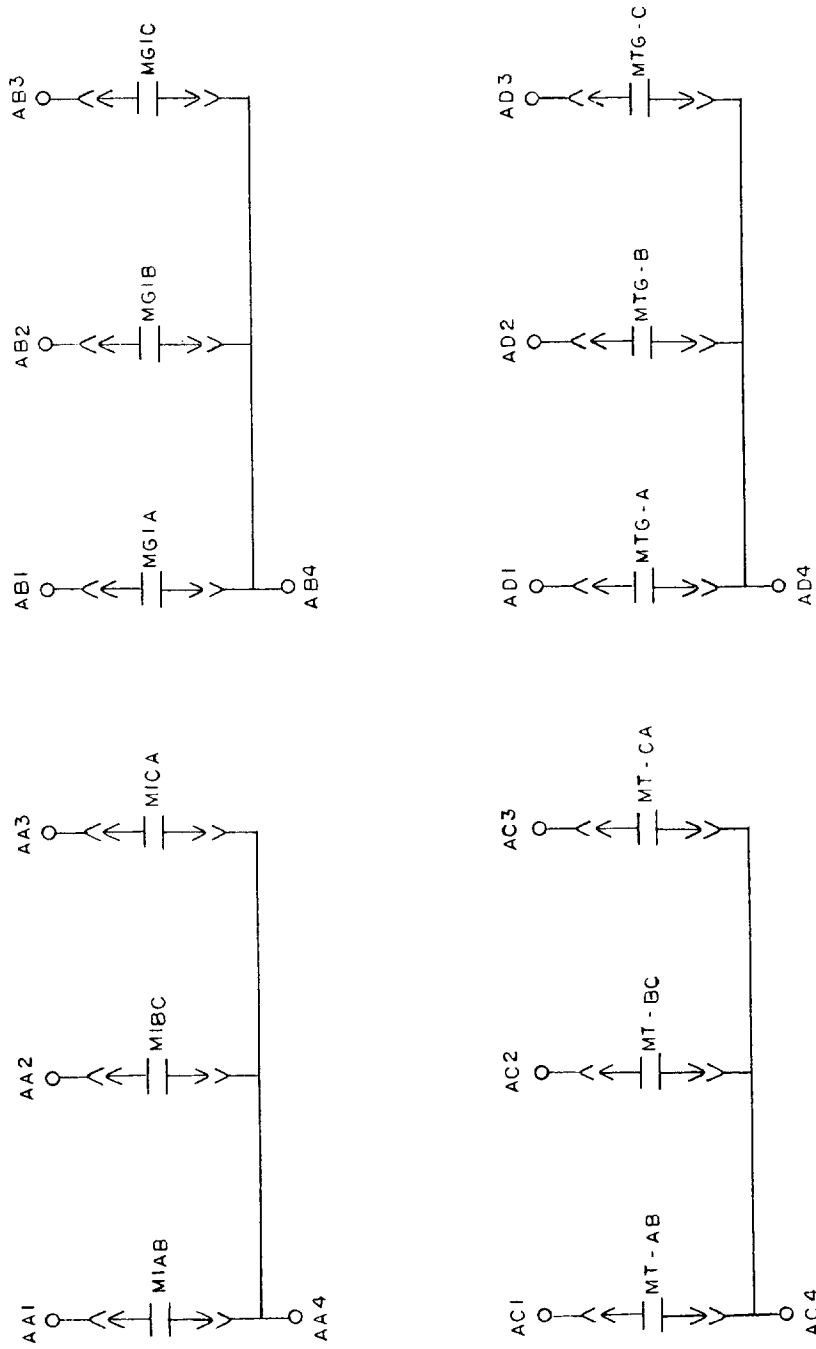


Figure 16F (0138B7777 Sh.6 [1]) Elementary Diagram, TRS1000



OPTIONAL DLA CONTACTS

Figure 16G (0138B7777 Sh.7 [1]) Elementary Diagram, TRS1000



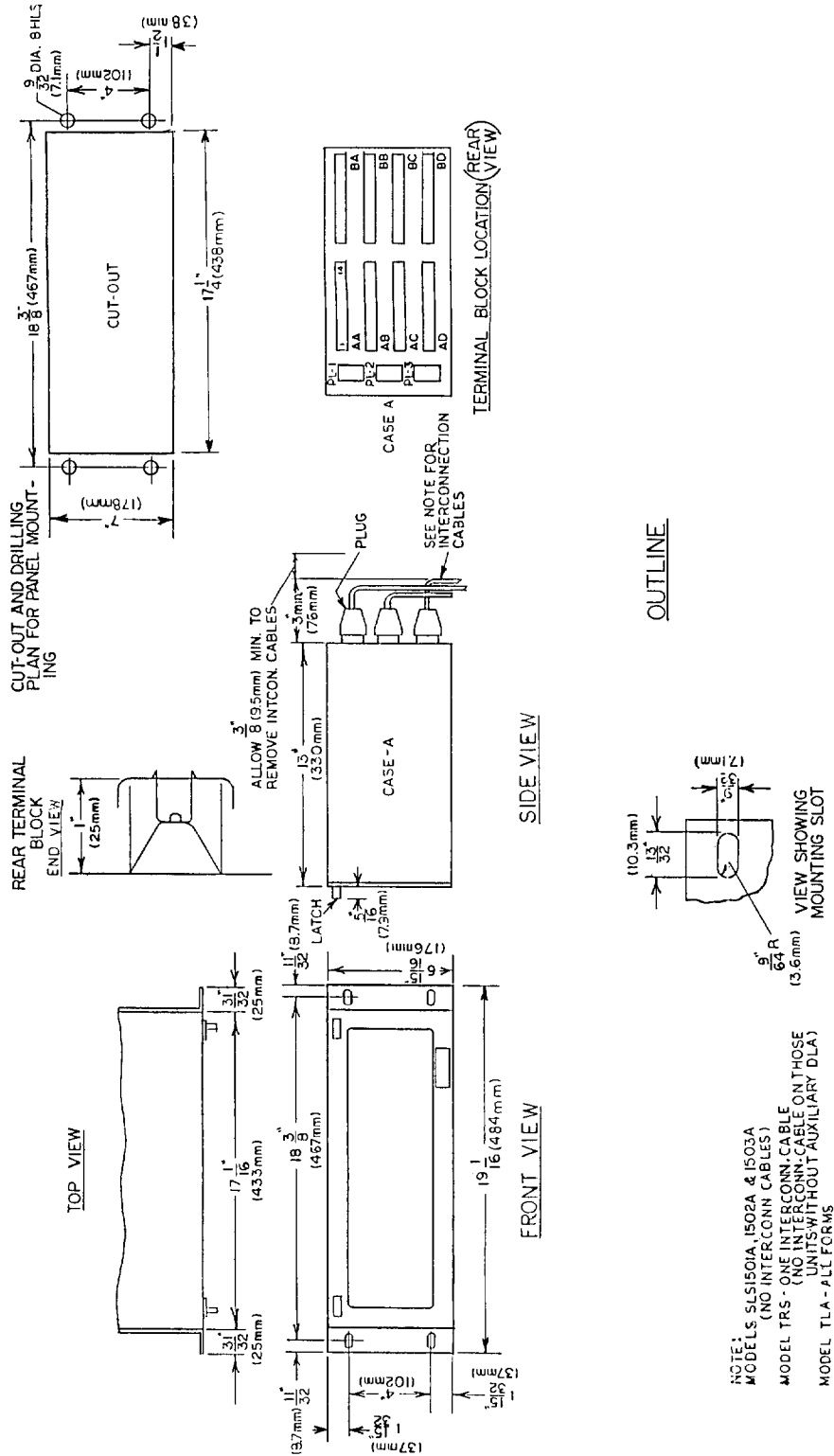


Figure 17 (013887600 SH1) Outline Diagram for TRS1000

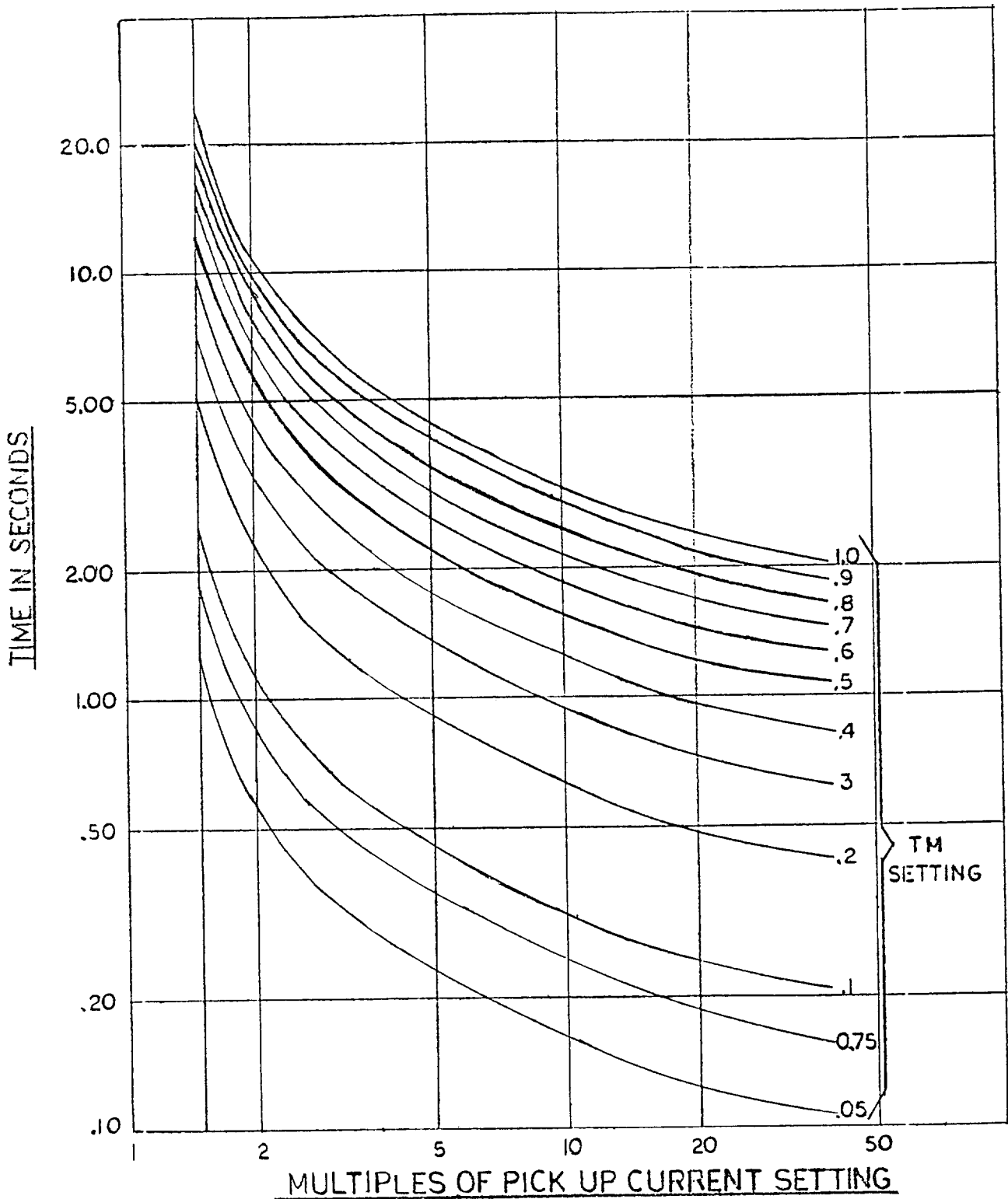
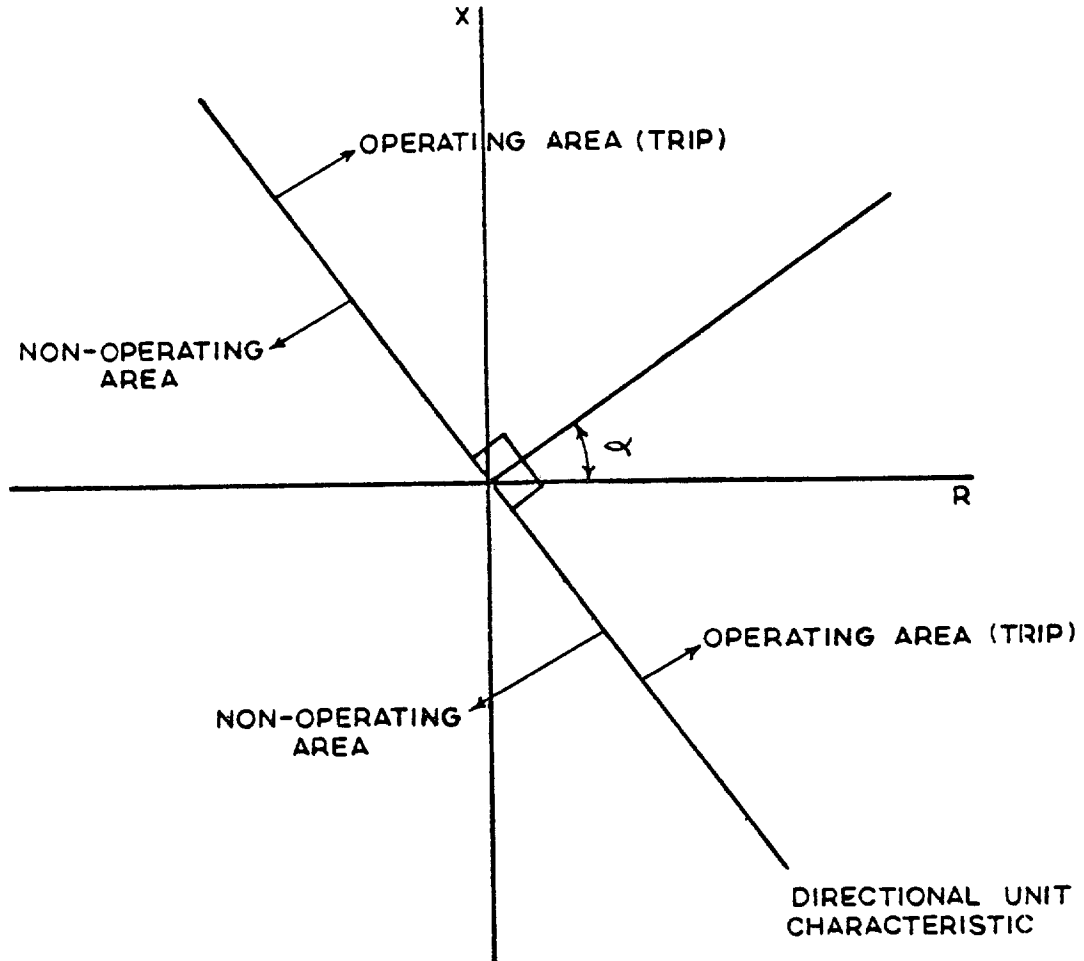
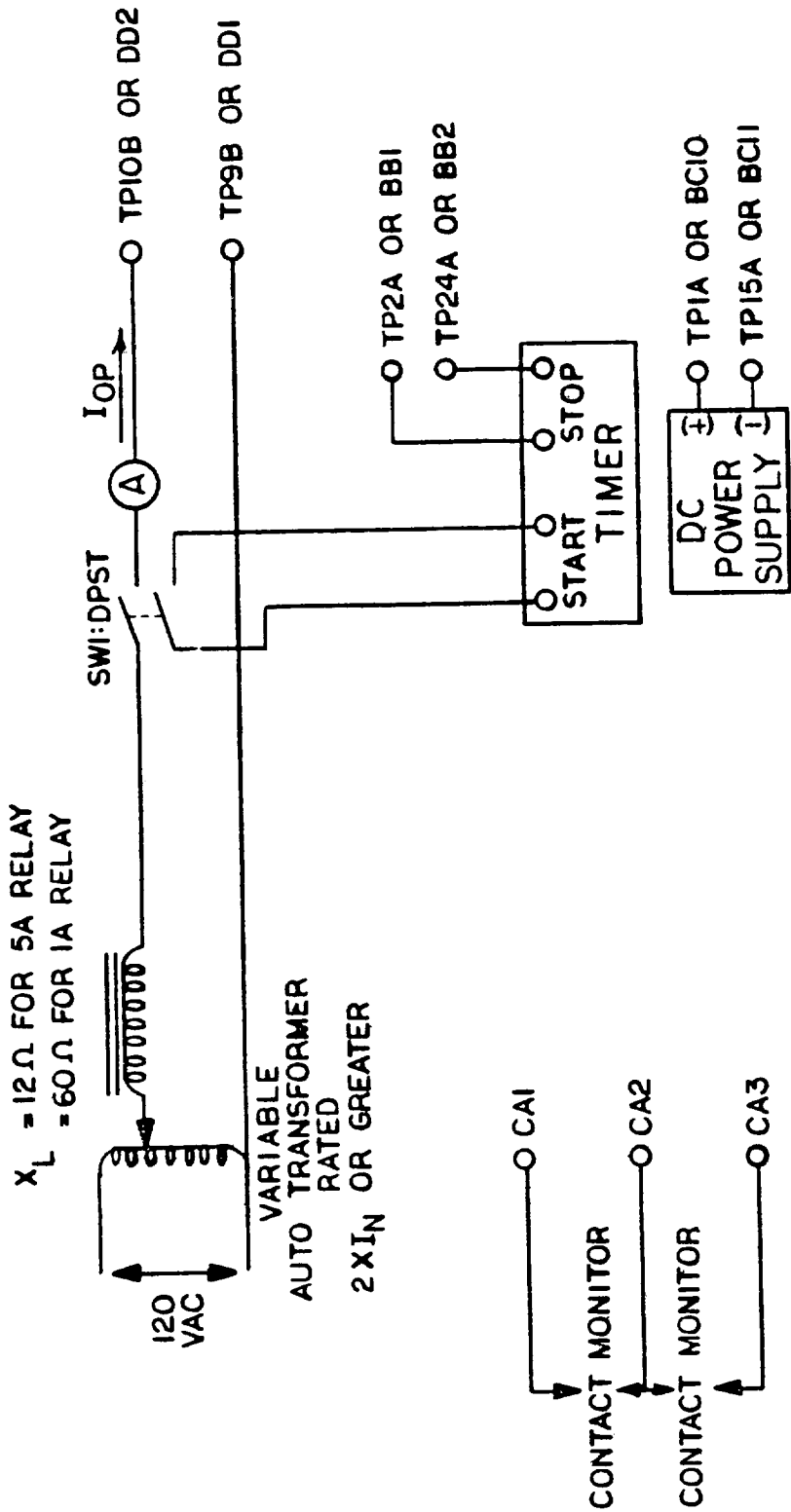


Figure 18 (0285A7557) Time Curves, Ground Overcurrent Function



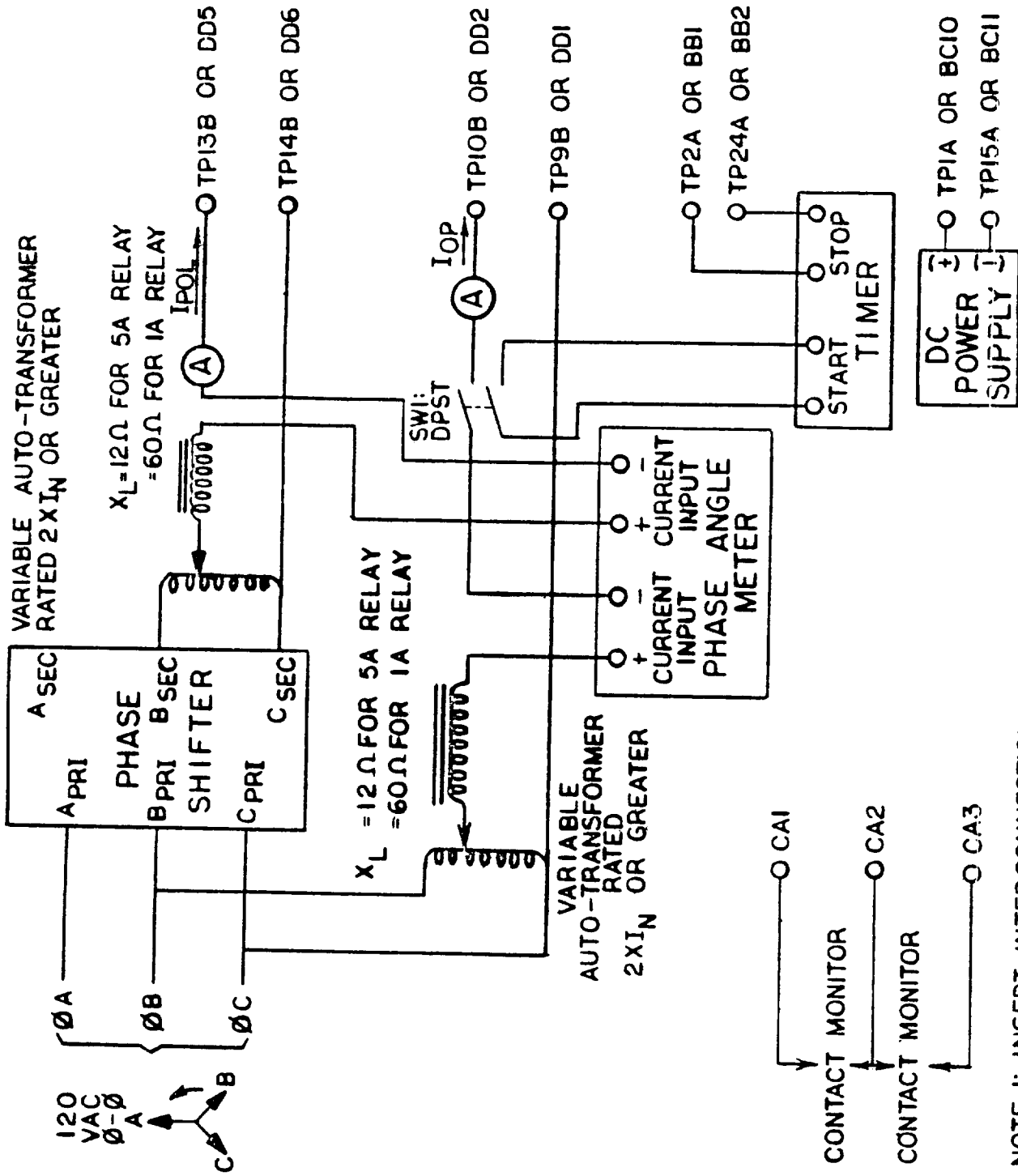
$\alpha$  = CHARACTERISTIC ANGLE SETTABLE AT 15°, 30°, 45°, 60°.

Figure 19 (0285A7553) R-X Characteristic for Ground Directional Unit with Voltage Polarizing



NOTE 1: INSERT INTERCONNECTION CABLE(S)  
 NOTE 2: OUTPUT ALARM CONTACTS MAY BE ISOLATED DURING POST INSTALLATION TESTS  
 ONLY BY REMOVING CONNECTIONS TO CA1,2,3

Figure 20 (0285A7578) Test Circuit for Time Overcurrent Unit



NOTE 1: INSERT INTERCONNECTION CABLE(S)  
 NOTE 2: OUTPUT ALARM CONTACTS MAY BE ISOLATED DURING POST-INSTALLATION TESTS ONLY BY REMOVING CONNECTIONS TO CA1,2,3

Figure 21 (0285A7568) Directional Ground Time Overcurrent Test Circuit Using Current Polarizing

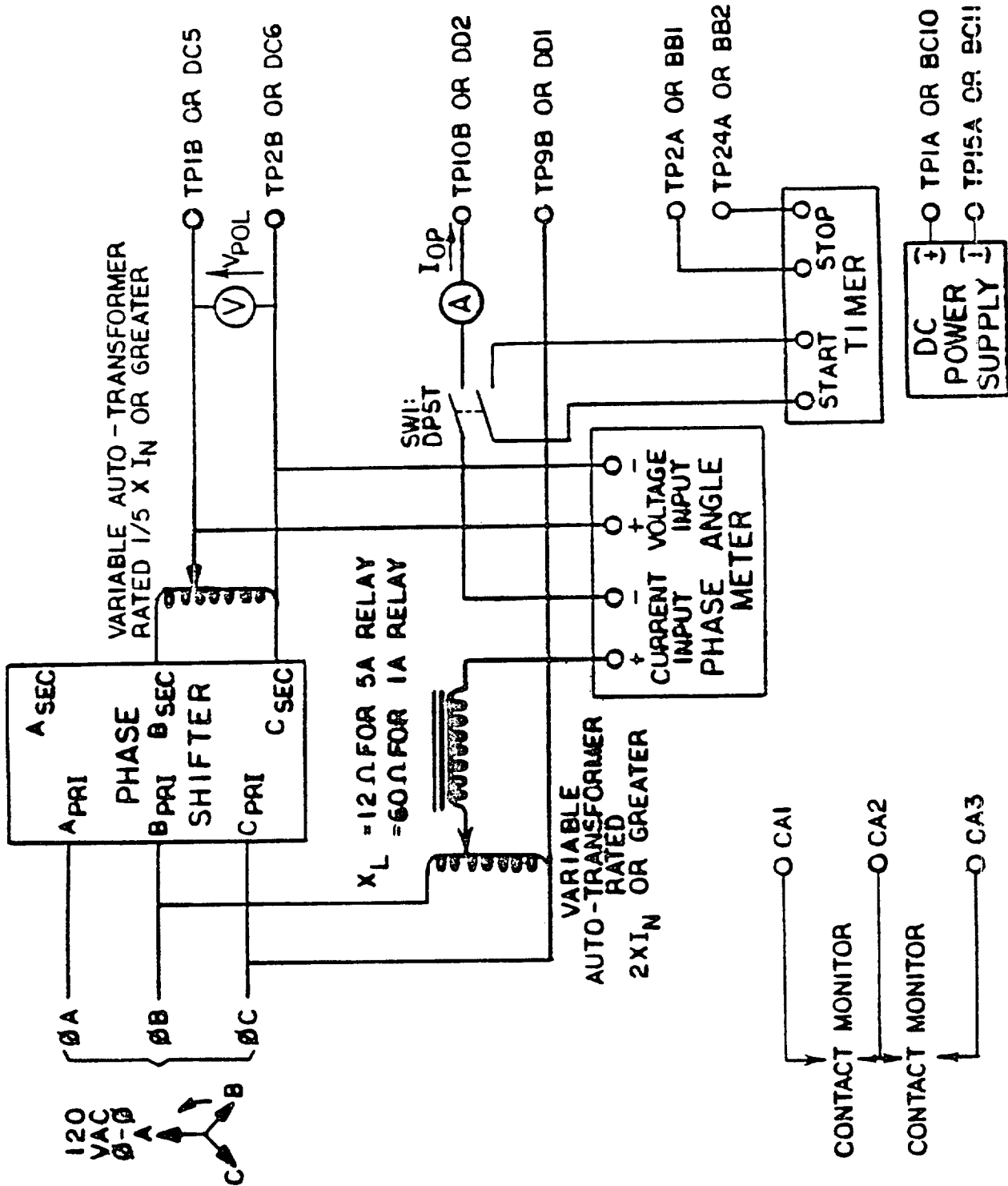


Figure 22 (0285A7572) Directional Ground Time Overcurrent Test Circuit Using Voltage Polarizing

NOTE 1: INSERT INTERCONNECTION CABLE(S)  
 NOTE 2: OUTPUT ALARM CONTACTS MAY BE ISOLATED DURING POST-INSTALLATION TESTS  
 ONLY BY REMOVING CONNECTIONS TO CA1,2,3

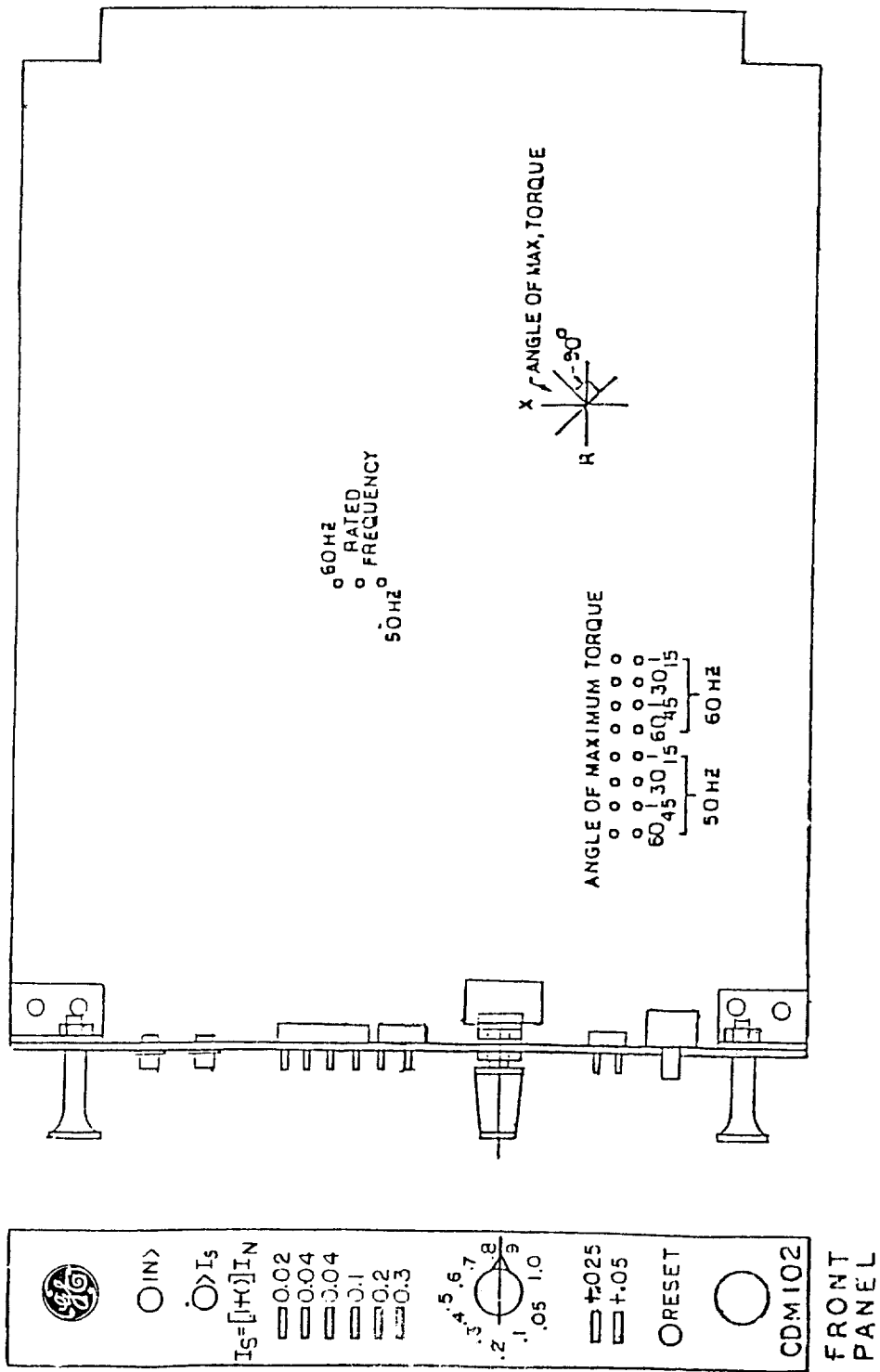


Figure 23 (0285A8237 [2]) Front Panel & On-Board Adjustments, CDM102 Module



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