GEK-86057

INSTRUCTIONS

SRS1000

MODULAR RECLOSER

GENERAL ELECTRIC

TABLE OF CONTENTS

	Page
INTRODUCTION	3
RECLOSER LOGIC	4
DESCRIPTION OF HARDWARE	16
APPLICATION AND SETTINGS	25
SETTINGS PROCEDURES	27
TESTING	30
SPECIFICATIONS	40
RECEIVING, HANDLING AND STORAGE	42
INSTALLATION	42
LIST OF ILLUSTRATIONS	43

SRS1000

TRANSMISSION LINE PROTECTIVE RELAY

INTRODUCTION

The SRS1000 recloser is intended for use with transmission line protective relays. It is designed for application in single pole/three pole tripping schemes, and it will attempt one or two reclosures (selectable) prior to locking out.

"b" Switch Monitoring

The SRS1000 requires connection to the breaker "b" switches through which it monitors the status of each pole (open or closed). Special logic is included to trip the breaker and lock out the recloser in the event that a reclosing attempt is unsuccessful (fail-to-close).

"Hold" Feature

Operation of the recloser may be externally blocked. A special "hold" feature is included so that the reclosing attempts which are initially blocked by an external signal may be sustained. Reclosing will then take place if and when the blocking signal is removed, before the reset time elapses. The "hold" feature may be taken out of service if desired.

Manual Closing

The SRS1000 offers the capability of manually closing the breaker through the recloser circuitry. When using this feature, a manual close signal need only be input to the recloser. The output contacts of the recloser are used to activate the individual pole breaker closing circuits.

Modular Design

The recloser is packaged in a modular design consisting of pluggable printed circuit board modules which are housed in a steel case having a vertical dimension of four rack units. The magnetic elements (telephone relays, transformers) are contained in a separate, larger module. A test receptacle is provided for access to the reclose initiate inputs, "b" switch inputs and closing contacts (outputs).

RECLOSER LOGIC

The SRS recloser operates according to the logic diagram shown in Fig. 1. It should be emphasized that this is a functional representation. The logic function designations have been assigned to facilitate the following written explanation of the operation of the recloser. They may not be directly related to the actual circuitry.

The recloser may be set for any one of the following modes (refer to **SETTINGS PROCEDURES** section):

1. One reclosing attempt, single-pole or three-pole, depending on trip
2. One reclosing attempt, single-pole only
3. One reclosing attempt, three-pole only
4. Two reclosing attempts, single-pole or three-pole on first, three-pole on second
5. Two reclosing attempts, three pole only.

This discussion will begin by describing mode 4 because it encompasses the full capability of the recloser circuitry. The remaining modes will be described subsequently.

A reclose initiation contact (RI) from the associated line relaying scheme(s) is used to automatically start the reclosing cycle when the line protection produces a trip output. When the SRS is used in conjunction with single pole tripping and reclosing schemes, a separate reclose initiation signal is required for each phase (RI-ØA, RI-ØB and RI-ØC). These signals are supplied to contact converters CC1, CC2 and CC3, respectively. In order to initiate a reclosing cycle, an input must also be supplied to contact converter CC10 (reclose enable) whose output supervises the reclose initiation via AND1. Typically this is used to permit reclosing only for faults in the first zone of protection.

First Reclosing Attempt after Single Phase Faults

Consider the case of a phase-A to ground fault resulting in a single-pole trip. The recloser receives an RI-ØA signal which provides, through OR1, the lower input to AND1. The upper input to AND1 is a supervisory "reclose enable" signal, and is present whenever reclosing is desired.

The output of AND1 is then applied to AND13 through timer TL1. This timer assures that the signal will persist for 20 milliseconds after the removal of the RI input which will disappear almost immediately when the breaker pole is opened to clear the fault. The lower input of AND13 is provided by the breaker "b" switch on pole A (52A/b). When pole A is opened as a result of the distance relay trip signal, the "b" switch closes and its associated contact converter (CC4) sends a signal to AND10 via OR3. Consequently, the "b" switch input to AND13 may occur at any point within 20 milliseconds following the reset of the RI-Ø input(s) and AND13 will still transmit the reclose initiate signal.

The tripping of the breaker indicated by RI-ØA and the actual opening of the pole indicated by 52A/b initiates the reclosing cycle. The output from AND13 will

be brief, disappearing when TL1 times out. The RI latch is therefore provided to sustain the signal. It operates as follows. Referring to the latch equivalent in Fig. 1, the momentary signal is applied to the SET input thereby providing, through the OR gate, the upper input to the AND gate. The NOT input to the AND gate will be absent as long as there is no resetting signal to the latch. The AND gate therefore gives an output which is fed back to its input via the OR gate. Through the feedback loop, the OR gate sustains the input to the AND gate even after the momentary SET input disappears. The AND gate therefore continues to produce an output until reset by a signal at its NOT input. In this manner, the momentary SET signal is latched in. All of the latches depicted in Fig. 1 operate in this manner.

The output from the RI latch causes the OPN (operation) LED (light emitting diode) indicator to light and the RECLOSE IN PROGRESS contacts to close via OR23, indicating that the reclosing cycle is under way. In addition, the latch output is simultaneously applied to AND15, AND16, AND17 and AND18.

Initially, the sequencer is in standby, providing an output at port 1 and no output at ports 2 and 3. AND15 and AND16 are therefore in a position to pass on the RI signal whereas AND17 and AND18 are disabled. The third input to AND15 and AND16 is the three-pole reclose initiate signal. This signal will be absent for the case under consideration (first reclosing attempt after a single-pole trip; recloser set for mode 4). The absence of this signal disables AND16 and enables AND15 through its NOT input. Of the four gates, AND15 is the only one to transmit the RI signal.

The output from AND15 initiates reclosing timer TL3a which is set for the single-pole reclosing time (refer to **SETTINGS PROCEDURES** section). When TL3a times out, its output is fed back through OR11 to reset the RI latch (through OR10) and advance the sequencer to port 2 following the three millisecond delay of TL2. In addition, it initiates the reset timer (TL4) through OR12, sets the zone-1 extension latch (to be discussed subsequently) and sets the delayed synchronism check latch following the TL2 delay (also to be discussed subsequently).

The output from OR11 constitutes the automatic reclosing signal. This is sent through OR13 to the first hold link L3. Assume for the time being that this link is set in the OUT position such that the hold latch is bypassed. The reclosing signal is then applied directly to AND20. It may be blocked at this point by an input to the NOT of AND20, which will be present during an out-of-synchronism condition (AND19 output through OR16) or in the event of an external block reclose signal (CC14 through OR16). These points will be discussed in further detail subsequently.

An output from AND20 indicates that the reclosing signal has been validated. This validated signal is simultaneously applied to AND21, AND22, AND23 and AND24. It also initiates timer TL5 which sends a signal to the line protection. This will be discussed subsequently.

The lower inputs to AND21, AND22 and AND23 are connected to the pole A, pole B and pole C "b" switches through CC4, CC5 and CC6, respectively. For the case of a single-pole trip clearing an A-G fault, only the pole A "b" switch will be closed. The lower input to AND24 is the three-pole reclosing signal from OR9. This will be absent during the first reclosing attempt for the conditions noted. Therefore, for the case under consideration, of the four gates receiving the validated reclosing signal, only AND21 will transmit the signal to its dwell timer, TL6a.

The TL6a dwell timer is initiated by AND21 through OR17. The timer immediately energizes its associated output relay, operating the CLOSE POLE A contacts which are connected to the breaker closing circuit. The contacts will remain closed for the duration of the dwell timer setting. This completes the first reclosing attempt.

The output of TL6a is sent to the OPN LED indicator and the RECLOSE IN PROGRESS relay through OR21 and OR23 so that they remain energized until the dwell timer times out. In addition, it is applied to the fail to close latch (a) through OR21 where it affects the lockout circuit and direct trip circuit which will be discussed subsequently.

Second Reclosing Attempt After Single Phase Fault

The first reclose initiate signal from TL1 set the supervise three-pole trip latch but the latch does not reset upon reclosing and, would normally not be reset until the reset timer gives an output (through OR28, OR7 and OR8). A continuous input is therefore applied to AND14, but the initial TL1 output blocked AND14 through its NOT input. The clearing of the fault (tripping pole A) removes the RI-ØA signal, thereby stopping the TL1 output (20 milliseconds thereafter) and enabling AND14. An output from AND14 energizes the 3-POLE TRIP ENABLE relay via OR27. A contact of the 3 POLE TRIP ENABLE relay is used to convert the line protection to a three pole tripping scheme. Thus, if the fault is still present after the breaker has been reclosed or if a second fault occurs before the reset time elapses, the line relay will again produce a trip output. This time, however, it will be a three-pole trip as a result of the 3-POLE TRIP ENABLE signal, regardless of the fault type.

In conjunction with its three pole trip output, the line relays simultaneously send RI-ØA, RI-ØB, and RI-ØC signals to the recloser. As before, the reclose initiation signal is sent through OR1, AND1, TL1, AND13 and the RI latch from which it is applied to AND15, AND16, AND17 and AND18. This time, however, only AND17 is enabled by the sequencer which has been advanced to port 2. Note that the delayed reclose link, L1, must be in the DLY position for AND17 to be enabled. This is a requirement to obtain reclosing mode 4 (refer to **SETTINGS PROCEDURES** section). Also note that the output from AND13 resets the timing cycle of the reset timer (TL4) and the output from the RI latch once again lights the OPN indicator.

The output from AND17 initiates reclosing timer TL3c which is set for the delayed reclosing time (refer to **SETTINGS PROCEDURES** section). When TL3c times out, its output is fed back through OR11 to reset the RI latch (through OR10) and advance the sequencer to port 3 (after the TL2 delay). It also re-initiates the reset timer (TL4) through OR12.

As before the automatic reclosing signal from OR11 is sent through OR13, L3 and AND20, from which it is applied to AND21, AND22, AND23 and AND24. The lower inputs to AND21, AND22 and AND23 will all be present because the "b" switches will all be closed following the three-pole trip. Furthermore, the lower input to AND24 will be present from the 2 or 3 RI latch through OR9, indicating a three-pole reclose initiation. Consequently, all four gates produce an output, hitting OR17, OR18, and OR19 with double inputs. Dwell timers TL6a, TL6b and TL6c are initiated simultaneously. They immediately energize their respective output relays, resulting in a three-pole closing of the breaker. This completes the second reclosing attempt.

If the fault persists beyond the second reclosing attempt, the line relays will again trip the breaker three-pole and send three RI-Ø signals to the recloser. The reclose initiate signal will again make its way to AND15, AND16, AND17 and AND18, but only AND18 will be enabled because the sequencer has been advanced to port 3. The output from AND18 will directly send the recloser into lockout, as will be discussed subseqeuntly.

First Reclosing Attempt after Phase-to-Phase or Three-Phase Fault

Consider the case of a phase-to-phase or three-phase fault. The line relays will trip the breaker three-pole and simultaneously send RI-ØA, RI-ØB, and RI-ØC signals to the recloser. As in the case of a single-pole trip, the reclose initiation signal is sent through OR1, AND1, TL1, AND13 and the RI latch from which it is applied to AND15, AND16, AND17 and AND18. The sequencer is in standby (port 1) thereby enabling only AND15 and AND16. Unlike the case of a single-pole trip, the three-pole reclose initiation signal is present in this situation, enabling AND16 and disabling AND15 at its NOT input.

The three-pole reclose initiation signal is produced simultaneously by AND2, AND3 and AND4, each of which require a pair of RI-Ø signals to give an output. It is sent through OR2 into the 2 or 3 RI latch which operates the same as the other RI latch except that it is reset via OR8 rather than OR10. From this latch, the three pole reclose initiation signal is sent through OR9 from which it is applied to AND15 and AND16.

The resulting output from AND16 initiates reclosing timer TL3b which is set for the three-pole reclosing time (refer to **SETTINGS PROCEDURES** section). When TL3b times out, it produces the automatic reclosing signal. The remaining steps in the reclosing sequence have already been described.

Second Reclosing Attempt After Phase-to-Phase or Three-Phase Fault

The second reclosing attempt after a phase-to-phase or three-phase fault will be identical to the second reclosing attempt after a single-phase fault since the second trip will be three-pole in both cases. Again, the recloser will go into lockout following the third trip.

One Reclose Attempt Only

The second automatic reclosing attempt may be bypassed by placing the delayed reclose link (L1) in the NO DLY position. In this case, after the first reclosing attempt, only AND18 will be enabled by the sequencer and the reclose initiate signal associated with the second trip will send the recloser into lockout.

Single Pole Reclosing Only

If it is desired to attempt automatic reclosing only after single-pole trips, the 1Ø single-pole only switch (SW1) should be closed. This provides the lower input to AND10 such that, in the event of two or three simultaneous RI-Ø signals from the line relays, the upper input from OR2 will cause AND10 to produce an output which, through OR8 and OR10, will block the reclose initiation signal by disabling the RI latch.

Note that in this mode there can be only one automatic reclosing attempt since the second trip would be three-pole and the recloser has been set to block three-pole reclose initiations (SW1 closed).

Three Pole Tripping and Reclosing Only

If it is desired to trip three-pole for any fault type, the 3Ø three-pole only switch (SW2) should be closed. This provides, through OR9, a continuous three-pole reclose initiation signal, enabling AND16 and disabling AND15. Furthermore, SW2 provides a direct input to OR27 such that the recloser sends a continuous 3-POLE TRIP ENABLE signal to the Consequently, the line relays will trip all three breaker poles for any type of fault and three-pole reclosing will follow automatically.

Note that, unlike single-pole only reclosing, the recloser will make a second reclosing attempt following a second trip when SW2 is closed, provided L1 is in the DLY position.

Manual Closing

Manual closings of the breaker may be made directly using external contacts or, if desired, through the recloser circuitry using the output contacts of the recloser. For direct manual closings, the manual close link (L4) should be placed in the NORM position; to use the recloser circuitry, it should be placed in the AUTO position. In either case, automatic reclosing attempts will be blocked in the event of a manual breaker closing.

The MANUAL CLOSE signal from CC12 is sent through AND9. It may be blocked at this point if the gate is disabled at its NOT input. This will occur when SW3 is in the OFF position (open) in which case NOT1 produces an output.

An output from AND9 sets the manual close latch and initiates the reset timer through OR12. Actually, the reset timer is initiated upon the opening of the manual close switch (falling edge of pulse through OR12). The manual close latch blocks automatic reclosing by disabling the RI latch through OR8 and OR10 and thereby stops the reclose initiate signal. The blocking is sustained until the manual close latch is reset via OR28 when the reset timer (TL4) gives an output.

With L4 in the AUTO position, the manual close signal is routed into the main reclosing circuit (OR13) through a pulse circuit. The pulse circuit is included so that the manual close signal resembles the automatic reclosing pulse from OR11. Once the manual close pulse has been transmitted through OR13, the sequence of events is the same as that described for automatic reclosing attempts.

Note that when L4 is in the AUTO position, the manual close signal is also routed into the synchronism check circuit (OR15). This provides synchronism check supervision of manual close attempts, as will be discussed subsequently.

Synchronism Check Supervision

Synchronism check is available as an option with the SRS recloser. When the voltages on either side of the open breaker are out of synchronism by more than the

set limit, the synchronism check circuit (indicated by a box in Fig. 1) gives an output which is applied to AND19. This circuit also performs a voltage magnitude difference check and slip rate checks, if desired.

The other input to AND19 represents those reclosing attempts which are to be supervised by the synchronism check circuit. These include 1) manual close attempts made through the recloser; 2) first and second automatic three-pole reclosing attempts; and 3) second automatic reclosing attempts only. Note that these are all three-pole reclosing conditions. There is no need to make synchronism checks with only one pole tripped.

The manual close signal comes into AND19 through CC12, AND9, L4 (AUTO position) and OR15. When it is desired to conduct a synchronism check on the first and second automatic three pole reclosing attempts, the synchronism check link (L2) should be placed in the ALL3P position (refer to SETTING PROCEDURES section) in which case the automatic three pole reclosing signal is sent into AND19 from the 2 or 3 RI latch through OR9, L2 and OR15. When it is desired to conduct a synchronism check on the second automatic reclosing attempt only, L2 should be placed in the DLY position. In this case, the port 2 sequencer output is applied (indirectly) to AND19. Because the sequencer is advanced to port 3 by TL3c and OR11 at the end of the delayed reclosing time, the port 2 output is not a suitable signal on which to conduct a sustained synchronism check. The delayed sync check latch is included for this purpose. It provides a continuous signal to AND19 through L2 (DLY position) and OR15. TL2 prevents the delayed sync check latch from being set prematurely. This latch will not be reset until the reset timer gives an output (via OR28, OR7 and OR8).

An output from AND19 indicates that the synchronism check circuit is giving a blocking output at the moment of the initiation of a three-pole reclosing attempt. This output invalidates the reclosing signal by disabling AND20 through its NOT input (via OR16).

In addition, the AND19 output is applied simultaneously to AND27 and AND28. The second hold link (L5) determined which of these two gates is to be used to set the synchronism check indicator latch. Assume, for the time being, that L5, like L3, is in the OUT position and thereby utilizes AND27. The other input to AND27 is the reclosing signal from OR13. Thus, when the sync. check circuit is giving a blocking output, AND27 produces an output at the time when a reclosing attempt would normally have taken place. This sets the synchronism check indicator latch which immediately lights the N/S LED indicator. It will remain lit until reset via OR6.

External Blocking of Reclosing

Reclosing attempts may be blocked by the closure of an external contact connected to CC14. A signal from CC14 blocks the reclosing signal by disabling AND20 at its NOT input (via OR16).

Permit Blocking of Reclosing to Clear (Hold)

In the event that a reclosing signal is initially blocked by synchronism check supervision or by an external BLOCK RECLOSE contact, the signal may be sustained (put on hold) for the duration of the reset timer setting (TL4) with the hope that the blocking signal will disappear within that time. This is accomplished by

placing the first hold link (L3) in the IN position. The second hold link (L5) should also be placed in the IN position to insure that the sync check indicator latch is not set erroneously.

The hold latch is set by the reclosing signal from OR13 and will not be reset (via OR14) until a validated reclosing signal is issued by AND20 or, if that doesn't occur, when the reset timer times out (via OR28, OR7 and OR14). This provides a sustained reclosing signal which is applied to AND20 via L3 (IN position). The signal also energizes the RECLOSE IN PROGRESS relay and OPN LED indicator through OR23.

The presence of a blocking signal inhibits reclosing by disabling AND20 through its NOT input. Should the blocking signal disappear before the reset timer times out, AND20 will be enabled and will transmit the reclosing signal which has been sustained by the hold latch. In this manner, the reclosing attempt is permitted when the blocking signal is removed. If the blocking does not clear, the recloser will go into lockout when the reset timer times out.

The second hold link (L5), when placed in the IN position, utilizes AND28 to set the synchronism check indicator latch. The upper input to AND28 is provided by AND19 and is present whenever a three-pole reclosing attempt is blocked by the synchronism check circuit. The other input to AND28 is provided by AND25 which gives an output when the reset timer times out, provided that the sustained reclosing signal has not been cleared from the hold latch. Thus, with the hold links (L3 and L5) in the IN position, if a three pole reclosing attempt is blocked by synchronism check and if the out-of-synchronism condition persists for the duration of the reset time, the N/S LED indicator will light at the end of the reset time and will remain lit until reset via OR6.

If the holding feature is not desired, L3 and L5 should be placed in the OUT position. In this case, reclosing signals which are initially inhibited at AND20 expire immediately and reclosing will not take place. When inhibited by synchronism check, the N/S LED will light immediately at the time of the would-be reclosing attempt.

Lockout

The recloser will go into lockout under each of the following three sets of conditions:

1) Lockout Resulting from a Trip Following the Last Reclose Attempt

   If a fault persists following the second reclosure (first reclosure if link L1 is in the NO DLY position), the recloser will go to lockout as soon as the associated line relays trip.

2) Lockout Resulting from a Failed Reclosing Attempt

   If a breaker pole(s) remains open throughout the duration of the dwell time, the reclosing attempt is assumed to have failed, and the recloser will be locked out. This is accomplished by the fail-to-close circuitry shown in Fig. 1. The circuitry consists of the following elements:

OR 20
Fail-to-Close Latch a (FTCa)
Fail-to-Close Latch b (FTCb)
NOT2
TL-7
AND26

The logic functions as follows: The tripping of the breaker and resulting closing of one or more "b" switches sets FTCa through OR3 while at the same time removing the continuous reset which was previously present at FTCb. A validated reclosing signal from one or more poles then sets FTCb via OR20 and the output of this latch is applied to the lower input of AND26 through TL7. At the same time, however, one or more of the dwell timers issues an output which, through OR21, resets FTCa. This signal is present for the duration of the dwell time. Due to the nature of the latch (refer to latch equivalent), the reset input overrides the set input so that the dwell timer signal causes the FTCa output to be cut off, thereby disabling AND26. Since the OR20 and OR21 outputs occur simultaneously, TL7 is included so that FTCa disables AND26 before the FTCb output is applied.

At the end of the dwell time, the resetting signal is removed from FTCa. If at that time, all the "b" switches are open (breaker closed), FTCa receives no set input. Therefore it produces no output and continues to disable AND26. If, on the other hand, the breaker has failed to close, one or more of the "b" switches will remain closed so that, as soon as the dwell timer signal ceases, FTCa issues an output which is applied to the upper input of AND26. The lower input to AND26 is still present due to the fact that FTCb was not reset by NOT2 because the "b" switch(es) did not open. The resulting output from AND26 constitutes the fail-to-close signal.

The fail-to-close signal sets the lockout latch via OR24 and OR25.

3) Lockout Resulting from a Blocked Reclosing Attempt

If the sustained reclosing signal from the hold latch is still present when the reset timer times out, it indicates that the reclosing attempt was not validated and the recloser should be locked out. AND25 is provided for this purpose. Its lower input is connected to the first hold latch output and its upper input is connected to the reset timer output through OR28. An output from AND25 sets the lockout latch via OR24 and OR25.

When the lockout latch is set, its output lights the L/O LED indicator energizes the lockout alarm relay, and energizes the 3-POLE TRIP ENABLE relay through OR27. It also energizes the ZONE-1 EXTENSION relay via OR22 thereby allowing the line relays to return to their normal zone-1 reach setting (zone-1 extension scheme only).

In the lockout state, all further reclosing is prevented by disabling the RI latch through OR28, OR7, OR8 and OR10.

The recloser may be taken out of the lockout state by an intentional reset signal from OR6 through OR26 which resets the lockout latch. This will be discussed subsequently. In addition, a manual close attempt will take the recloser out of lockout by resetting the latch via AND9 and OR26.

Signals Available for Use in Line Relaying Schemes

ZONE-1 EXTENSION:

These contacts are intended for use in those distance relay schemes where it is desired that the zone 1 functions reach beyond the end of the line, and "pull back" to a normal first zone reach for a period of time after the circuit breaker closes. These contacts are open in standby, and closed when a reclosing cycle is in progress.

The first automatic reclosing signal from OR11 sets the zone-1 extension latch and closes the contacts to the distance relay (via OR22) until the latch is reset by an output from the reset timer via OR28. The distance relay is therefore switched from its extended zone-1 reach to its normal zone-1 reach upon the first reclosing attempt.

The ZONE-1 EXTENSION relay will be energized in the event of a lockout (middle input to OR22) or if the recloser is taken out of service by opening the ON/OFF switch, SW3 (lower input to OR22). This is done because it is not desirable to have the distance relay using an extended zone-1 reach when the recloser is not operating and therefore unable to return the distance relay to its normal zone-1 reach.

LINE PICKUP (CLOSE ONTO FAULT):

This signal is sent to the line relays when AND20 transmits a validated reclosing signal. It is sustained for 128 milliseconds by timer TL5, the first 128 milliseconds for which the output closing contacts (CLOSE POLE A, etc.) are closed.

The LINE PICKUP signal may be used in the line relay scheme in conjunction with an overcurrent detector and an undervoltage detector. If these detectors both issue outputs in the presence of the LINE PICKUP signal, the fault is regarded as a severe close-in fault. The normal measuring unit fault detection may be bypassed and the line pickup circuit can trip directly.

ONE POLE OPEN

This signal is produced by a circuit which continuously monitors the breaker "b" switches through CC4, CC5 and CC6. In order to have a ONE POLE OPEN output from AND11, the following three conditions must be met:

1) OR3 must be producing an output which indicates that one or more of the "b" switches is (are) closed (pole or poles open).

2) OR4 must not be producing an output. The absence of an output from OR4 indicates that there are not two poles open because, if there were, two "b" switches would be closed and either AND5, AND6 or AND7 would provide a signal to OR4.

3) AND8 must not be producing an output. The absence of an output from AND8 indicates that not all three poles are open. Note that this is redundant, because the same condition will cause an OR4 output which alone disables AND11.

In summary, with (1) one or more poles open, but (2) not two poles open and (3) not three poles open, one and only one pole must be open.

FAIL TO CLOSE:

These contacts will be energized under either of the following two sets of conditions:

1) A Fail-to-Close Condition

If the breaker fails to close during a reclosing attempt and there are one or two (not three) poles open, the FAIL TO CLOSE relay will pick up. The FAIL TO CLOSE signal is provided by AND26 as described in paragraph 2 of the Lockout subsection. It is applied to the upper input of AND29 through OR24. The one or two poles open signal is provided by AND12 and is applied to the lower input of AND29. In order for AND12 to produce an output, it must receive a signal at its upper input from OR3 which indicates that one, two or three "b" switches are closed. In addition, it must not receive a signal at its lower (NOT) input from AND8 which indicates that all three "b" switches are closed. Therefore, AND12 will produce an output only for the cases of one or two closed "b" switches (open poles).

2) A Blocked Reclosing Attempt

If the sustained reclosing signal from the hold latch is still present when the reset timer times out and one or two poles remain open, the reclosing attempt was not successful. The remaining pole(s) should be tripped and the recloser should be locked out. This is accomplished by AND25 as described in paragraph 3 of the Lockout subsection. AND25 provides the upper input to AND29 through OR24. As before, the lower input to AND29 is provided by AND12.

TL8 causes the FAIL TO CLOSE signal to have a duration of 100 milliseconds. The FAIL TO CLOSE contacts can be used in the associated line relay scheme to cause a direct three pole trip. Note that these contacts are not rated for trip duty.

3-POLE TRIP ENABLE

These contacts may be used to switch the line relays into the three-pole mode so that the detection of any type of fault will result in a three-pole trip output. It is produced under the following four sets of conditions, each of which provide an input to OR27.

1) When the recloser is in lockout.

2) When the recloser is set for three-pole only operation (SW2 closed).

3) Following the first reclosing attempt. In this case, the OR27 input is provided by AND14 as described in the subsection entitled Second Reclosing Attempt After Single-Phase Fault.

4) When the ON/OFF switch (SW3) is in the OFF position (open). In this case, there is no means of reclosing so it is imperative that all three poles of the breaker be tripped.

Resetting

The recloser circuitry will be automatically reset by an output from OR28. This signal will be present when the reset timer gives an output or in the event that the recloser is locked out. The reset timer (TL4) operates as follows. A pulse input from OR12 initiates the timing cycle which is adjustable from one second to 99 seconds (refer to **SETTINGS PROCEDURES** section). At the end of the timing cycle, the timer produces a single pulse output. TL4 may be reset at any point during the timing cycle by a signal at its reset input.

The OR28 output accomplishes the following:

- Resets the zone-1 extension latch directly. This de-energizes the ZONE-1 EXTENSION relay.
- Resets the manual close latch directly, thereby terminating the blocking of automatic reclosing by removing the reset on the RI latch (via OR8 and OR10).
- Resets the hold latch through OR7 and OR14. This terminates the sustained reclosing signal which would still be present if the reclosing attempt was never validated at AND20.
- Resets the three-pole trip latch through OR7 and OR8. This removes the 3-POLE TRIP ENABLE signal thereby permitting the line relays to trip single-pole once again.
- Resets the 2 or 3 RI latch through OR7 and OR8.
- Returns the sequencer to port 1 (standby position) through OR7 and OR8.
- Resets the delayed synchronism check latch through OR7 and OR8.

The recloser may also be reset manually by depressing the RESET push button (PB1) or it may be remotely reset by closing an external contact connected to CC11. In either case, OR5 produces an output which is sent to OR6, from which it accomplishes the following:

- Removes the recloser from lockout by resetting the lockout latch through OR26.
- Extinguishes the N/S LED indicator by resetting the synchronism check indicator latch.
- Resets the hold latch through OR7 and OR14.
- Resets the three-pole trip latch through OR7 and OR8.
- Resets the 2 or 3 RI latch through OR7 and OR8.
- Returns the sequencer to port 1 through OR7 and OR8.
- Resets the delayed synchronism check latch through OR7 and OR8.
- Resets all timers.

ON/OFF Switch

The recloser may be taken out of service by opening the ON/OFF switch (SW3). When the switch is open, NOT1 produces an output which accomplishes the following:

- Energizes the 3-POLE TRIP ENABLE relay so that all tripping will be three pole.
- Lights the OFF LED indicator.
- Energizes the RECLOSER IN SERVICE relay which operates its associated "C" contacts.
- Blocks manual close signals through the NOT input of AND9.
- Blocks automatic reclosing by disabling the RI latch through OR6, OR7, OR8 and OR10.
- Energizes the ZONE-1 EXTENSION relay via OR22 thereby allowing the distance relay to return to its normal zone-1 reach setting (zone-1 extension scheme only).
- Serves all the resetting functions of the RESET push button described above (via OR6).

DESCRIPTION OF HARDWARE

The SRS1000 recloser consists of plug-in modules housed within a steel case.

STEEL CASE ASSEMBLY

Construction

The case is fabricated from sheet steel. A heavier gage steel is used on the rear cover plate and side mounting brackets for added strength in these critical areas. Overall case dimensions are given in the **SPECIFICATIONS** section.

The front cover consists of plate glass with a steel frame. It is hinged on the bottom and opened from the top by way of two spring-loaded plastic latches. Sliding steel strips are included on the edges to restrain the cover from swinging open more than 96 degrees. This prevents the cover from blocking access to adjoining equipment while still allowing sufficient clearance for the removal of modules and the insertion of the test device.

The cases are painted with a textured finished baked enamel. Gasketing is inserted around the edges of the rear cover plate and along the top and bottom edges of the front cover in order to minimize dust infiltration.

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, when closed, provides further restraint on the modules. Proper alignment is maintained by slotted plastic guides, one above and one beneath each module (with the exception of the MGM module which requires two guides above and two beneath).

Electrical Connections and Internal Wiring

External connections are made to eight terminal blocks mounted on the rear cover plate. Each block contains 14 terminal points which consist of a Number 6 screw threaded into a flat contact plate. Plastic covers are included over every terminal block. These reduce electrical shock hazard and protect against inadvertent short circuits between terminals. These covers are held on by plastic clips and are easily removed by hand (no tools necessary). There are slots in the covers above and below each terminal point to guide the incoming wire dress. In addition, there are small holes in the covers directly in front of each terminal point which allow probes to be inserted so that points may be tested without having to remove the protective cover.

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 a 104-pin signal block (not all pin positions are used).

The printed circuit board edge connectors and the MGM module connector socket are mounted on the same backplane assembly approximately 23 centimeters (nine inches) from the front of the case. The receptacle for the connection plugs and test device (test receptacle) on the other hand, is mounted only four centimeters (1.6 inches) from the front of the cases. This receptacle will be discussed in detail in a subsequent section.

Internal wiring between module connectors, to the test receptacle, and to the rear cover terminal blocks utilizes the wire wrap method. For wiring between the module connectors, the pattern is random except for signal paths sensitive to coupling. The sensitive wires are arranged in harnesses and the harnesses are routed such that they cross at right angles in order to minimize the electrostatic and electromagnetic coupling effects. All wires connecting to the test receptacle and to the rear terminal blocks are arranged in harnesses.

It should be noted that a standard internal wiring arrangement is used in the construction of the SRS1000. This of course means that in some instances internal wiring is not used because a particular functional module is not included. The use of standard wiring permits simple additions of features in the field.

Identification

The SRS model number is indicated on a label located on the inside of the front cover in the lower left-hand corner.

A marking strip which indicates the name and position of every module in a given 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.

The terminal blocks are identified by two letter codes which are given on labels directly beneath the left-hand edge (rear view) of each block. There are eight terminal blocks coded CA through DD.

On each terminal block, the screw terminals (1 through 14) are labelled top and bottom by stamped numbers. The numbers are visible even when the protective covers are in place.

PRINTED CIRCUIT BOARD MODULES

Basic Construction

Each module consists of a printed circuit board and attached front panel mounted perpendicular to the board. 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.

In those cases where the circuit modules do not fill the available space, dummy modules are inserted. These consist simply of a blank board and a blank front panel.

Identification

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

RLM101 - Logic Module

This module contains the reclosing logic circuitry. The decision whether a reclose attempt should be made single pole or three pole is made in this module. If single pole, the proper phase is selected based on the status of the breaker "b" switches. The three command signals which initiate reclosure (phase A, B, C) are produced in this module.

In addition, the module contains

1) fail-to-close (breaker failure) logic which sends a trip command to the distance relay

2) lock-out circuitry which blocks further reclose attempts

3) supervision of manually initiated breaker closures (if desired)

4) a dwell timer which establishes the length of time for which the reclose output contacts, once closed, remain in the closed position.

5) circuitry which permits an initially invalidated (blocked) reclosing attempt to be sustained for the duration of the reset time (if desired).

Front Panel Light Emitting Diodes (LED's)

Identity	Color	Indication Given	Description
OPN	Yellow	Reclose in Progress (Operation)	Lights while the reclosing cycle is in progress. It remains lit for the duration of the reclose time plus the dwell time.
OFF	Red	Recloser Out-of-Service	Lights when the recloser is taken out of service by switching the ON/OFF switch on this module to the OFF position.
L/O	Red	Lockout	Lights when the recloser goes into lockout.
N/S	Red	No Reclose Due to Synchronism Check	Lights whenever a reclose attempt is blocked because the voltages are beyond the synchronism check limits.

Front Panel Switches

Identity	Type	Function	Description
ON/OFF	Toggle	Recloser in Service	When in the OFF position, the recloser is taken out of service and the 3 POLE TRIP ENABLE contacts close, thereby signalling the associated distance relay to trip three pole for all types of faults. Single pole trips are undesirable when there is no means of reclosing.
1Ø	Toggle	Single Pole Reclosing Only	When set to the right, reclosing is attempted only after single pole trips.
3Ø	Toggle	Three Pole Reclosing Only	When set to the right, the 3 POLE TRIP ENABLE contacts close thereby causing all trips to be three pole. Consequently, subsequent reclose attempts will be three pole.
X1/X10, 1Ø	Toggle	Single Pole Reclose Time Multiplier	Allows the single pole reclosing time to be one or ten times the setting of the 1Ø switch on the RTM101 module.
X1/X10, 3Ø	Toggle	Three Pole Reclose Time Multiplier	Allows the three pole reclosing time to be one or ten times the setting of the 3Ø switch on the RTM101 module.
RESET	Push Button	Reset	Momentarily depressing this push button resets all timers and flip-flops within the recloser to their initial states.

Internal Links

Identity	Function	Description
0.25/0.5/1.0/2.0	Dwell Timer Setting	Establishes the dwell time (contact closure time) of the reclose output contacts. The settings are given in seconds.
1/2	One or Two Breaker Reclosing	If the recloser includes an RLM201 module, it may be used to reclose two breakers. This link is then set accordingly.
MAN CLOSE	Supervised Manual Close	When placed in the AUTO position, manually initiated reclose attempts may be made through the recloser. When in the NORM position, the recloser is essentially by-passed.

Internal Links (continued)

Identity	Function	Description
ALL3P/DLY	Synchronism Check Supervision	The position of this link determines whether all three-pole reclose attempts are to be supervised by synchronism check (ALL3P position) or only delayed (second shot) attempts (DLY position).
HOLD (#1)	Permit Blocking of Reclosing to Clear	When placed in the IN position, reclose attempts which have been invalidated by a blocking signal (synchronism check or inhibit) will be sustained for the duration of the reset time. Therefore if the blocking signal disappears before the reset time expires, the reclose attempt will be validated. When placed in the OUT position, if an attempt is blocked initially, there will be no reclosure.
HOLD (#2)	Synchronism Check	In the IN position, when a reclosing attempt is blocked by an out-of-synchronism condition which persists for the duration of the reset time, the N/S LED indicator will light at the end of the reset time. In the OUT position, the N/S LED indicator will light immediately when a reclosing attempt is blocked by synchronism check. This second hold link must be set the same as the first hold link.

ROM102 - Interface Module

This module contains interface circuitry for translating external contact operation (48, 110-125, or 220-250 volts DC) to signals compatible with the internal electronic circuitry. Isolation is provided between the external and internal circuits. Ten contact converters are included for the following external contacts:

Reclose Initiate, ØA
Reclose Initiate, ØB
Reclose Initiate, ØC
Breaker "b" Switch, Pole A
Breaker "b" Switch, Pole B
Breaker "b" Switch, Pole C
Block Reclose
Reclose Enable
Manual Close
Remote Reset

In addition, this module contains three board mounted auxiliary relays with output contacts to indicate the following:

Recloser in Service ("c" contact)
Fail to Close ("a" contact)
One Pole Open ("a" contact)

Internal Links

Identity	Quantity	Function	Description
48V/110-125V/220-250V	10	DC Control Voltage	These links set the interface circuitry for the proper DC control voltage. There is a separate link for each contact converter.

ROM201 - Auxiliary Output Module

This module contains ten board mounted auxiliary relays with output contacts to indicate the following:

Zone One Extension ("a" contact) - two relays
3 Pole Trip Enable ("a" contact) - two relays
Reclose in Progress ("a" contact) - two relays
Lockout Alarm ("a" contact)
Manual Close ("a" contact)

RTM101 - Recloser Module

This module contains timing circuits for the recloser, specifically the main reclosing timer and the reset timer. The main reclosing timer requires three separate settings:

1) single pole reclosing time

2) three pole reclosing time

3) delayed reclosing time.

Each of these settings is individually adjustable.

The timers are of the digital type, that is, the time ranges are established by counting a prescribed number of reference pulses (clock pulses). These reference pulses are produced by a fixed frequency oscillator included in this module.

In addition, this module receives the reclose initiate signals and it contains logic to determine whether the initiation is single pole or three pole.

Front Panel Switches

Identity	Type	Function	Description
1Ø	Double Digit Thumbwheel	Single Pole Reclosing Time	Determines the time delay in seconds before the first reclosing attempt following a single pole trip.
3Ø	Double Digit Thumbwheel	Three Pole Reclosing Time	Determines the time delay in seconds before the first reclosing attempt following an initial three pole trip.
3Ø-D	Double Digit Thumbwheel	Delayed Reclosing Time	Determines the time delay in seconds before the second reclosing attempt. The second trip, if it occurs, will always be three pole and this switch is therefore designated as 3Ø-D.
RESET	Double Digit Thumbwheel	Reset Time	Determines the time delay in seconds before the recloser is reset to its initial state following the final reclose attempt.

Internal Link

Identity	Function	Description
DLY/NO DLY	One or Two Reclose Attempts	In the NO DLY position there will be no second reclose attempt (delayed reclosure). The recloser will go to lockout following a second trip.

PSM101 - Power Supply Module

This module contains the power supply used by all the functions in the SRS. It consists of a DC-to-DC converter with a dual-rated input and regulated outputs. The internal transformer provides isolation between the external control voltage leads and the internal SRS circuitry.

The outputs include a regulated plus and minus 12 volt DC around a center reference. In addition, a 30 volt DC output is provided to operate the board mounted relays and light emitting diodes.

Front Panel Light Emitting Diode (LED)

Identity	Color	Indication Given	Description
24V	Green	Power Supply Functioning	This LED is lit continuously as long as external control voltage is connected. It provides a visual checkpoint to verify proper operation of the power supply.

Front Panel Jacks

These jacks permit direct measurement of the regulated power supply output voltages. They accept standard 0.080 inch (two millimeter) diameter pin connectors.

Internal Links

Identity	Function	Description
48V-110V/125V	DC Control Voltage Setting	This link sets the primary circuit of the power supply converter to correspond to the DC control voltage being used.

MAGNETICS MODULES

Basic Construction

The magnetics modules, designated MGM, consist of a steel framework which houses the magnetic circuit components. These include potential transformers for the sync check option, and telephone-type output relays which provide the output contacts for reclosing. In addition, one printed circuit board is included for each set of three telephone relays. It contains interface circuitry such that these relays are driven directly by the DC control voltage (48 or 110-125 volts DC).

Electrical connection is made by means of a 104-pin signal block.

Handles are provided top and bottom for removing and inserting the module.

Identification

The MGM model number is given at the bottom of the front panel. Rating information for the module is given in the center of the front panel as indicated below:

V_N - AC voltage rating (AC volts)
FREQ - Frequency rating (Hertz)
V_{NA} - DC control voltage rating (DC volts)

The front panel identification includes only those ratings which apply to that particular MGM module. For example, MGM201 has no AC inputs. Therefore, V_{NA} is the only rating given on its front panel.

Internal Links

DC Control Voltage Setting:

There is one link on the printed circuit board within the module for the DC control voltage setting (48 volts or 110-125 volts). For those modules containing six telephone-type relays, there are two printed circuit boards, each including a DC voltage link.

Description of Individual Magnetics Modules

The four magnetics modules used in the SRS1000 reclosers are differentiated in Table I.

Table I - MAGNETICS MODUELS

Model	Telephone Relays	Driver Boards	Potential Transformers	For Use With
MGM301	3	1	0	SRS1001
302	3	1	2	1002
201	6	2	0	1003
202	6	2	2	1004

APPLICATION AND SETTINGS

The SRS1000 recloser can be used to initiate one or two reclosures of a breaker, and is designed for application with a single-pole/three-pole tripping type relaying scheme. The recloser may be set to operate in any of the following modes:

1. One reclosing attempt, single-pole or three-pole, depending on trip
2. One reclosing attempt, single-pole only
3. One reclosing attempt, three-pole only
4. Two reclosing attempts, single-pole or three-pole on first, three-pole on second
5. Two reclosing attempts, three pole only.

After an appropriate mode of operation has been selected, it will be necessary to make some, or all, of the following time settings:

1. Reset time (1 to 99 seconds)
2. Dwell time (0.5, 1.0, 1.5 or 2.0 seconds)
3. Reclose time:

   a. Single-pole
   b. Three-pole } (0.01 to 9.9 seconds)
   c. Delayed (1 to 99 seconds)

The following should be considered in selecting appropriate settings.

1. Reset time - The reset time is started when an output is produced from the reclose timer. During the reset period, the following will occur:

   a. The recloser will wait for permission from the synchronism check function, if one is used, and if the hold latch is in the IN position. If permission is not received before the reset time expires, the recloser will go to lockout. It will be necessary to set the reset time long enough to allow time for the synchronism check function to operate.

   b. Further reclosing will not be permitted following the last attempt in the reclosing cycle because the breaker must be allowed time to recover. The reset time must be based on the recovery time of the breaker to prevent reclosing until the recovery can be completed.

   Other functions in the recloser will also be affected during the reset period and by the output of the reset timer, but the above two are the predominant factors in selecting a reset time. The reset time should be set equal to the longer of the two times described above.

2. Dwell time - The dwell time sets the time that the reclose output contacts will remain closed. Select a dwell time that meets the needs of the breaker closing circuit.

3. Reclose time - This time starts with a reclose initiate input to the recloser, and ends with an output directly to the breaker closing circuits, or through the hold circuit when this option is employed.

For high speed reclosing, the reclose time should be set long enough to allow the breaker to reclose with sufficient time delay to allow arc extinction to occur. The time to reclose is a function of the breaker clearing time, plus the total dead time of the line, which includes the closing time of the breaker. The reclose time can be calculated as follows:

$$RT = TD + BO - BC$$

where:

RT = Reclose time
TD = Total dead time
BO = Breaker clearing time
BC = Breaker closing time

The reclose time for a delayed reclosure should be based on the requirements of the breaker or the requirements of the power system, whichever of the two needs the longer time.

SETTINGS PROCEDURES

Unless otherwise noted, the switches referred to in this section are located on the front panels of the modules. Internal switches and links, where indicated, may be accessed by removing the module (or modules) in which they are contained. Figs. 5 through 8 are included expressly for the purpose of locating and setting the internal switches and links.

DC CONTROL VOLTAGE SETTINGS

Internal links must be set in each of the modules indicated in Table II below to correspond to the DC control voltage being used.

TABLE II - DC CONTROL VOLTAGE LINKS

MODULE	NUMBER OF DC CONTROL VOLTAGE LINKS	FUNCTION
PSM101	1	Power Supply
ROM102	10	Contact Converters
MGM Module	1 or 2**	Output Relays

** The MGM module under consideration will have one or two DC voltage control links depending upon whether it houses three or six output relays, respectively. The link(s) is located on the printed circuit board(s) within the module and is accessible from the top.

Mode of Operation

There are five modes of operation for the recloser:

1) One reclosing attempt, single pole or three pole, depending on type of trip
2) One reclosing attempt, single pole only
3) One reclosing attempt, three pole only
4) Two reclosing attempts, single pole or three pole on first, three pole on second.
5) Two reclosing attempts, three pole only.

The desired mode is selected by positioning the switches and links indicated in Table III below:

TABLE III - MODE OF OPERATION

MODE	SWITCHES ON RLM101 FRONT PANEL 1Ø	3Ø	RTM101 INTERNAL LINK
1	LEFT	LEFT	NO DLY
2	RIGHT	LEFT	DOES NOT MATTER
3	LEFT	RIGHT	NO DLY
4	LEFT	LEFT	DLY
5	LEFT	RIGHT	DLY

The recloser is taken out of service by simply moving the ON/OFF switch on the front panel of the RLM101 module to the OFF position.

Time Settings

First Reclosing Attempt - Single Pole

The time between a reclose initiation (trip) and the first reclosing attempt is set by the top double-digit thumbwheel switch on the RTM101 module, designated 1Ø. The digits are advanced by the lower push buttons labelled (+) and reduced by the upper push buttons labelled (-). The left digit indicates tenths of seconds, the right digit indicates hundredths of seconds.

The time setting may be made to equal ten times the reading on the 1Øthumbwheel switch by moving the X1/X10, 1Ø toggle switch on the RLM101 module to the X10 (right) position.

First Reclosing Attempt - Three Pole

If the first reclosing attempt is three pole, the reclosing time will be according to the setting on the second double-digit thumbwheel switch on the RTM101 module, designated 3Ø. Again, the left and right digits indicate tenths and hundreths of seconds, respectively.

This time setting may also be made to equal ten times the reading on the 3Øthumbwheel switch by moving the X1/X10, 3Ø toggle switch on the RLM101 module to the X10 (right) position.

Second Reclosing Attempt (Always Three Pole)

The time between the second reclose initiation (first attempt failed) and corresponding reclosing attempt (delayed reclosure) is according to the setting on the third double-digit thumbwheel switch on the RTM101 module, designated 3Ø-D. In this case, the left digit indicates tens (not tenths) of seconds and the right digit indicates seconds.

Reset Time

The reset time is according to the setting on the bottom double-digit thumbwheel switch on the RTM101 module, designated RESET. The left and right digits indicate tens of seconds, and seconds, respectively.

Dwell Time

The dwell time is set by positioning a link within the RLM101 module. There are four possible settings; 0.25 second, 0.5 second, 1.0 second and 2.0 second.

Auxiliary Functions

Manual Close Through Recloser

In order for manual closing to be accomplished using the recloser circuitry, the MAN CLOSE link within the RLM101 module must be placed in the AUTO position. Otherwise it should be placed in the NORM position.

Number of Breakers

If the recloser purchased does not include the two breaker reclosing option, the BKRS link in the RLM101 module must be placed in the 1 position. If the recloser does include the two breaker reclosing option, it must contain an RLM201 module. If it is desired to utilize this feature, the BKRS link (in RLM101) should be placed in the 2 position. Note that if two breaker reclosing capability is included but it is desired not to utilize this option, the Breaker Two control circuitry may be disabled by placing the BKRS link (in RLM101) in the 1 position.

Supervision of Reclosing by Synchronism Check

If the recloser purchased includes the synchronism check option, it will contain an SVM101 module. Three pole reclosing attempts may then be supervised by the synchronism check signal. If it is desired to have this supervision on both first and second reclosing attempts, the ALL3P/DLY link in the RLM101 module should be placed in the ALL3P position. If it is desired to supervise only the second (delayed) reclosing attempt, place the link in the DLY position.

Permit Blocking of Reclosing to Clear

By placing the HOLD links in the RLM101 module in the IN position, reclosing attempts which have been initially invalidated by a blocking signal (be it from the synchronism check module or from an external contact) will be sustained for the duration of the reset time with the hope that the blocking signal will disappear. This feature may be disabled by placing the link in the OUT position. Both links must be set the same. The first controls the reclosing signal, the second controls the N/S LED indicator.

TESTING

DIELECTRIC TESTS

Dielectric testing may be performed 1) between all terminals (tied together) and the case (except DD14) and 2) between independent circuit groups (refer to elementary diagram, Fig. 11). The recommended voltage is 2200 volts rms for initial testing, and 1600 volts rms for subsequent periodic testing. The test voltage should be applied for one second.

ACCEPTANCE TESTS

It is recommended that the operational tests described in this section be conducted prior to installation. These may be done on a "bench-top" basis.

Test Equipment

The acceptance tests described herein require the following equipment:

DC control voltage source (48, 110 or 125 volts)
3 normally open - momentarily closed pushbutton switches
5 single pole single throw toggle switches
12 contact monitors - indicating lamps or otherwise
Stopwatch or ordinary wristwatch with sweep-second hand

Test Connections

Connect the SRS1000 according to the test circuit shown in Fig. 9. The indicating lamps shown are used strictly as contact monitors. Other means of contact monitoring (e.g., ohmmeters or LEDs) may be used if desired.

Fig. 9 indicates terminal numbers (rear cover terminals) and the corresponding XTM test plug terminal numbers (TP points). For the acceptance tests, it is recommended that test connections be made to the rear cover terminals. The test plug is intended for post-installation testing, and is described in a separate subsection under PERIODIC TESTING.

Initial Test Settings

To begin the acceptance tests, the module settings should be as indicated in Tables IV and V. Note that it is necessary to remove the modules in order to gain access to the links and switches referred to in Table IV.

TABLE IV - Internal Link and Switch Settings For Acceptance Tests

Module	Link or Switch Identity	Initial Position
MGM	48V/110-125V LINK	ACCORDING TO AVAILABLE DC SUPPLY
ROM102	48/110-125/220-250V LINKS (10)	" " " " "
RTM101	DLY/NO DLY LINK	DLY
RLM101	.25/.5/1.0/2.0 LINK	2.0 SECONDS
"	1/2 LINK	1
"	AUTO/NORM LINK	NORM
"	S.C. ALL/DLY LINK	ALL
"	HOLD IN/OUT LINKS (2)	OUT
PSM101	48/110-125V LINK	ACCORDING TO AVAILABLE DC SUPPLY

TABLE V - Front Panel Switch Settings for Acceptance Tests

Module	Switch Identity	Initial Setting or Position
RTM101	1Ø	.50 SECONDS
"	3Ø	.90 SECONDS
"	3Ø-D	15 SECONDS
"	RESET	60 SECONDS
RLM101	ON/OFF	ON
"	1Ø	LEFT
"	3Ø	LEFT
"	X1/X10, 1Ø	X10
"	X1/X10, 3Ø	X10

A. Automatic Two Shot Reclosing Following a Single Pole Trip

1) Open SW1, 2, 3 and 5. Close SW4 and leave it closed throughout these tests unless otherwise specified. Apply power. Depress PB1 momentarily to simulate a trip signal (RI-ØA) and simultaneously close SW2 to simulate that pole A of the breaker has opened ("b" switch closes). Leave SW2 closed when PB1 is released. Verify the following indications:

- The yellow OPN LED on the RLM101 module should light immediately to indicate that the reclosing cycle is underway.
- Test lamp RIP should light in conjunction with the OPN LED.
- Test lamp 1PO should light immediately indicating that one pole is open.
- As soon as PB1 is released, test lamp 3PT should light indicating that the recloser is setting up three pole tripping on the succeeding trip.
- Five seconds after PB1 was depressed, test lamp CPA should light. This is according to the time setting on the 1Ø thumbwheel switch on the RTM101 module (.50 x 10).

- Test lamp Z1X should light when CPA lights.

- Test lamp LPU should blink on when CPA lights. It may light only dimly since the line pickup output contacts will be closed for only one-tenth of a second (approximately).

2) As soon as CPA lights, open SW2 to simulate that pole A of the breaker has successfully reclosed ("b" switch opens). Verify the following:

   - 1PO should go out immediately.

   - CPA should go out in two seconds. This is the dwell time setting in RLM101.

   - RIP (test circuit) and OPN (RLM101 module) should go out concurrently with CPA.

   - 3PT and Z1X should remain lit.

3) Before the reset time (set for 60 seconds) elapses, close SW3. Again depress PB1 momentarily and simultaneously close SW2. This simulates a three pole trip. Verify the following indications:

   - RIP (test circuit) and OPN (RLM101 module) should light immediately.

   - Fifteen seconds after PB1 was depressed, CPA, CPB and CPC should light simultaneously. This is according to the time setting on the 3Ø-D thumbwheel switch on the RTM101 module.

   - LPU should blink on when CPA lights.

4) As soon as CPA, CPB and CPC light, open SW2. Verify the following:

   - CPA, CPB and CPC should go out in two seconds.

   - RIP (test circuit) and OPN (RLM101 module) should go out concurrently with CPA, CPB and CPC.

   - 3PT and Z1X should remain lit.

5) Again, before the reset time elapses, depress PB1 momentarily and simultaneously close SW2 (SW3 should still be closed from step 3). This simulates the third consecutive trip. Verify the following:

   - The recloser should immediately go into lockout, indicated by the lighting of the red L/O LED on the RLM101 module and the LCO lamp in the test circuit

   - 3PT and Z1X should remain lit.

6) Open SW2 and SW3. Reset the recloser by momentarily depressing PB2 in the test circuit. Verify the following:

- L/O on RLM101 and LCO in the test circuit should go out.
- 3PT and Z1X should also go out.

7) Open SW4 and repeat step 1). Verify that the recloser does not operate. The 1PO test lamp should be the only lamp to light. The OPN LED on RLM101 should not light.

8) Close SW4 and leave it closed throughout the remainder of these tests.

B. Automatic Two Shot Reclosing Following a Three Pole Trip

1) Close SW1 and SW3. This sets up a three pole trip condition. Now momentarily depress PB1 and simultaneously close SW2. Verify the following:

- RIP (test circuit) and OPN (RLM101 module) should light immediately.
- As soon as PB1 is released, 3PT should light
- Nine seconds after PB1 was depressed, CPA, CPB and CPC should light simultaneously. This is according to the time setting on the 3Ø thumbwheel switch on the RTM101 module (.90 x 10).
- Z1X should light when CPA, CPB and CPC light.
- LPU should blink on when CPA, CPB and CPC light.

2) As soon as CPA, CPB and CPC light, open SW2. Verify the following.

- CPA, CPB and CPC should go out in two seconds.
- RIP (test circuit) and OPN (RLM101 module) should go out concurrently with CPA, CPB and CPC.
- 3PT and Z1X should remain lit.

3) through 6) - same as 3) through 6) in test A.

C. One Shot Reclosing

1) De-energize the test circuit and the recloser. Remove the RTM101 module and move the DLY/NO DLY link in that module to the NO DLY position. Reinsert the module and reapply power.

2) Repeat steps 1) and 2) of test A.

3) Before the reset time elapses, close SW3. Depress PB1 momentarily and simultaneously close SW2. Verify the following:

- The recloser should go into lockout, indicated by the lighting of LCO (test circuit) and L/O (RLM101 module).

- 3PT and Z1X should remain lit.

4) Open SW2 and SW3. Reset the recloser by momentarily depressing the RESET button on the RLM101 module. Verify the following:

   - LCO (test circuit) and L/O (RLM101 module) should go out.

   - 3PT and Z1X should also go out.

5) Remove power and return the DLY/NO DLY link in RTM101 to the DLY position.

D. Single Pole Only Operation

1) Move the 1Ø switch on the front of the RLM101 module to the right. This puts the recloser into the single pole only mode.

2) Repeat steps 1) and 2) of test A.

3) Reset the recloser via the RESET button on RLM101 or via PB2 in the test circuit.

4) Close SW1 and SW3. This sets up a three pole trip condition. Momentarily depress PB1 and simultaneously close SW2. Verify that the recloser does not operate.

   - No LEDs on RLM101 should light.

   - No lamps in the test circuit should light.

5) Open SW1 and SW2 and reset the recloser.

E. Three Pole Only Operation

1) Return the 1Ø switch on the front of the RLM101 to the left and move the 3Ø switch to the right. Verify that test lamp 3PT lights.

2) With SW3 still closed from test D5, momentarily depress PB1 and simultaneously close SW2. Verify the following:

   - RIP (test circuit) and OPN (RLM101 module) should light immediately.

   - Nine seconds after PB1 was depressed, CPA, CPB and CPC should light simultaneously.

   - Z1X should light when CPA, CPB and CPC light.

   - LPU should blink on when CPA, CPB and CPC light.

3) As soon as CPA, CPB and CPC light, open SW2. Verify the following:

   - CPA, CPB and CPC should go out in two seconds.

- RIP (test circuit) and OPN (RLM101 module) should go out concurrently with CPA, CPB and CPC.

- 3PT and Z1X should remain lit.

4) Open SW3, return the 3Ø switch on RLM101 to the left, and reset the recloser.

F. Manual Closing

1) Send the recloser into lockout by repeating tests A1 through A5.

2) With the recloser in lockout, momentarily depress PB3 and simultaneously open SW2 to simulate a manual closure. Verify the following:

- Test lamp MC should light for as long as PB3 is closed.

- L/O (RLM101 module) and LCO, 3PT, Z1X (test circuit) should go out immediately.

3) Before the reset time elapses, open SW3. Momentarily depress PB1 and simultaneously closeSW2. Verify that the recloser does not operate. The 1PO test lamp should be the only lamp to light. The OPN LED on RLM101 should not light. This step verifies that automatic operation of the recloser is blocked during the reset time interval.

4) Open SW2 and reset the recloser.

5) De-energize the test circuit and the recloser. Remove the RLM101 module and place the AUTO/NORM link in the AUTO position. Reinsert the module. Manual closing will now be done through the recloser. Reapply power.

6) Close SW2 and SW3 to simulate that all three poles of the breaker are open. Momentarily depress PB3 and open SW2 within two seconds thereafter. Verify the following:

- MC should light for as long as PB3 is closed.

- LPU should blink on when PB3 is first closed.

- CPA, CPB and CPC should light for two seconds.

- OPN (RLM101 module) and RIP (test circuit) should light for two seconds.

7) Open SW3 and reset the recloser.

G. Fail-to-Close Test

1) Depress PB1 momentarily and simultaneously close SW2 to simulate a phase A trip.

2) When CPA Lights five seconds later, do not open SW2. This simulates that the breaker has failed to close. Verify the following:

- Test lamp FTC should blink on when CPA goes out after being lit for two seconds.
- The recloser should go into lockout when FTC blinks on. This is indicated by the lighting of L/O (RLM101 module) and LCO (test circuit).

3) Open SW2. Reset the recloser.

H. Hold Feature

1) De-energize the test circuit and the recloser. Remove the RLM101 module and place the two HOLD links in that module in the IN position. Reinsert the module and reapply power.

2) Close SW5 to simulate a block reclosing condition. Depress PB1 momentarily and simultaneously close SW2 to simulate a phase A trip. Verify the following:

- OPN (RLM101 module) and RIP (test circuit) light immediately.
- 1PO also lights immediately
- 3PT should light when PB1 is released
- Z1X should light five seconds after PB1 is depressed.
- There should be no reclose output, i.e., CPA should not light and LPU should not blink on.

3) Wait 20 seconds to verify the CPA does not light. OPN (RLM101 module) and RIP (test circuit) should remain lit. Open SW5 and verify a successful reclosure as follows:

- CPA should light immediately.
- LPU should blink on when CPA lights.

4) As soon as CPA Lights, open SW2 and verify the following:

- 1PO should go out immediately.
- CPA should go out in two seconds.
- OPN (RLM101 module) and RIP (test circuit) should go out concurrently with CPA.
- 3PT and Z1X should remain lit.

5) Reset the recloser.

6) Repeat step 2), but do not open SW5 after 20 seconds as indicated in step 3). Rather, leave SW5 closed and verify that the recloser goes into lockout at the end of the reset time (set for 60 seconds).

- L/O (RLM101 module) and LCO (test circut) should light.
- FTC should blink on.
- 3PT and Z1X should remain lit.

7) Open SW2 and SW5 and reset the recloser.

I. On/Off Test

1) Move the ON/OFF switch on the RLM101 module to the OFF position. Verify the following:

- The red OFF LED on the RLM101 module should light.
- Test lamp OFF should also light.
- 3PT and Z1X should light.

2) Momentarily depress PB1 and simultaneously close SW2. Verify that the recloser does not operate. 1PO should be the only lamp to light other than those indicated in step 1).

PERIODIC TESTING (Post-Installation)

It is recommended that a periodic test program be developed which checks all of the SRS functions employed in the reclosing scheme under consideration. It is left to the user's discretion to choose from among the Acceptance Tests in the previous section those which are applicable as Periodic Tests for a particular installation.

Additional Test Equipment

The post-installation tests described herein require the following test equipment in addition to that listed for the acceptance tests:

Six 1.2K ohm resistors (1 watt or greater)
Nine DC voltmeters (30 volts or greater)
Two card extenders (GE 0138B7406G1)
One set of XTM test plugs (XTM28L1 and XTM28R1) - described below.

XTM TEST PLUGS

Description

The XTM test plugs are designed specifically for post-installation testing of modular equipment. There are two plugs; XTM28L1 (left-hand plug) and XTM28R1

(right-hand plug), each providing access to fourteen recloser 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.

Not all of the external connections to the SRS are wired through the test receptacle for accessibility via the test plugs. Only those signals which are required for testing have been selected, as listed below:

Reclose Initiate Inputs

Breaker "b" Switches

AC Voltage Inputs (for the Sync Check option)

DC Control Power

Output Closing Contacts

Terminal Designation

The test receptacle and connection plugs are located to the left of the magnetics module (extreme left-hand position). 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 (Fig. 11) and test circuit diagrams (Figs. 9 and 10) as TP1 through TP28.

The left-hand test plug (XTM28L1) terminals are labelled 1R through 14R and 1S through 14S for the recloser 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 diagrams, should be made to the recloser 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 recloser 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 SRS. As mentioned earlier, wiring is facilitated by the slide-out, swing-away handles.

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 SRS for those signals which are wired through the test receptacle (refer to TP points on elementary diagram, Fig. 11).

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, the power system remains isolated from the SRS insofar as the test signals are concerned.

DC Disconnect

The primary DC control power feeding the power supply module (PSM101) may be disconnected by removing either connection plug. It may also be disconnected by removing the magnetics module.

Connections and Procedural Notes for Post-Installation Tests

Fig. 10 is intended for post-installation testing of the SRS recloser. It is similar to Fig. 9 ("bench-top" tests) except steps have been taken to isolate the pertinent inputs and outputs from the connected power system. The XTM test plugs serve this purpose for the basic functions, but special measures must be taken for certain auxiliary and alarm functions as follows:

1) Place ROM102 and RLM101 modules on card extenders.
2) Remove ROM201 module altogether.
3) Use resistor/voltmeter combinations in place of contact monitors.

The output monitoring for the post-installation tests corresponds to that used in the acceptance ("bench-top") tests as follows:

"Bench-top" Test	Post-Installation Test
Relay De-energized, contact open	Voltage across resistor: 0 VDC
Relay energized, contact open	Voltage across resistor: 20-30 VDC

In these tests, the switches simulate the closure of external contacts and the voltmeters monitor the driver signals for the board mounted auxiliary relays. Using these methods, the contact converters (inputs) and auxiliary relays (outputs) are bypassed. If it is desired to test these components, the external wiring must be disconnected so that the tests may be conducted in a "bench-top" fashion.

Note that in Fig. 10, the FTc, 1PO and OFF monitors (V1, V2 and V3, respectively), do not require parallel resistors. This is due to the fact that the ROM102 module is still inserted (it must be so to receive the RI and "b" switch inputs), and the FTC, 1PO and OFF auxiliary relays are therefore connected. Their coils provide the impedance across which is measured the voltage of the driver signals. The shortcoming here is that the associated output contacts are not isolated from the system and will operate during testing. Special consideration must be given to the fail-to-close (FTC) Output contact which may conceivably be used to initiate tripping. If it is undesirable to have this contact connected (and operating) during testing, the external connections to terminals CD4 and CD5 must be broken. The same holds true for the 1PO and OFF output contacts, although these will likely be used only to activate alarms.

CAUTION MUST BE EXERCISED WHEN THE CARD EXTENDER IS INSERTED IN THE ROM102 POSITION SINCE STATION BATTERY POTENTIAL WILL LIKELY BE PRESENT ON CERTAIN POINTS.

SPECIFICATIONS

Features

Mode Selection	1. One reclosing attempt, single pole or three pole, depending on type of trip 2. One reclosing attempt, single pole only 3. One reclosing attempt, three pole only 4. Two reclosing attempts, single pole or three pole on first, three pole on second. 5. Two reclosing attempts, three pole only.
Breaker "b" Switch Monitoring	Recloser may be taken out of service
External Blocking of Reclosing	
Fail-to-Close Logic	• Trips breaker 3 pole and locks out recloser
Manual Closing Through Recloser	• Utilizes recloser circuitry and output contacts. Permits sync check supervision (optional) on manual closures. (may be bypassed)
Hold Feature	• Allows reclosing attempts which are initially blocked by an external signal or by sync check (optional) to be sustained. Reclosing will take place if the blocking condition clears before the reset time elapses. (may be disabled)
Reclosing Attempts to be Supervised by Sync Check (optional)	• Supervision on all 3 pole reclosing attempts or only on delayed (second shot) reclosing attempts, selectable.

Reclosing Timers

Single and Three Pole Reclose Timers (independently adjustable)	• 0.01 to 0.99 second in 0.01 second steps • 0.1 to 9.9 seconds in 0.1 second steps
Delayed Second Reclosure	• 1 to 99 seconds in 1.0 second steps (may be disabled)
Dwell Time of Reclosing Contacts	• 0.25, 0.5, 1.0, 2.0 seconds
Reset Time	• 1 to 99 seconds in one second steps

ACCURACY

Timers	• Plus and minus three percent of setting

DIMENSIONS

Each standard rack mounted unit:	• 177 millimeters high • 484 millimeters wide (standard 19-inch rack) • 359 millimeters deep (including terminal blocks)

WEIGHT

Each standard rack mounted unit weights approximately 12 kilograms net.

DC BURDEN

Approximately 12 watts steady state.

RECEIVING, HANDLING AND STORAGE

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

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

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 SRS case has been designed for standard rack mounting. The case measures four rack units in height. The outline diagram is given in Fig. 12.

The units may also be flush mounted on a panel with an appropriate cutout. Refer to Fig. 12 for the required 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 Fig. 11. This is a general diagram incorporating all of the available options. Connection need not be made to those terminals associated with options not included in the equipment purchased.

The terminal block points indicated in Fig. 11 may be located without having the equipment in hand by referring to Fig. 12.

LIST OF ILLUSTRATIONS

Figure		Title
1	(0145D8968-0)	Logic Diagram for SRS1000 Recloser
2	(8043726-0)	Front View Photograph of RTM101 Module
3	(8043727-0)	Front View Photograph of RLM101 Module
4	(8043729-0)	Front View Photograph of PSM101 Module
5	(0285A6624-0)	Internal Link - RTM101 Module
6	(0285A6623-0)	Internal Links - RLM101 Module
7	(0285A6625-1)	Internal Links - ROM101 Module
8	(0285A6626-0)	Internal Link - MGM Module
9	(0285A8122-0)	Test Circuit for Acceptance Tests - Reclosing Functions
10	(0285A8121-0)	Test Circuit for Periodic Tests - Reclosing Functions
11A	(0138B7649 Sh. 1, Rev. 1)	Elementary Diagram - AC Connections, Sync Check
11B	(0138B7649 Sh. 2, Rev. 0)	Elementary Diagram - DC Connections, Contact Converters
11C	(0138B7649 Sh. 3, Rev. 0)	Elementary Diagram - DC Connections, Output Contacts
12	(0183B3626-0)	Outline and Mounting Dimensions

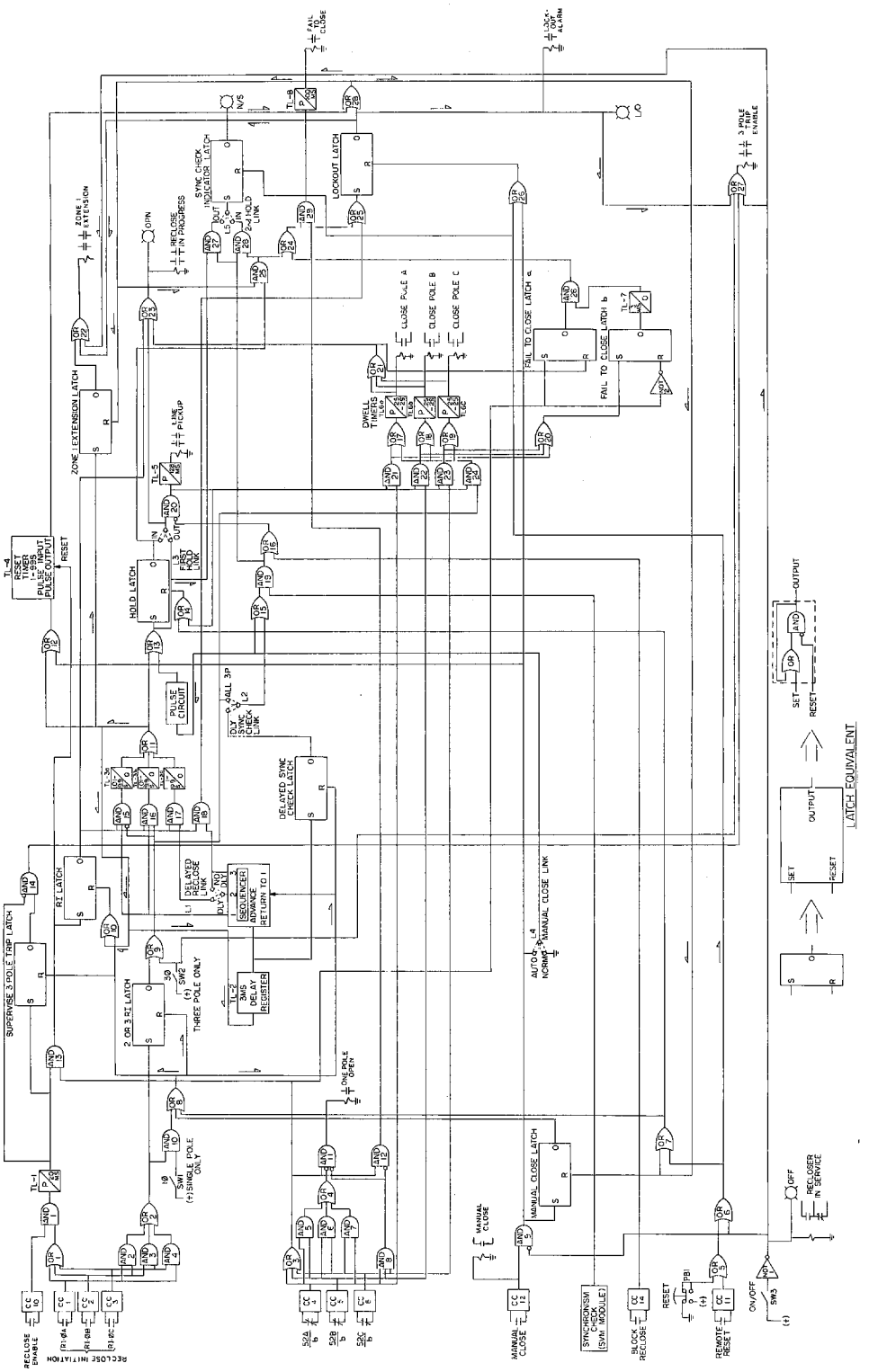

Figure 1 (0145D8968-0) Logic Diagram for SRS1000 Recloser

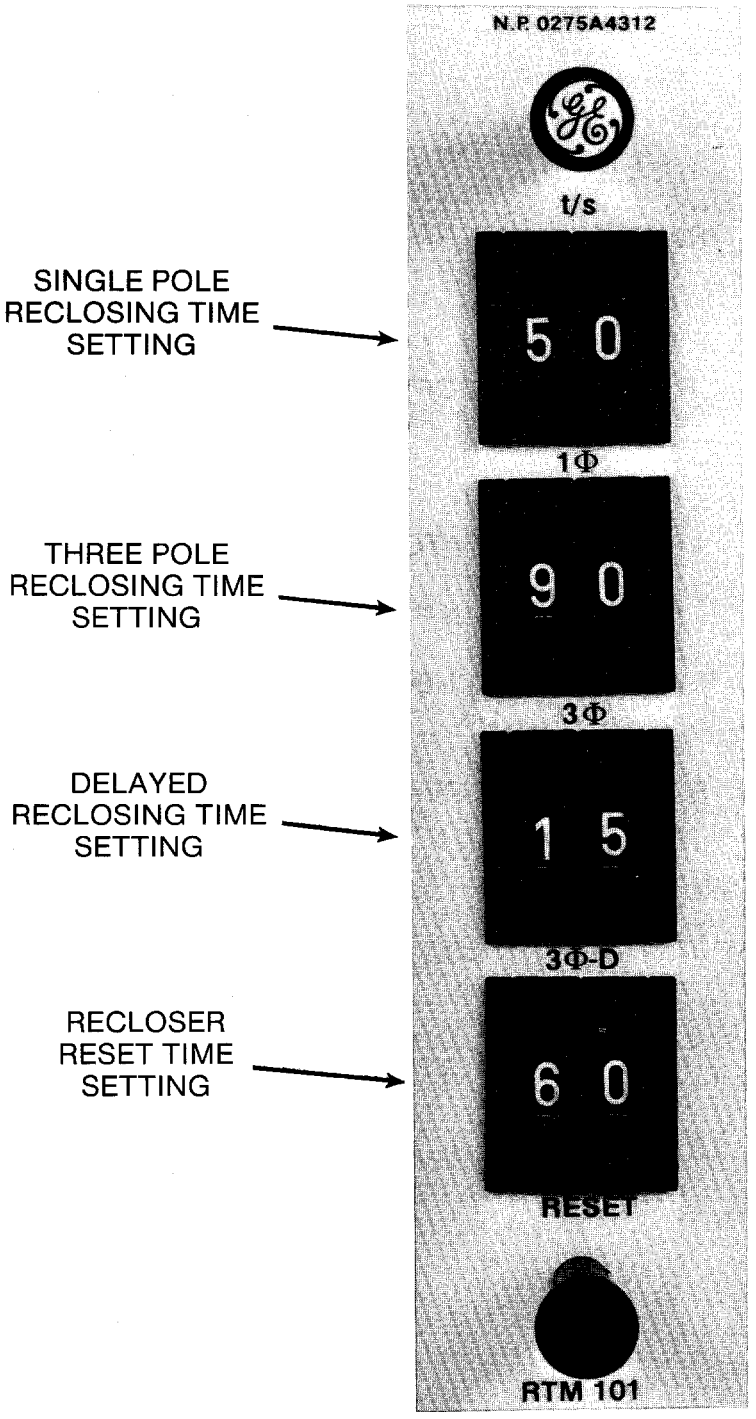

Figure 2 (8043726-0) Front View Photograph of RTM101 Module

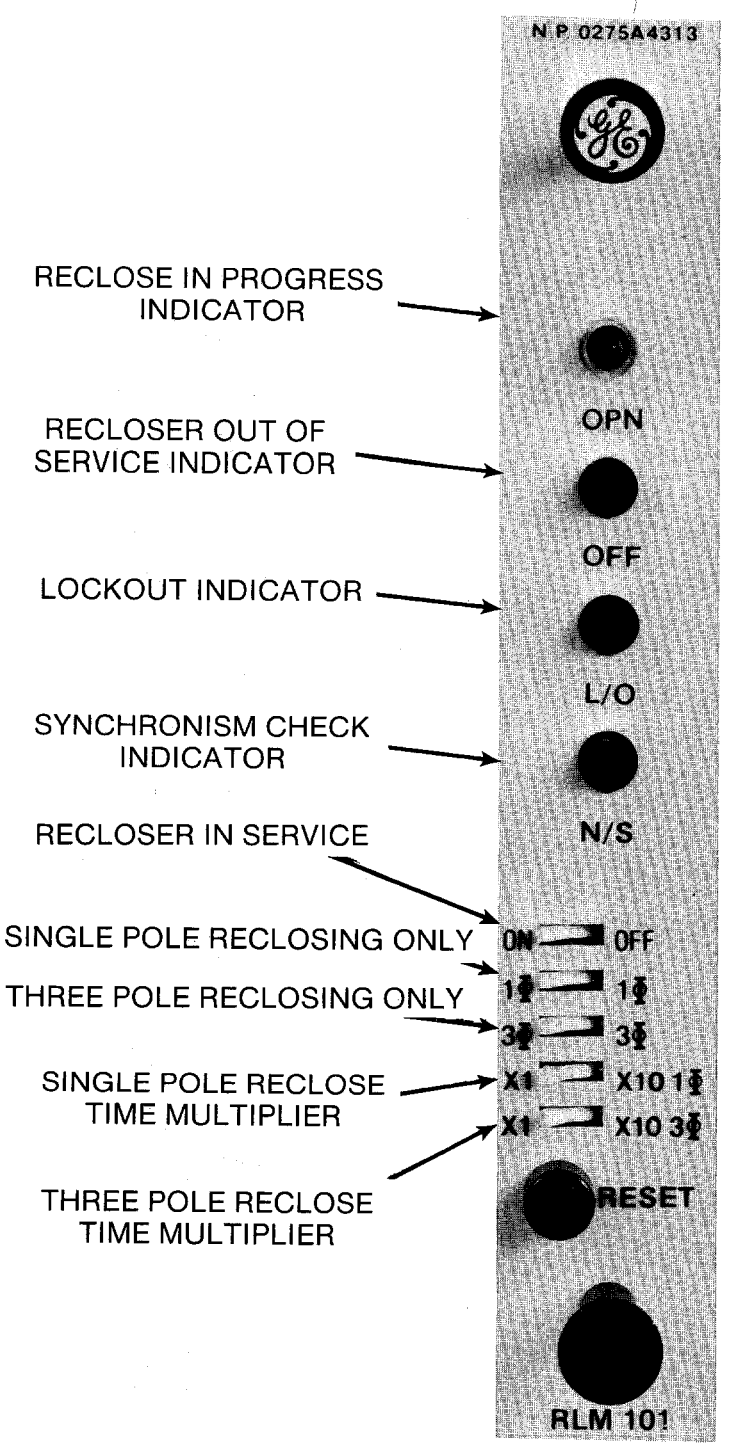

Figure 3 (8043727-0) Front View Photograph of RLM101 Module

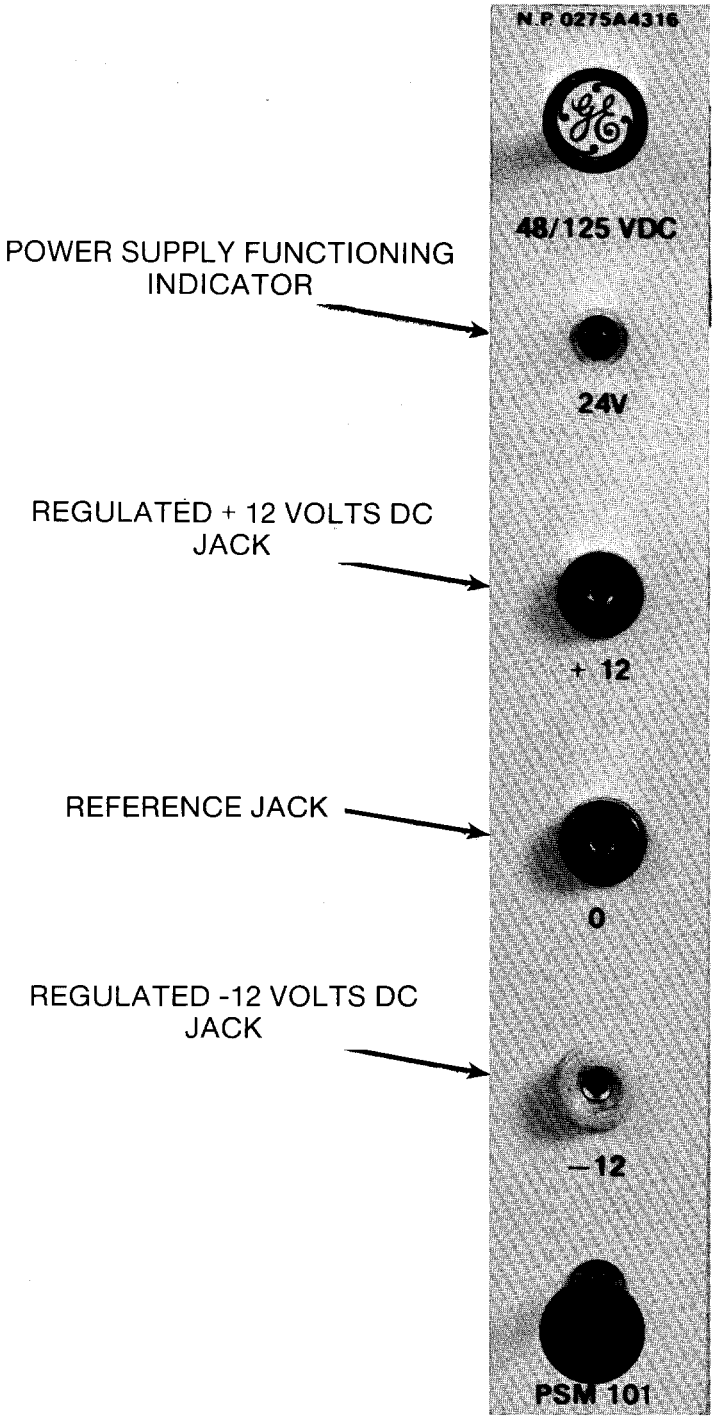

Figure 4 (8043729-0) Front View Photograph of PSM101 Module

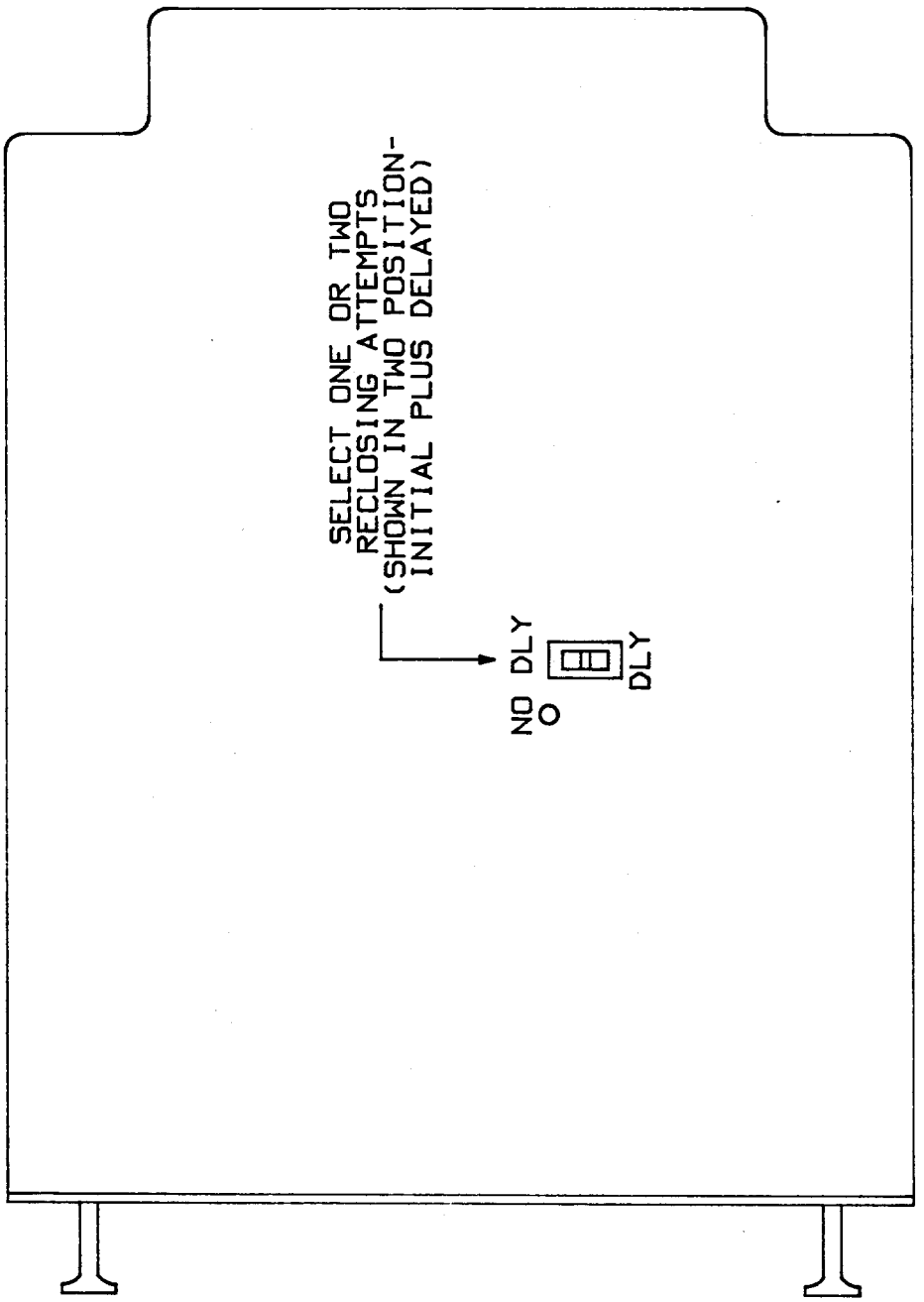

Figure 5 (0285A6624-0) Internal Link - RTM101 Module

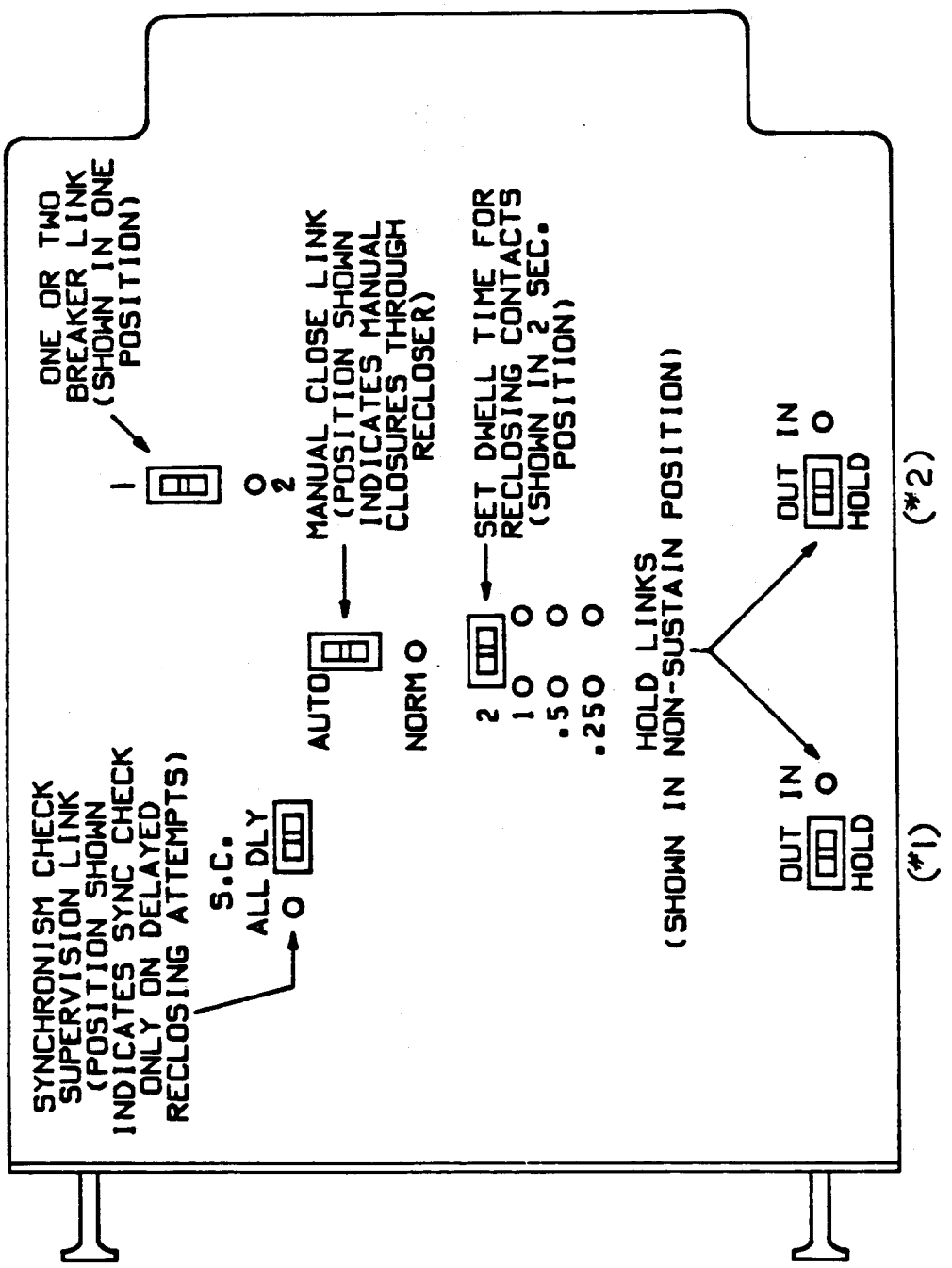

Figure 6 (0285A6623-0) Internal Links - RLM101 Module

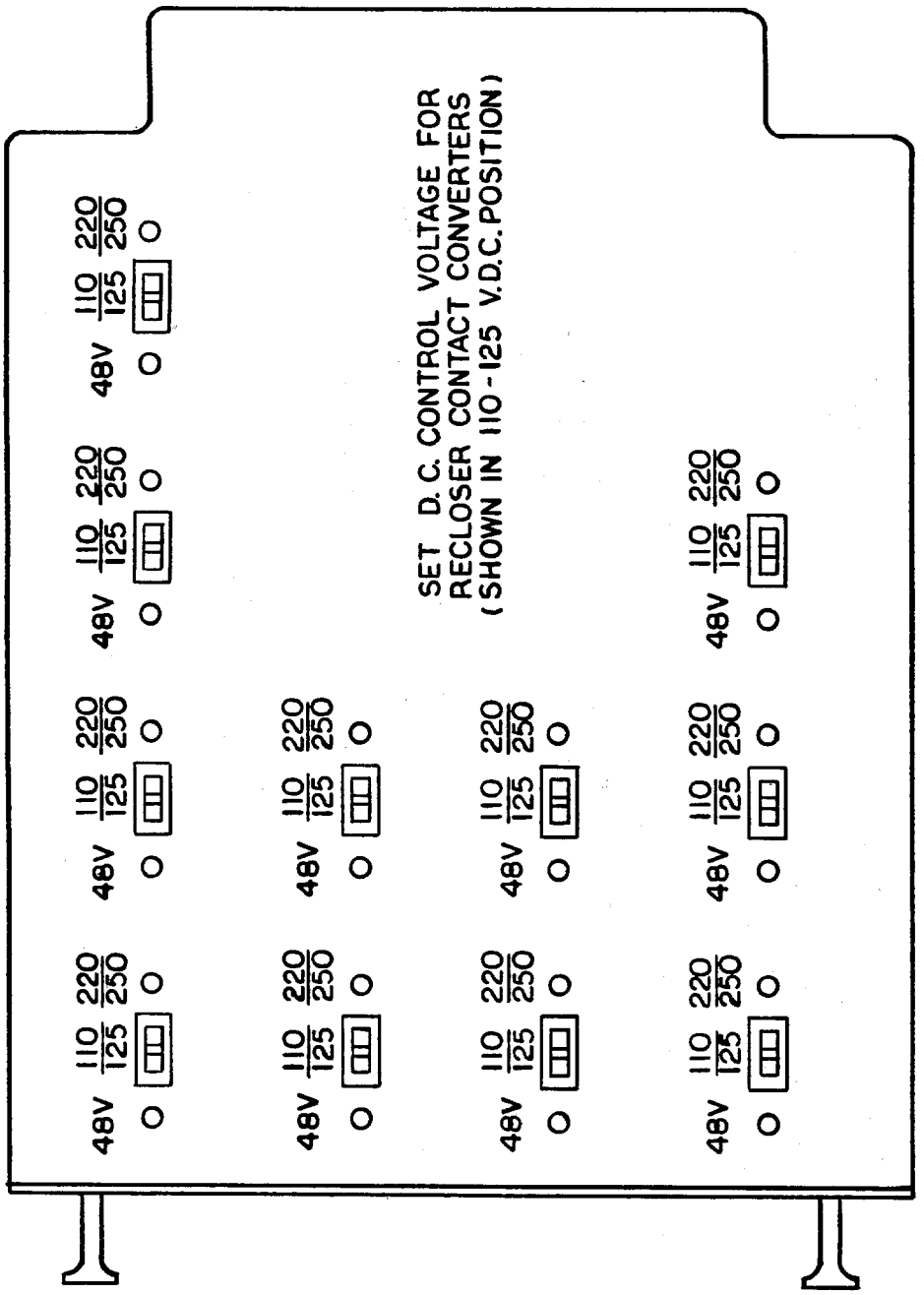

Figure 7 (0285A6625-1) Internal Links - ROM101 Module

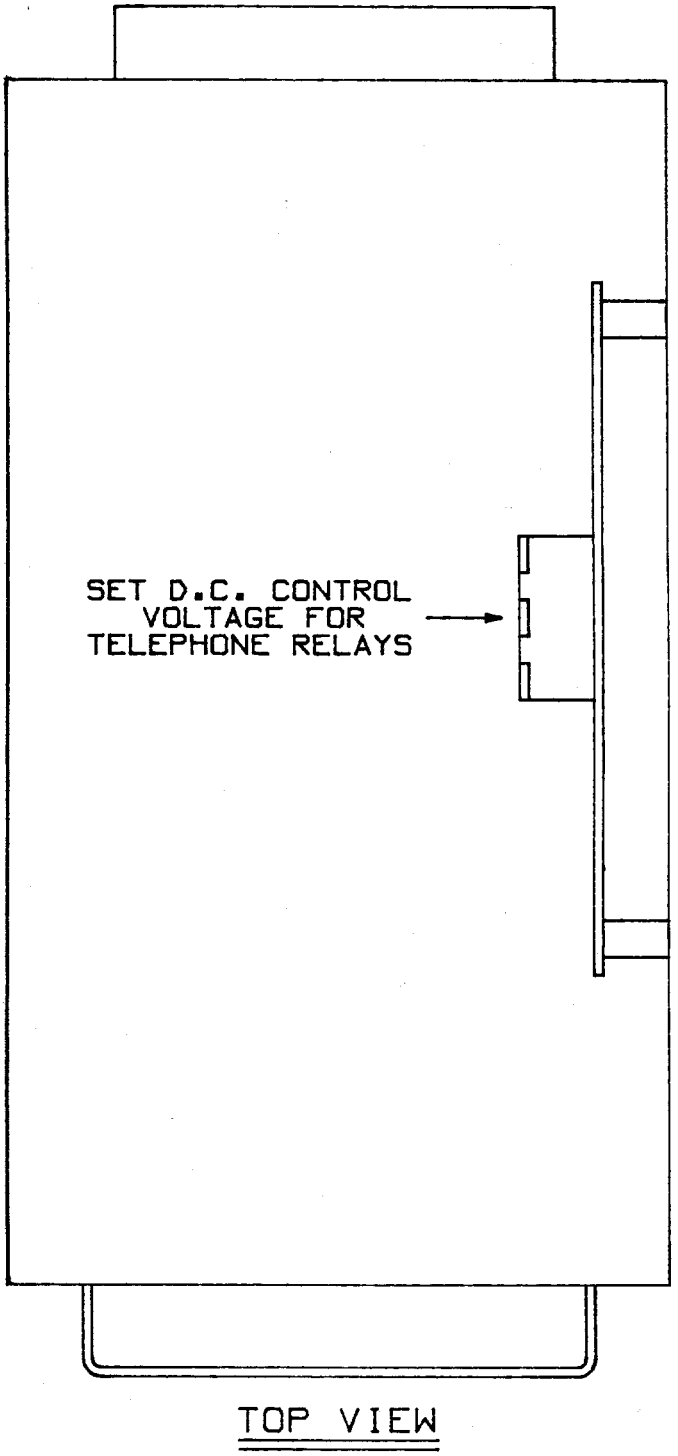

Figure 8 (0285A6626-0) Internal Link - MGM Module

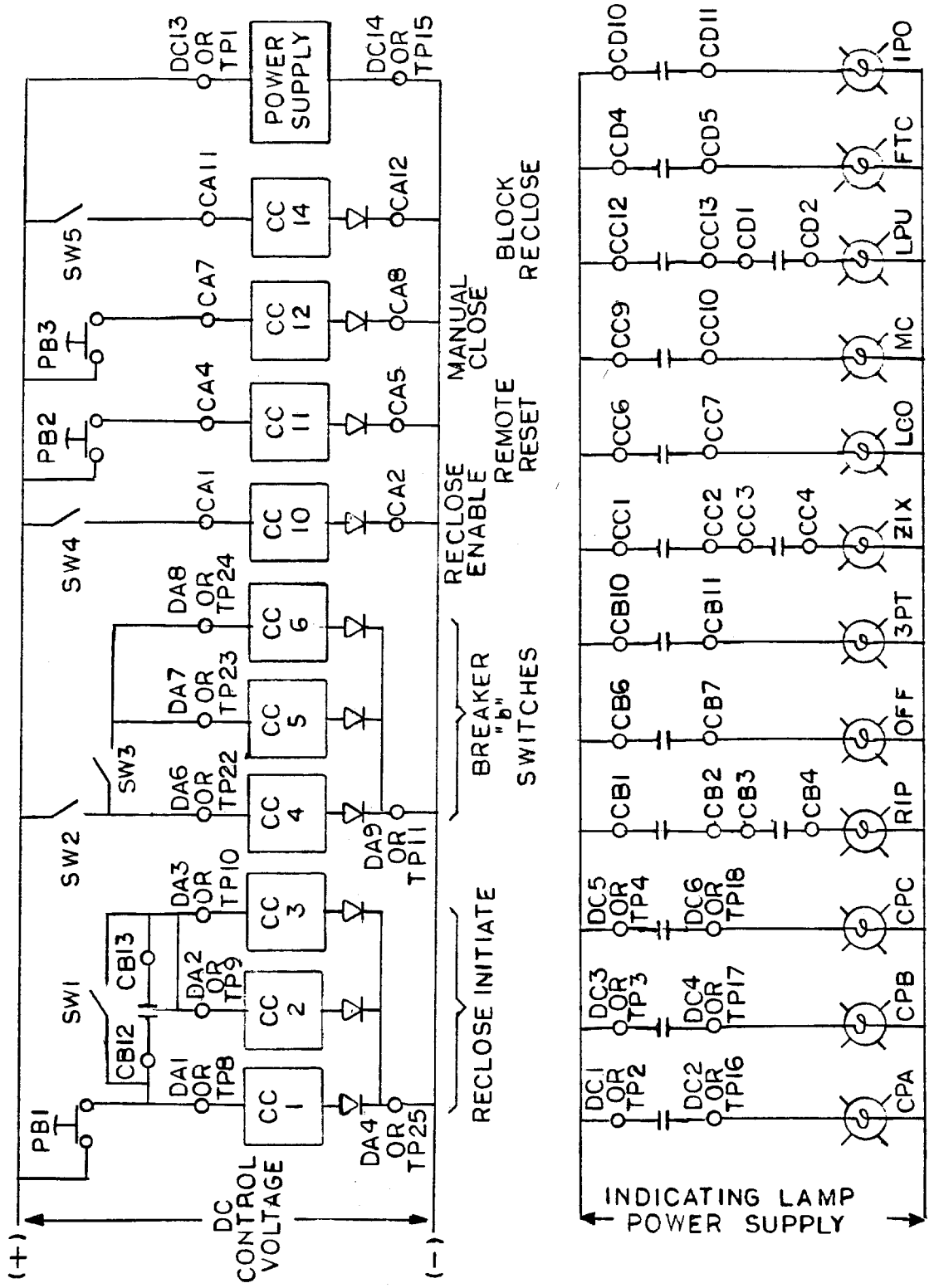

Figure 9 (0285A8122-) Test Circuit for Acceptance Tests - Reclosing Functions

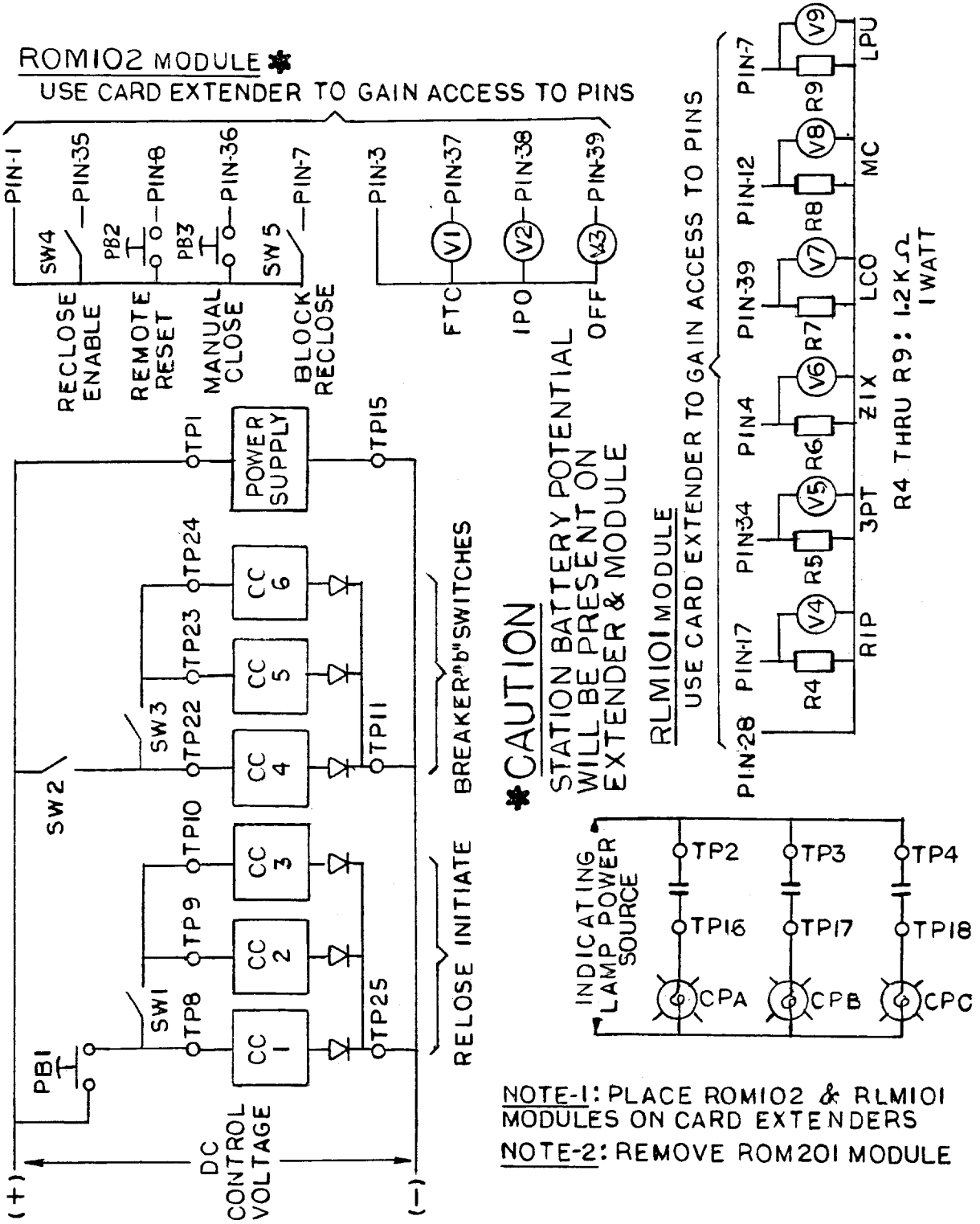

Figure 10 (0285A8121-0) Test Circuit for Periodic Tests - Reclosing Functions

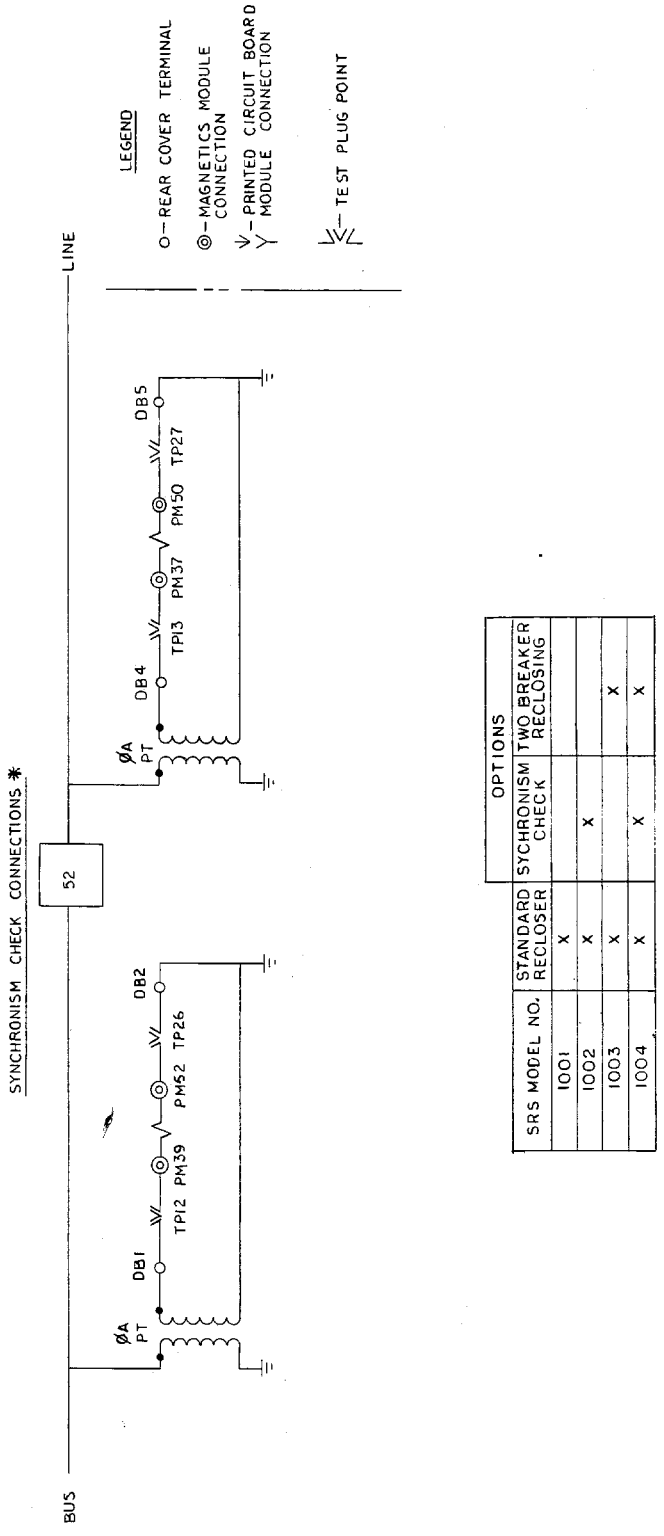

Figure 11A (0138B7649 Sh. 1, Rev. 1) Elementary Diagram - AC Connections, Sync Check

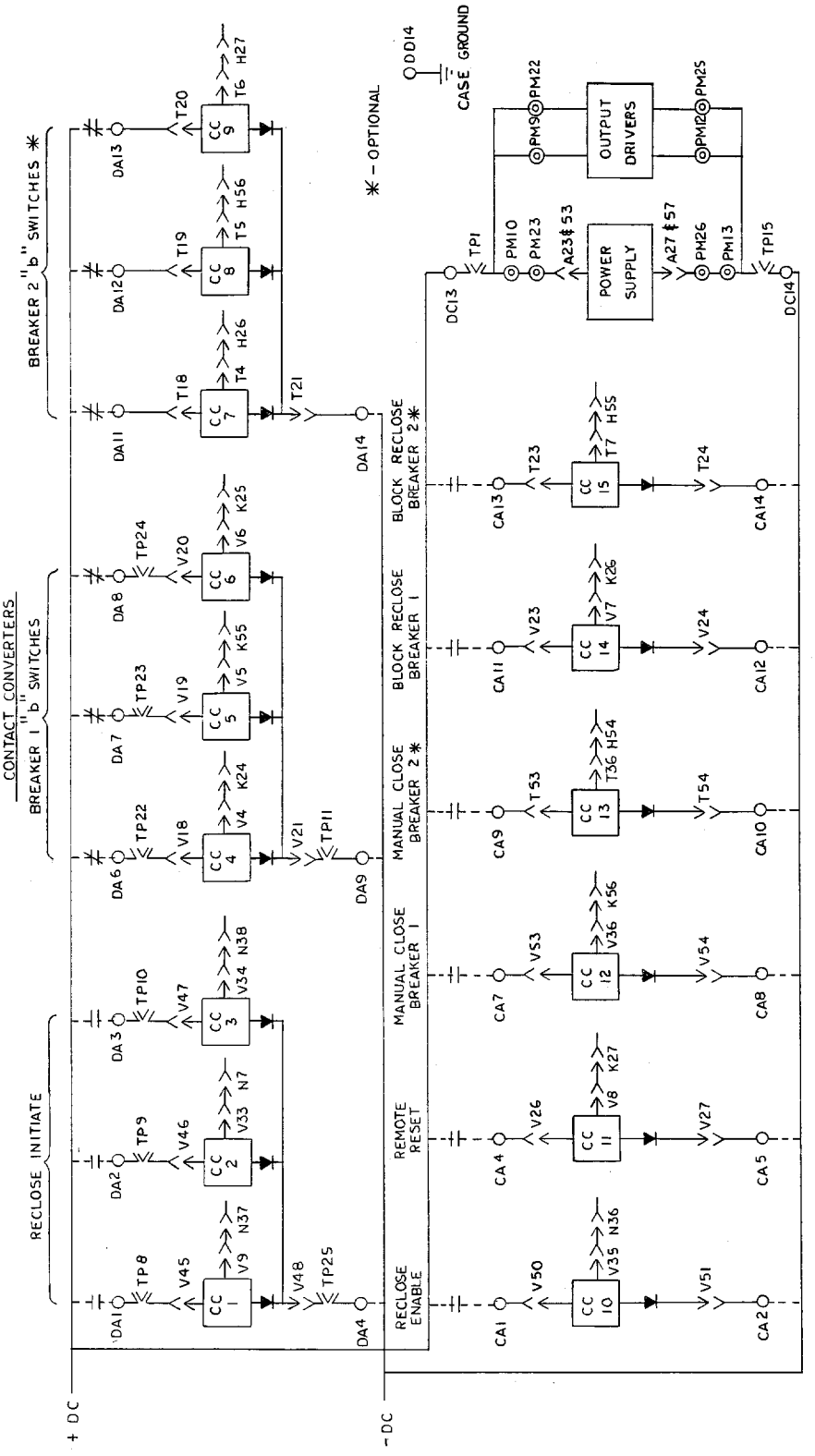

Figure 11B (0138B7649 Sh. 2, Rev. 0) Elementary Diagram - DC Connections, Contact Converters

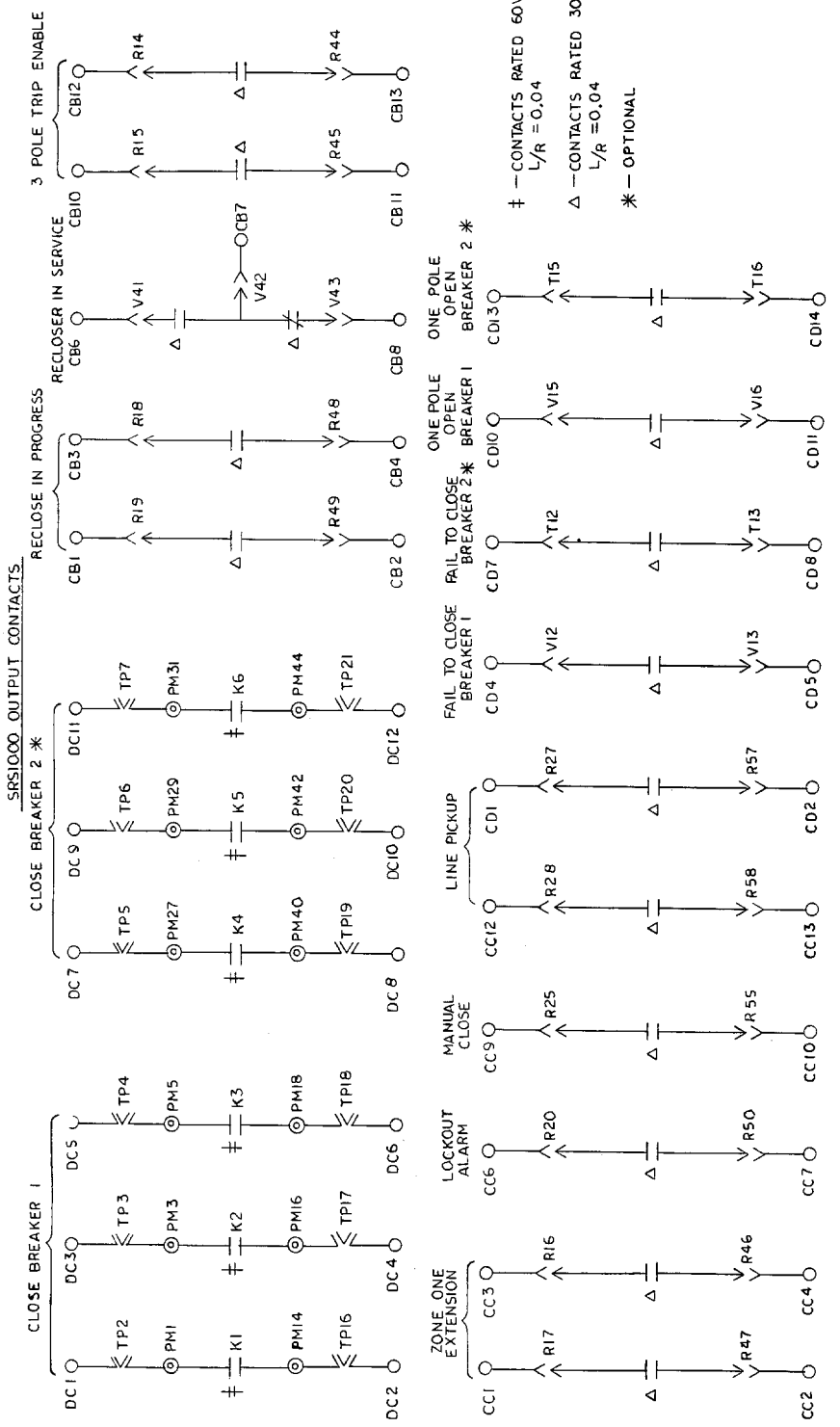

Figure 11C (0138B7649 Sh. 3, Rev. 0) Elementary Diagram - DC Connections, Output Contacts

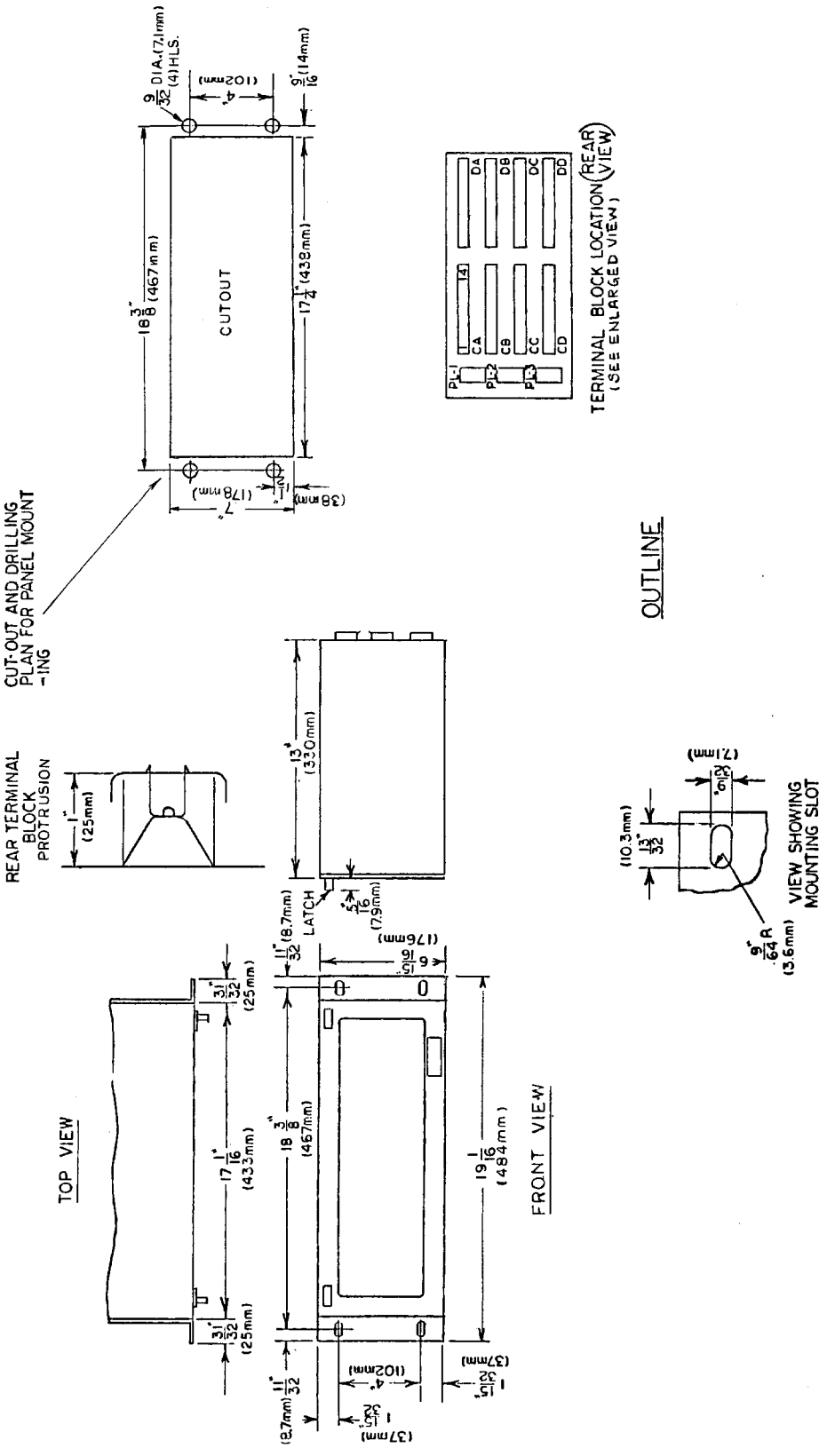

Figure 12 (0183B3626-0) Outline and Mounting Dimensions

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10-83

INSTRUCTIONS

GEK-86057
ADDENDUM

SYNCHRONISM CHECK FUNCTION
(Optional)

GENERAL ELECTRIC

TABLE OF CONTENTS

Section	Page
SYNCHRONISM CHECK FUNCTION (Optional)	3
DESCRIPTION OF HARDWARE	6
SETTINGS PROCEDURES	9
APPLICATION AND CALCULATION OF SETTINGS	11
TESTING	15
TABLE I	15
TABLE II	15
SPECIFICATIONS	19
ILLUSTRATIONS	19

SYNCHRONISM CHECK FUNCTION
(Optional)

Overall

Figure 1 is a combination block/logic diagram of the overall sync check circuit. The bus and line voltages are stepped down by external PTs and again by PTs within the relay, this time to a level compatible with the internal electronics. The relay PTs are located in the magnetics module of case B. The remainder of the circuitry depicted in Figure 1 is located in the SVM101 module.

The line voltage is supplied to both a live and a dead detector, each of which compare the magnitude of the voltage to a preset (adjustable) threshold. The live detector produces an output when the voltage exceeds the live threshold and the dead detector produces an output when the voltage is less than the dead threshold. In other words, outputs are produced when conditions are as desired for reclosing. The bus voltage is similarly sent into separate live and dead detectors.

In addition to the magnitude detectors, the bus and line voltages are together sent into: 1) a combined angle detector and high set slip detector and 2) a low set slip detector. Unlike the magnitude detectors, these circuits produce outputs when conditions are undesirable for reclosing, i.e., 1) the angle is out of limits or the slip exceeds the high set cut-off, or 2) the slip exceeds the low set cut-off.

The mode of supervision is selected by closing the appropriate switch. More than one switch may be closed at a time to obtain a combination of functions.

Consider the case of reclosing under dead line, dead bus conditions. Closing the DLDB switch enables AND1 while AND2, 3 and 4 remain disabled. For AND1 to produce an output, both the dead line and dead bus detectors must be issuing outputs, indicating that the line and bus voltages both register as being dead. In the dead line, dead bus mode, an output from AND1 constitutes the "Permit Reclosing" signal through OR2. Its absence results in reclosing being blocked. The dead line, live bus and live line, dead bus modes operate in similar fashion through AND2 and AND3, respectively.

In the sync check mode (SYNC CK switch closed), an output is required from AND4 to permit reclosing. This will occur only when: 1) the line and bus are both live, and 2) there is no output from either the angle and high set slip detector or the low set slip detector. An output from either of these detectors blocks reclosing by disabling AND4 at its NOT input (via OR1).

Angle and High Set Slip Detectors

The angle and high set slip detectors are depicted in Figure 2. The bus and line voltages are brought into an anti-coincidence circuit which produces a positive output only when the instantaneous voltages are of opposite polarity, either the bus

positive and line negative or vice versa. When the instantaneous voltages are both positive or both negative, there is no output from the anti-coincidence circuit. Thus, the output of the anti-coincidence circuit (waveform A) can be considered as a pulse train in which the width of the positive pulses (or blocks) is equal to the angular separation Ø (phase shift) between the bus and line voltages.

The output of the anti-coincidence circuit is fed into the angle timer. This timer produces an output only when the width of an input block exceeds the angle setting θ (adjustable). The timer output consists of a narrow pulse (waveform B) which is issued at the instant that the angle setting delay elapses.

$$\text{Angle Setting Delay} = \frac{\theta}{360^{o}} \times \frac{1}{f} \text{ seconds}$$

where: f is the nominal system frequency (50 or 60 hertz)

A pulse from the angle timer sets the output flip flop (FF1), resulting in a continuous "Block Reclosing" signal (waveform D). The pulse also initiates the high set slip timer. This timer will produce an output only if the time delay T_{HS} elapses before the next pulse comes along because each successive pulse resets and re-initiates the timer.

$$T_{HS} = \frac{1}{F_{HS}} \times \frac{2\theta}{360^{o}}$$

where: F_{HS} is the high set slip cut-off (in hertz)

By coupling the angle setting into the high set slip timer, the angle setting may be changed without having to readjust the slip timer setting, F_{HS}.

An output from the high speed slip timer (waveform C) resets FF1 and thereby permits reclosing.

Consider the example of the bus and line voltages being at exactly the same frequency (no slip) and having an angular separation of Ø between them which exceeds the setting θ. The waveforms will be as illustrated in Figure 2, item 1. The dots at the left of each waveform indicate the reference point.

The output from the high set slip timer (waveform C) is continuously low because the steady stream of pulses from the angle timer (waveform B) continually reset and re-initiate the slip timer, preventing it from timing out. Therefore, FF1 gets set and never gets reset, resulting in the "Block Reclosing" output shown in waveform D.

If Ø is less than θ, waveforms B, C and D will all be continuously low.

Now consider the example of a frequency difference between the voltages which is less than the high set slip cut-off, F_{HS}. The waveforms will be as illustrated in Figure 2, item 2. Eleven cycles of V_L are shown in the same interval as 12 cycles of V_B (90^{o} to 90^{o}). This is one complete slip cycle and the angular labels above the V_B wave and around the circle are slip degrees. If the V_B sine wave is

taken to represent 60 hertz, the V_L sine wave has a frequency of 11/12 x 60 = 55 hertz and the slip rate is 60 - 55 = 5 hertz. Although this exceeds the maximum acceptable setting of the circuit (2.5 hertz), it is shown for the sake of discussion to be less than the high set slip setting. A slip of 5 hertz was used only so that the diagram might be clear and not be unreasonably long.

The voltages are shown to be 90 degrees out of phase initially (V_L lagging V_B). This is an arbitrary starting point as far as the high set slip detector is concerned. The anti-coincidence circuit output blocks vary in width as the angular separation between the two voltages changes throughout the slip cycle (waveform A).

The angle timer measures the varying anti-coincidence blocks and responds accordingly. When the block width exceeds the angle setting, a pulse is produced. As the angular separation increases, the block width may be two or more mutliples of the angle setting, in which case the angle timer will output two or more pulses. For example if the angle is set to 35^o, the maximum anti-coincidence block in the slip cycle (at 180^o) has a width of 180/35 = 5.14 multiples of the angle setting and the angle timer will output 5 consecutive pulses (integer part only).

The angle timer produces no output during the portion of the slip cycle in which the angular separation between the voltages is less than the angle setting θ. This dead band is labelled the slip measurement interval on waveform B. It represents a reclosing "window" so to speak, having a dimension of 2θ slip degrees. The slip measurement interval will always have a dimension of 2θ slip degrees, but its duration (t_{SMI}) will decrease as the slip rate increases and vice versa. It therefore provides a convenient means of measuring the slip.

$$t_{SMI} = \frac{1}{f_s} \times \frac{2\theta}{360^o}$$

where: f_s is the actual slip frequency.

The absence of pulses from the angle timer during the slip measurement interval gives the slip timer an opportunity to time out because it is not being reset and re-initiated. After a delay of T_{HS} following the last pulse before the slip measurement interval, the high set slip timer produces an output (waveform C) which resets FF1 and thereby removes the "Block Reclosing" signal. This signal reappears on the first pulse from the angle timer. Its momentary absence, however, provides an opportunity to reclose (waveform D).

If the slip is greater than the high set cut-off ($f_s > F_{HS}$), t_{SMI} will be less than T_{HS}, the slip timer will not time out, and reclosing will be continuously blocked.

Low Set Slip Detector

This detector determines the rate of slip by measuring the time it takes for the line voltage to traverse 90 degrees in the slip cycle (one quadrant). This time, T_{90^o}, is then compared against the time limit established by the low set slip cut-off, T_{LS}.

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

where: F_{LS} is the low set slip cut-off (in hertz) and the factor of 1/4 pertains to one quadrant.

If T_{90^o} is less than T_{LS}, the rate of slip exceeds the cut-off (F_{LS}) and reclosing is blocked. If T_{90^o} is greater than T_{LS}, the rate of slip is less than the cut-off, and reclosing is permitted.

DESCRIPTION OF HARDWARE

SVM101 - Synchronism Check Module (Optional)

This module contains the synchronism check circuitry used to supervise reclosing. It includes the following:

(1) Voltage detectors to determine if the line and bus are dead or live. Reclosing may be permitted or blocked for any combination of dead and live line and bus.

(2) An angle measurement circuit to determine if the phase angle between the two voltages is within the selected limit. Reclosing is blocked when the angle is outside the limit.

(3) A low set slip measurement circuit to determine if the frequency difference between the two voltages is within the selected limit (low set slip cut-off). Reclosing is blocked when the slip exceeds the setting.

(4) A special high set slip measurement circuit which permits a fast synchronism check in the interval before the low set slip circuit has enough time to make its measurement, provided the angle between the bus and line voltages does not at any point exceed the angle setting (V_L phasor never leaves reclosing window).

(5) A "dead time" timer set to coordinate with the reclosing time of the remote breaker. If the remote breaker does not close in the allotted time, the high set slip detector may issue an erroneous output. The "dead time" timer prevents this by disabling the high set slip detector after the allotted time has elapsed. Slip measurement is then made by the low set slip detector only.

Front Panel Switches

Identity	Type	Function	Description
ANGLE	Double Digit Thumbwheel	Angle Setting	Determines the phase angle limit (in degrees) between the bus and line voltages for which reclosing is permitted.

Front Panel Switches (continued)

Identity	Type	Function	Description
SYNC CK	Toggle	Synchronism Check Mode	Places the SVM module in the synchronism check mode so that reclosing is supervised by the angle and slip detectors. In addition, both voltages must be above their respective live thresholds to permit reclosing.
LLDB	Toggle	Live Line, Dead Bus Mode	Permits reclosing only when the line voltage is above its live threshold (adjustable) and the bus voltage is below its dead threshold (also adjustable).
DLLB	Toggle	Dead Line, Live Bus Mode	Permits reclosing only when the line voltage is below its dead threshold and the bus voltage is above its live threshold.
DLDB	Toggle	Dead Line, Dead Bus Mode	Permits reclosing only when the line and bus voltages are below their respective dead thresholds.

Internal Switches

Identity	Type	Function	Description
PT VOLTAGE	4 stage Miniature Toggle (1 stage not used)	Nominal PT Secondary Voltage	The setting of these switches determines the nominal phase-to-neutral AC voltage from which the live and dead thresholds are established.
BUS LIVE	4 stage Miniature Toggle	Threshold for Live Bus Detector	The setting of these switches determines the percentage of the nominal voltage above which the bus is considered live.
BUS DEAD	4 stage Miniature Toggle	Threshold for Dead Bus Detector	The setting of these switches determines the percentage of the nominal voltage below which the bus is considered dead.
LINE LIVE		Same as for Bus Live (adjusted separately)	
LINE DEAD		Same as for Bus Dead (adjusted separately)	

Internal Switches (continued)

Identity	Type	Function	Description
LOW SET SLIP	4 stage Miniature Toggle	Low Slip Detector Setting (Cut-off)	The setting of these switches establishes the slip rate (F_{LS}) beyond which reclosing will be blocked (except instantaneous reclosing).
HIGH SET SLIP	4 stage Miniature Toggle	High Slip Detector Setting (Cut-off)	The setting of these switches establishes the cut-off (F_{HS}) for the special high speed slip detector used to supervise instantaneous reclosing.
DEAD TIME	6 stage Miniature Toggle	"Dead Time" Timer Setting	The setting of these switches establishes the time (following the trip) after which the high set slip detector is disabled.
50 Hz/60 Hz	First Quarter of 4 stage Miniature Toggle (Double Stages)	System Frequency Setting	This switch adjusts the synchronism check circuitry for the proper system frequency
1	Second Quarter of 4 stage Miniature Toggle	Low Set Slip Cut-off Multiplier	When set to the right (positioned towards bottom edge of the board) this switch multiplies the slip frequency setting on the LOW SET SLIP switches by ten
2	Third Quarter of 4 stage Miniature Toggle	Low Set Slip Control for second breaker	This switch is not used in the SRS. It should be set to the left (positioned towards top edge of board).
LOW SET ONLY	Fourth Quarter of 4 stage Miniature Toggle	Cancels High Set Slip	This switch effectively cancels synchronism check via the high set slip detector by requiring a low set slip measurement to be made before permitting reclosing.

Internal Light Emitting Diodes (LEDs)

Identity	Color	Indication Given	Description
TL1	Red	Angle Out-of-Limits	This LED lights whenever the phase angle between the line and bus voltages exceeds the angle setting on the front panel of the module.

Internal Light Emitting Diodes (LEDs) (continued)

Identity	Color	Indication Given	Description
TL2	Red	Slip Exceeding Low Set Cut-off	This LED lights if the frequency difference between the line and bus voltages exceeds the low set cut-off, but it lights only after the slip measurement has been made.
TL3	Red	OK to Reclose	This lights whenever the SVM101 module is outputting a signal which is permitting reclosing. It works in conjunction with the voltage check modes (DLDB, etc.) as well as with the sync check mode.

SETTINGS PROCEDURES

Auxiliary Functions

Supervision of Reclosing by Synchronism Check

If the recloser purchased includes the synchronism check option, it will contain an SVM101 module. Three pole reclosing attempts may then be supervised by the synchronism check signal. If it is desired to have this supervision on both first and second reclosing attempts, the ALL3P/DLY link in the RLM101 module should be placed in the ALL3P position. If it is desired to supervise only the second (delayed) reclosing attempt, place the link in the DLY position.

SYNCHRONISM CHECK MODULE (SVM101 - Optional)

Mode of Operation

There are four modes by which to supervise reclosing:

1. SYNC CK - Synchronism check using angle and slip detectors. This requires live line, live bus conditions.
2. LLDB - Live Line, Dead Bus
3. DLLB - Dead Line, Live Bus
4. DLDB - Dead Line, Dead Bus

The desired mode is selected by closing (moving to the right) the appropriate switch on the SVM101 module. The functions may be combined by closing more than one switch at a time. If none of the switches are closed, reclosing will always be blocked.

Synchronism Check Settings

Angle

The maximum phase angle between the bus and line voltage for which reclosing is to be permitted is set by the double digit thumbwheel switch on the SVM101 module. The digits are advanced by the lower pushbuttons labelled (+) and reduced by the upper pushbuttons labelled (-). The value displayed is in degrees.

Low Set Slip Cut-off

The low set slip cut-off value is set by positioning four miniature toggle switches within the SVM101 module. The setting is equal to the sum of the values corresponding to those switches which are closed. The switch values (in hertz) are given on the printed circuit board. The setting may be multiplied by ten by moving the miniature switch adjacent to the 50 Hz/60Hz switch (switch labelled 1) to the right (towards bottom of board).

High Set Slip Cut-off

The high set slip cut-off value is also set by positioning four miniature toggle switches within the SVM101 module. The setting is equal to the sum of the values corresponding to those switches which are closed. The switch values (in hertz) are given on the printed circuit board.

Low Set Slip Only

The capability of the sync check circuit to permit a high speed reclosure based on an output from the high set slip detector may be defeated by positioning the miniature switch labelled LOW SET ONLY in the SVM101 module to the right (towards bottom of board). This requires that a low slip measurement be made before reclosing is permitted.

"Dead Time" Timer Setting

This time (T_D) is set by positioning six miniature toggle switches within the SVM101 module. The setting is equal to the sum of the values corresponding to those switches which are closed. The switch values (in seconds) are given on the printed circuit board.

Voltage Threshold Settings

Potential Transformer Voltage

The synchronism check circuit must be set according to the nominal secondary voltage of the potential transformers connected to the SRS. This setting is made using four miniature toggle switches within the SVM101 module, designated PT VOLTAGE. One of these should be closed, according to the value given on the printed circuit board (phase-to-neutral voltage).

Live Bus

The voltage threshold which determines whether or not the bus is to be considered live is set using four miniature toggle switches within the SVM101 module designated BUS LIVE. The setting is made in terms of a percentage of the nominal voltage and is equal to 65 percent plus the sum of the values corresponding to the switches that are closed. The values are given on the printed circuit board.

Live Line

Similar to Live Bus.

Dead Bus

The voltage threshold which determines whether or not the bus is to be considered dead is set in similar fashion to the live thresholds. The setting is equal to ten percent plus the sum of the values corresponding to the switches in the BUS DEAD group that are closed.

Dead Line

Similar to Dead Bus.

Frequency Setting

The synchronism check circuit is set for the nominal system frequency by positioning the 50 HZ/60 HZ miniature switch within the SVM101 module.

APPLICATION AND CALCULATION OF SETTINGS

Synchronism Check Function

An optional synchronism check function may be included to supervise the closing of the breaker. Typically, a synchronism check function checks the angle between the voltages on the bus and line sides of the breaker and will produce an output if the angle is within set limits for a set period of time. The combination of angle and time settings establishes the slip cut-off frequency; that is, the slip frequency above which the synchronism check function will not permit reclosing. For any given closing angle, a lower slip cut-off will result in a longer time delay. Because this time delay is introduced for all measurements, a requirement for high speed reclosing and low slip cut-off settings may result in conflict.

The synchronism check function used in the SRS system (SVM101 module) has been designed to permit fast reclosing while setting a reasonably low slip cut-off frequency. To accomplish this, the relay is provided with both a high set and a low set slip cut-off circuit. The low slip cutoff setting is based on the maximum slip that can be tolerated and still allow reclosing. The high slip cut-off setting is a function of the set closing angle, and the time that the line is de-energized.

To explain the operation of this sync check function, assume the following:

1. The line shown in Figure 5 has a fault cleared by opening breakers 1 and 2. Breaker 2 is then allowed to close without synchronism check, thereby re-establishing the line voltage, V_L, at breaker 1.

2. The bus voltage, V_B, is assumed to be fixed in phase and is the reference voltage.

3. The line voltage, V_L, can appear anywhere relative to V_B and may be rotating in either direction, relative to V_B, if the systems on each side of the breaker are out of synchronism.

CASE 1:

The systems are in synchronism, but separated by an angle $\emptyset$.

A. If the angle between V_L and V_B is greater than the set closing angle θ, then the synchronism check function will not operate and reclosing will not be permitted.

B. If the angle between V_L and V_B is less than the set closing angle θ, then the synchronism check function will operate and permit reclosing, but only after a time delay that is related to the high slip cut-off setting, F_{HS}, and the set closing angle θ. This time delay is expressed as follows:

$$T_{HS} = \frac{1}{F_{HS}} \times \frac{20}{360} \times 1000$$

where: T_{HS} is the time delay in milliseconds
F_{HS} is the high slip cut-off setting in hertz
θ is the set closing angle in degrees

Typically, the high set slip cut-off frequency would be set equal to the slip frequency required to traverse $(270 - \theta)^0$ during the time that the line is dead; that is:

$$F_{HS} = \frac{(270 - \theta)}{(360)\ (T_{LD})}$$

where: T_{LD} is the time that the line is dead in seconds. This is equal to the time setting on the recloser at Breaker 2.

The high slip cut-off frequency setting, F_{HS}, is based on $(270 - \theta)$ to insure that, if the slip rate is less than F_{HS}, V_L will have traversed less than three quadrants during the interval when both breakers are open (dead time). If the slip rate is just slightly less than F_{HS}, V_L will return in quadrant III for clockwise rotation, or quadrant II for counterclockwise rotation (Figure 5). If V_L does return in quadrant II or III, the low slip cut-off frequency measurement will be set up and the actual slip will have to be less than the low slip cut-off setting to permit reclosing.

There are three possible conditions that might 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 slip cut-off circuit will prevent reclosing. A second condition is an extremely low slip frequency. For this condition, reclosing will be permitted provided that V_L remains within the closing angle for the time associated with the high set slip measurement (T_{HS}). If V_L has not moved outside the closing angle during the time that the line was de-energized, there is little risk in permitting reclosing without making a low slip cut-off measurement.

The third condition that might cause V_L to appear in quadrant I or IV is a reclosing attempt at the remote end (breaker 2) that has been delayed longer than the normal reclosing time. An example of a delayed reclosure would be a manual closing of the breaker. The SVM module includes a timer whose output enables the low slip cut-off circuit, thus preventing the high slip cut-off and angle check circuits from permitting a reclose attempt until the low set slip cut-off circuit 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 time that the line is de-energized, plus a suitable margin.

The setting is:

$$T_D = [(\text{time that the line is de-energized}) + (\text{channel time}) \times 1.1]$$

The channel time is included to account for possible differences in clearing time of the two line terminals due to a channel trip at one terminal and a direct trip at the other

CASE 2:

The systems are out of synchronism, and V_L is rotating relative to V_B

A. If the voltage V_L plots in quadrants I or IV when the voltage is re-established, and if it enters the set closing angle without entering either quadrant II or III, and if it remains within the closing angle longer than the time associated with the high set slip measurement, then a sync check output will be provided after a time delay established by the high slip cut-off setting (T_{HS}).

B. If the line voltage V_L returns in quadrants II or III, or rotates into quadrants II or III from I or IV, the low slip cut-off circuit is enabled and used to supervise the closing angle and high slip cut-off circuits. Thus, a sync check output cannot be produced unless the slip is less than the low slip cut-off setting and the voltage V_L remains within the closing angle for the time established by the high slip cut-off setting (T_{HS}).

The low set slip frequency cut-off circuit establishes the slip rate by comparing the time that V_L remains in any quadrant against a reference time established by the low set slip cut-off setting. This reference time

is the time it takes the voltage phasor, V_L, to traverse 90° (one quadrant) at a frequency equal to the low slip cut-off setting. This is expressed by:

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

where: F_{LS} is the low slip cut-off setting
T_{LS} is the time required to traverse 90°

If V_L remains in a quadrant longer than the reference time, then the slip rate is less than the low slip cut-off setting and the circuit will produce a permissive output signal to enable the angle and high slip cut-off circuits. The low slip cut-off measurement is started whenever V_L enters a new quadrant; however, if a permissive signal was generated in the previous quadrant, it will remain unless the slip is determined to be greater than the low slip cut-off, at which time the permissive signal will be removed.

If V_L returns in quadrant II (Figure 5) and is rotating in a counterclockwise direction, the low set slip cut-off circuit will produce a permissive output to the angle and high set slip cut-off circuits only if V_L remains in quadrant II longer than the time established by the low slip cut-off setting (T_{LS}). After V_L enters quadrant I, reclosing will be permitted after V_L has entered the set closing angle and remained there for a time established by the high set slip cut-off frequency (T_{HS}). If on the other hand, V_L returns in quadrant II, but does not remain in that quadrant for the time established by the low slip cut-off setting, then the low set slip cut-off circuit will block reclosing. However, after V_L enters quandrant I, a new measurement will be started and if V_L remains in quadrant I longer than the time established by the low slip cut-off setting, (T_{LS}), the low slip cut-off circuit will produce a permissive output which will enable the high set slip cut-off and angle check circuits. Reclosing will then be permitted if the voltage V_L is within the closing angle (or enters the closing angle) and remains there for a time established by the high set slip cut-off setting (T_{HS}).

Similar operation will occur if V_L returns in quadrant III and is rotating in a clockwise direction.

Note that if V_L returns in quadrant III and is rotating counterclockwise, the low set slip cut-off measurement made in that quadrant is inconsequential because reclosing cannot occur until V_L enters the closing angle in quadrant I. Therefore, the evaluation of the slip rate made in quadrant II will determine the operation.

An option exists in the SVM module to prevent a sync check output unless a low slip cut-off measurement is made and satisfied. In this mode of operation, after the frequency is determined to be less than the low slip cut-off setting, the voltage V_L must still remain within the closing angle for a time established by the high set slip cut-off circuit (T_{HS}). This is so even though the high set slip cut-

off feature is not in service. A minimum delay will be obtained by setting the high slip cut-off frequency to its maximum setting.

Voltage Supervision

Because the synchronism check function requires that a voltage be present (live) on both the bus and line sides of an open breaker, this function alone will not allow a dead line to be energized. For those applications that require dead line and/or dead bus operation, the undervoltage detecting functions can be used. Selection switches are provided on the front panel of the SVM101 module to permit reclosing 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 "live" and "dead" voltage levels are adjustable, and may be set with switches located within the SVM101 module.

TESTING

TABLE I
Internal Link and Switch Settings For Acceptance Tests

Module	Link or Switch Identity	Initial Position
SVM101 (optional)	50 HZ/60 HZ SWITCH	ACCORDING TO SYSTEM FREQUENCY
"	LOW SLIP CUT-OFF MULTIPLIER SW	OFF (LEFT TOWARDS TOP)
"	LOW SLIP ONLY SWITCH	OFF (LEFT-TOWARDS TOP)
"	LOW SLIP SECOND BREAKER SWITCH	OFF (LEFT-TOWARDS TOP)
"	LOW SET SLIP CUT-OFF	0.2 HZ
"	HIGH SET SLIP CUT-OFF	1 HZ
"	PT VOLTAGE SWITCHES	69V
"	BUS LIVE SWITCHES	80%
"	LINE LIVE SWITCHES	80%
"	BUS DEAD SWITCHES	20%
"	DEAD LINE SWITCHES	20%
"	DEAD TIME SWITCHES	3.0 SEC

TABLE II
Front Panel Switch Settings for Acceptance Tests

Module	Switch Identity	Initial Setting or Position
SVM101 (optional)	ANGLE	30
"	SYNC CK	LEFT
"	LLDB	LEFT
"	DLLB	LEFT
"	DLDB	RIGHT

Synchronism Check Tests (optional)

Recloser Supervision Tests

In order to test the capability of the SVM101 module to permit and to block reclosing, connect the SRS system according to the test circuit shown in Figure 65. Interconnection cable PL-1 must be inserted for this test. Set the distance relay as follows:

Switch	Location	Setting
Z_P (1 amp relay)	DSM101	75 ohms
(5 amp relay)	"	15 ohms
I (1 amp relay)	DIM101	50 ohms
(5 amp relay)	"	10 ohms
$ØZ_1$, $ØZ_0$	DFM101, 102	75 degrees
K_0	DIM101	4

Adjust V_T to 20 volts. With pushbutton SW1 closed, adjust I_T to 1.7 amperes (five amp relay) or 0.24 amperes (one amp relay). This is sufficient to cause a zone one trip. Release the pushbutton and reset the targets. Also reset the recloser by depresing the RESET pushbutton on the RLM101 module.

Move the 3Ø toggle switch on RLM101 to the right. Apply a pulse of test current and simultaneously close SW3. Verify a three pole trip and nine second three pole reclosure. Open SW3 within two seconds thereafter. Reset the distance relay targets. The recloser should operate as described herein because no connections have been made to the sync check bus and line voltage inputs. They therefore both register as dead, and the SVM101 module is set to permit reclosing under dead line, dead bus conditions.

Reset the recloser by depressing the RESET pushbutton on the RLM101 module. Move the DLDB switch to the left and the SYNC CK switch to the right on SVM101.

Again apply a pulse of test current and simultaneously close SW3. Verify another three pole trip but this time verify that there is no reclosure (the reclosing contacts should not close at any point). After nine seconds the red N/S LED on the RLM101 module should light. This indicates that the reclosing attempt has been blocked by the synchronism check module. In the SYNC CK mode, live line and bus voltages are required to permit reclosing. As mentioned above, with no connections to their inputs, they both register dead and hence reclosing is blocked.

TEST NOTE:

The preceding tests verify the ability of the synchronism check module to work in conjunction with the recloser. With that established, it is recommended that the remaining tests monitor only the output of the SVM101 module so as to avoid repeated runs through the reclosing sequence. The test circuits and procedures described subsequently follow this approach.

Voltage Level Tests

Connect the SRS according to the test circuit given in Figure 6. Interconnection cable PL-1 must be inserted. The SVM101 module should be removed, a card extender inserted, and the module reinserted into the card extender. This is done for the purpose of viewing the three red LEDs within the SVM module. Remove the RLM101 module altogether in order to preclude operation of the recloser.

Apply the line and bus voltages and adjust V_{bus} and V_{line} while watching red LED TL3 (closest LED to bottom edge of board). When this LED is lit, reclosing is permitted; when it is out, reclosing is blocked. Check the thresholds for each mode of operation. To check the thresholds at other than 20 and 80 percent (dead and live, respectively), the setting switches within the module need to be adjusted.

TL3 should be lit only when:

1. LLDB a) V_{line} is above 55 volts and
   b) V_{bus} is below 14 volts

2. DLLB a) V_{line} is below 14 volts and
   b) V_{bus} is above 55 volts

3. DLDB a) V_{line} is below 14 volts and
   b) V_{bus} is below 14 volts

Angle Tests

Connect the SRS according to the test circuit of Figure 7. Interconnection cable PL-1 should remain inserted, SVM101 should remain on a card extender and RLM101 should still be out.

Place the SVM101 module in the SYNC CK mode. With SW1 closed, adjust V_{bus} and V_{line} to 69 volts each. Wait approximately 20 seconds for the circuit to stabilize, then vary the angle between the two voltages (test angle) with the phase shifter. When the angle is less than the setting (plus or minus 30 degrees), TL3 should be lit and TL1 should be out. When the angle exceeds the setting, TL3 should go out and TL1 should light. Other settings may be checked if desired. In order to avoid activating the low set slip detector, the test angle should never be rotated to or beyond 90 degrees either side of zero.

"Dead Time" Timer Tests

With the angle on SVM101 set to 30 degrees, adjust the applied test angle to 20 degrees and then allow 20 seconds for the circuit to stabilize. Open SW1 and close it in less than three seconds (dead time setting). Verify that TL1 lights and TL3 goes out when SW1 is open, and that the pattern reverses almost immediately when SW1 is closed (actually 167 milliseconds after; the delay of the high set slip detector). TL2 should not light during this test sequence.

Repeat the above test, but this time wait longer than three seconds before closing SW1. When SW1 is closed, verify that TL1 goes out and TL2 lights

immediately, but TL3 remains out. Approximately 13 seconds later, TL2 should go out and TL3 should light concurrently, corresponding to the time delay of the low set slip detector. This verifies that the "dead time" timer has switched the synchronism check circuit out of the high speed mode.

Low Set Only Operation

Move the LOW SET ONLY miniature switch in the SVM101 module towards the bottom of the board. Leave the angle setting at 30 degrees and the applied test angle at 20 degrees. Again open SW1 and close it in less than three seconds. Verify that TL1 and TL2 light when SW1 is open (TL3 goes out), and that only TL1 goes out initially when SW1 is closed (TL3 remains out). Approximately 13 seconds later, TL2 should go out and TL3 should light concurrently. This time the circuit has been taken out of the high speed mode by the LOW SET ONLY switch. Return this switch to its normal position (towards top of board).

Slip Test

With the angle setting still at 30 degrees, the applied test angle still at 20 degrees, and SW1 closed, allow another 20 seconds for stabilization. TL3 should be the only LED lit. Now swing the test angle from 20 to 200 degrees in ten seconds or less to simulate a slip condition. When the angle exceeds 30 degrees, TL1 should light and TL3 should go out. When the angle reaches 180 degrees, TL2 should light because the test angle has swung through one full quadrant (90^{o} to 180^{o}) in less time than allotted by the low set slip detector, T_{LS}, where:

$$T_{LS} = \frac{1}{4} \times \frac{1}{F_{LS}} = \frac{1}{4} \times \frac{1}{.02} = 12.5 \text{ seconds}$$

Thus, the synchronism check circuit interprets this test as a slip condition in which the slip frequency is exceeding the low slip cut-off (.02 hertz) and gives an output accordingly (TL2 lights).

If the angle is left at 200 degrees, TL2 should go out 12.5 seconds after crossing through 180 degrees, but TL1 should remain lit and TL3 should remain out.

Return the test angle to 20 degrees, and again allow 20 seconds for stabilization. TL3 should be the only LED lit. Now slowly swing the test angle from 20 to 200 degrees so that it traverses the 90 to 180 degree span in greater than 12.5 seconds. Again, TL1 should light and TL3 should go out when the angle exceeds 30 degrees. However, since the simulated slip is slower than the cut-off, TL2 should not light at any point.

SPECIFICATIONS

SYNCHRONISM CHECK CIRCUIT (optional)

Angle Adjustment	• 1 to 99 degrees in one degree steps
High Set Slip Cut-off	• .25 to 2.5 hertz in .25 hertz steps
Low Set Slip Cut-off	• .01 to .1 hertz in .01 hertz steps .1 to 1 hertz in .1 hertz steps
Voltage Check (Live)	• 65 to 110 percent of nominal in five percent steps
Voltage Check (Dead)	• 10 to 70 percent of nominal in five percent steps
"Dead Time" Supervision Timer	• .05 to 3.15 seconds in .05 second steps
Nominal Potential Transformer Secondary Voltage (Phase-to-Neutral)	• 57.7, 63.5, 66.4, 69 volts; selectable

ILLUSTRATIONS

Figure	Title
1 (0285A7556-0)	Logic/Block Diagram of SRS Synchronism Check Circuit
2 (0285A7549-1)	SRS Angle and High Set Slip Detector
3 (8043760-0)	Front View Photograph of SVM101 Module
4 (0285A7564-1)	Internal Switches and LEDs - SVM101 Module
5 (0285A8201-0)	System and Phasor Diagram for Synchronism Check Discussion
6 (0285A7581-1)	Test Circuit for Synchronism Check Voltage Level Tests
7 (0285A7580-1)	Test Circuit for Synchronism Check Angle and Slip Tests

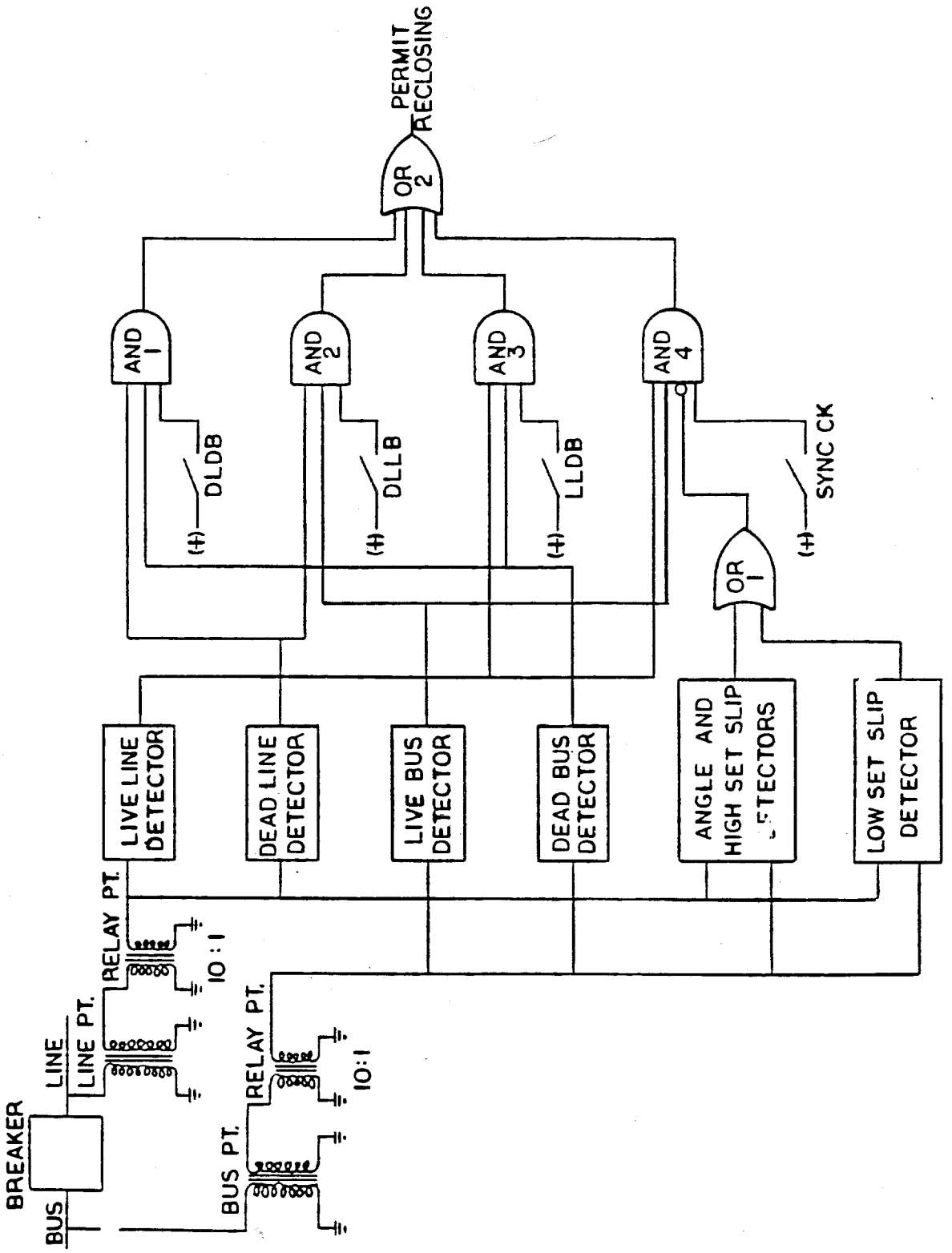

Figure 1 (0285A7556-0) Logic/Block Diagram of SRS Synchronism Check Circuit

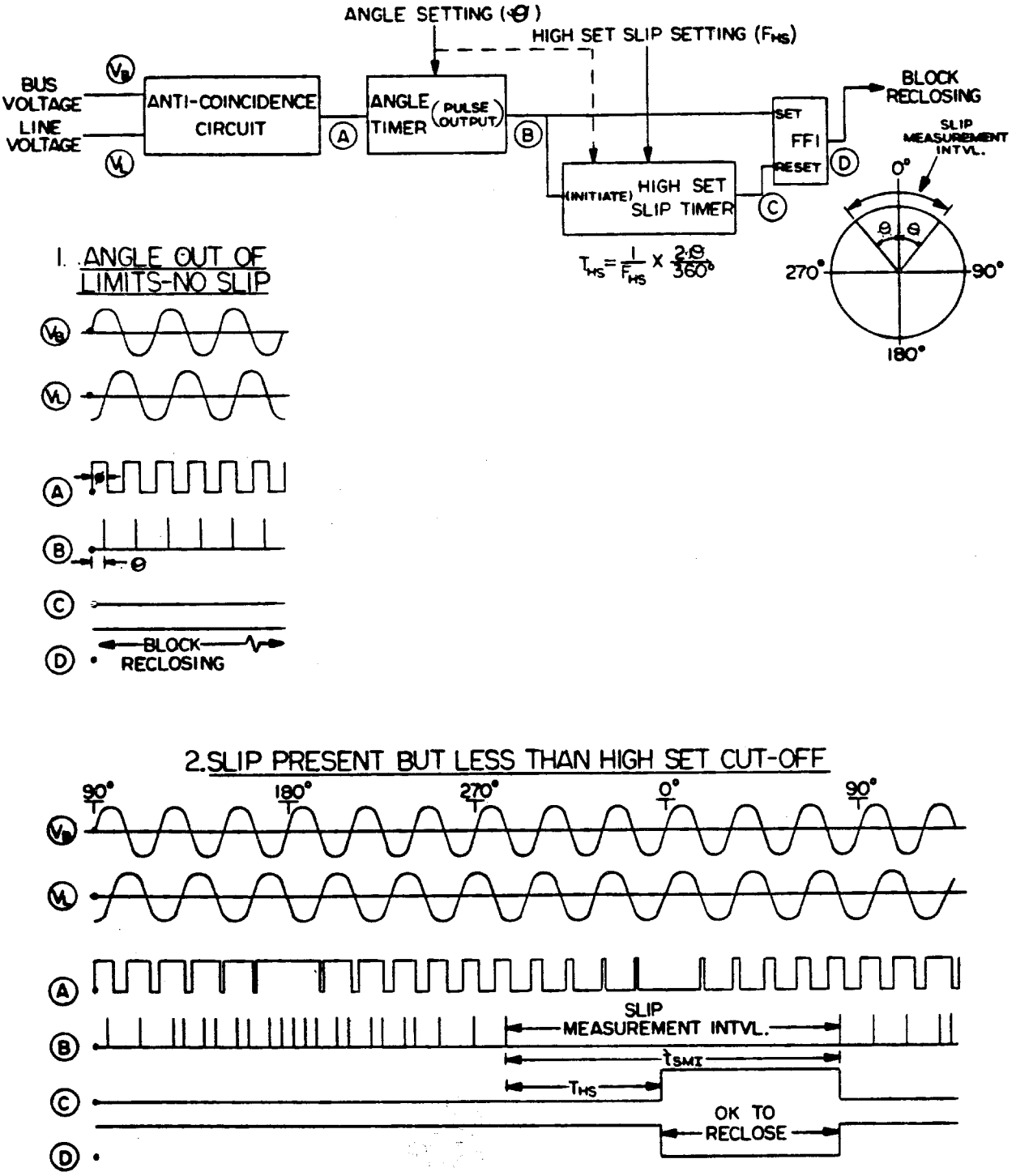

Figure 2 (0285A7549-1) SRS Angle and High Set Slip Detector

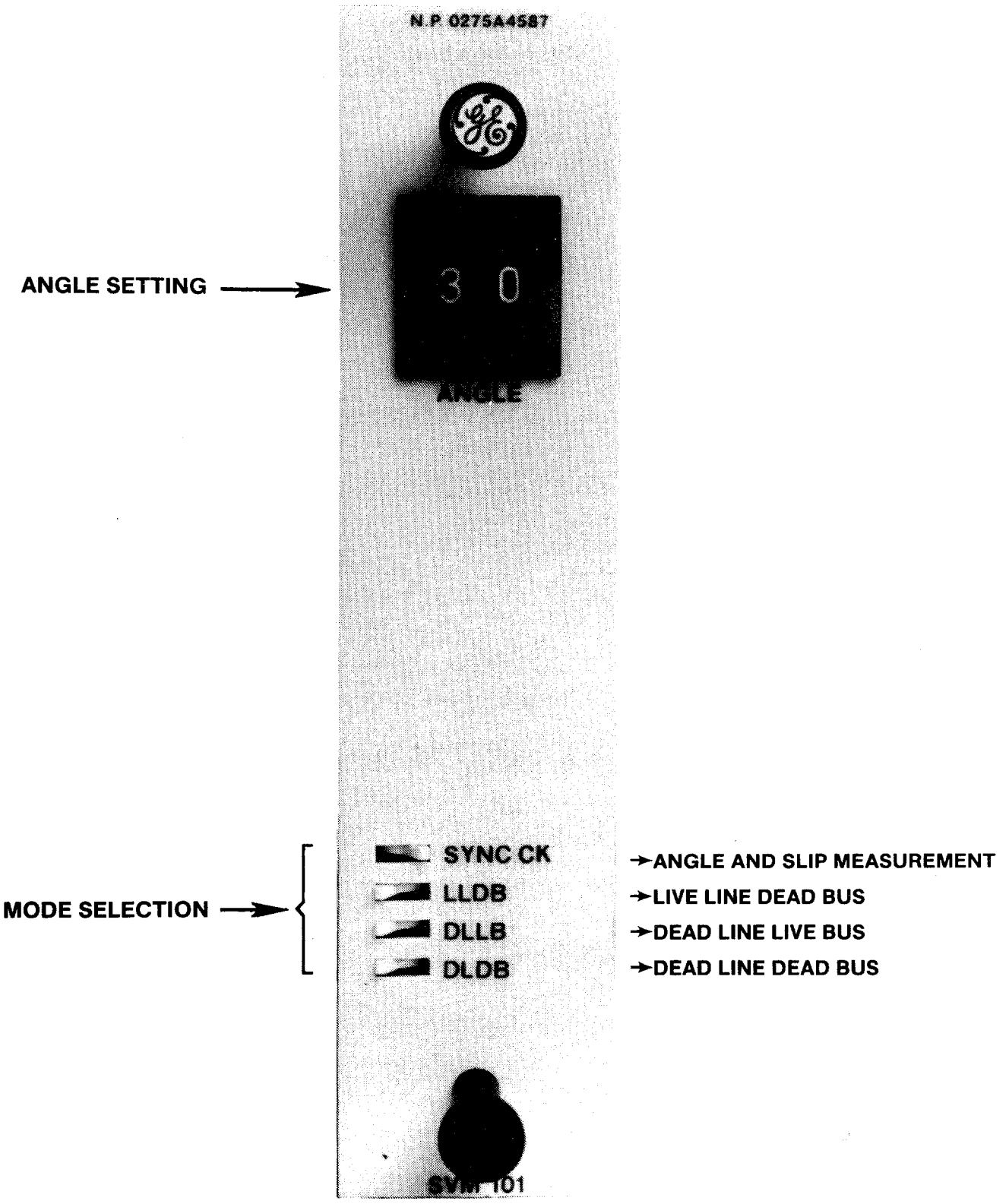

Figure 3 (8043760-0) Front View Photograph of SVM101 Module

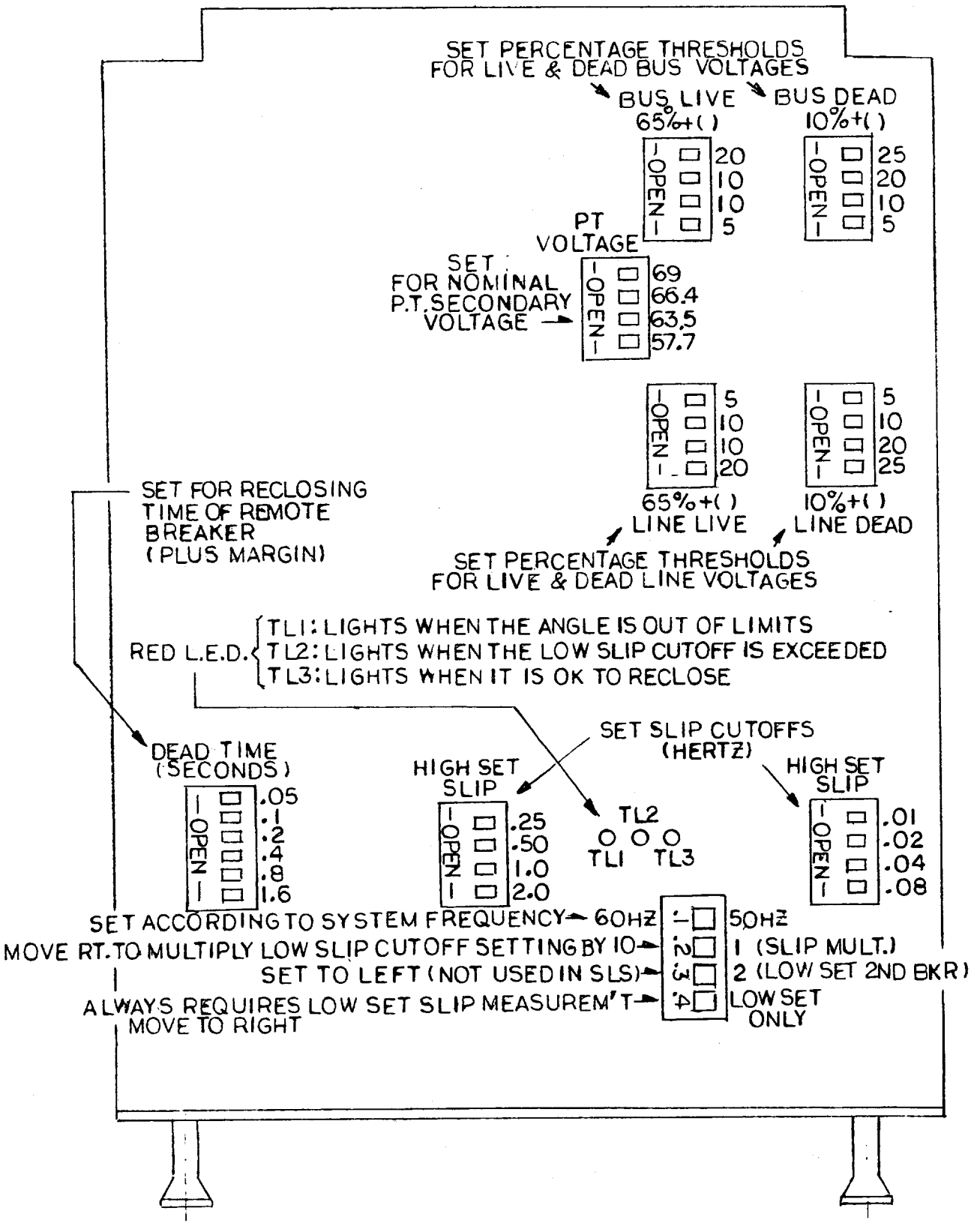

Figure 4 (0285A7564-1) Internal Switches and LEDs - SVM101 Module

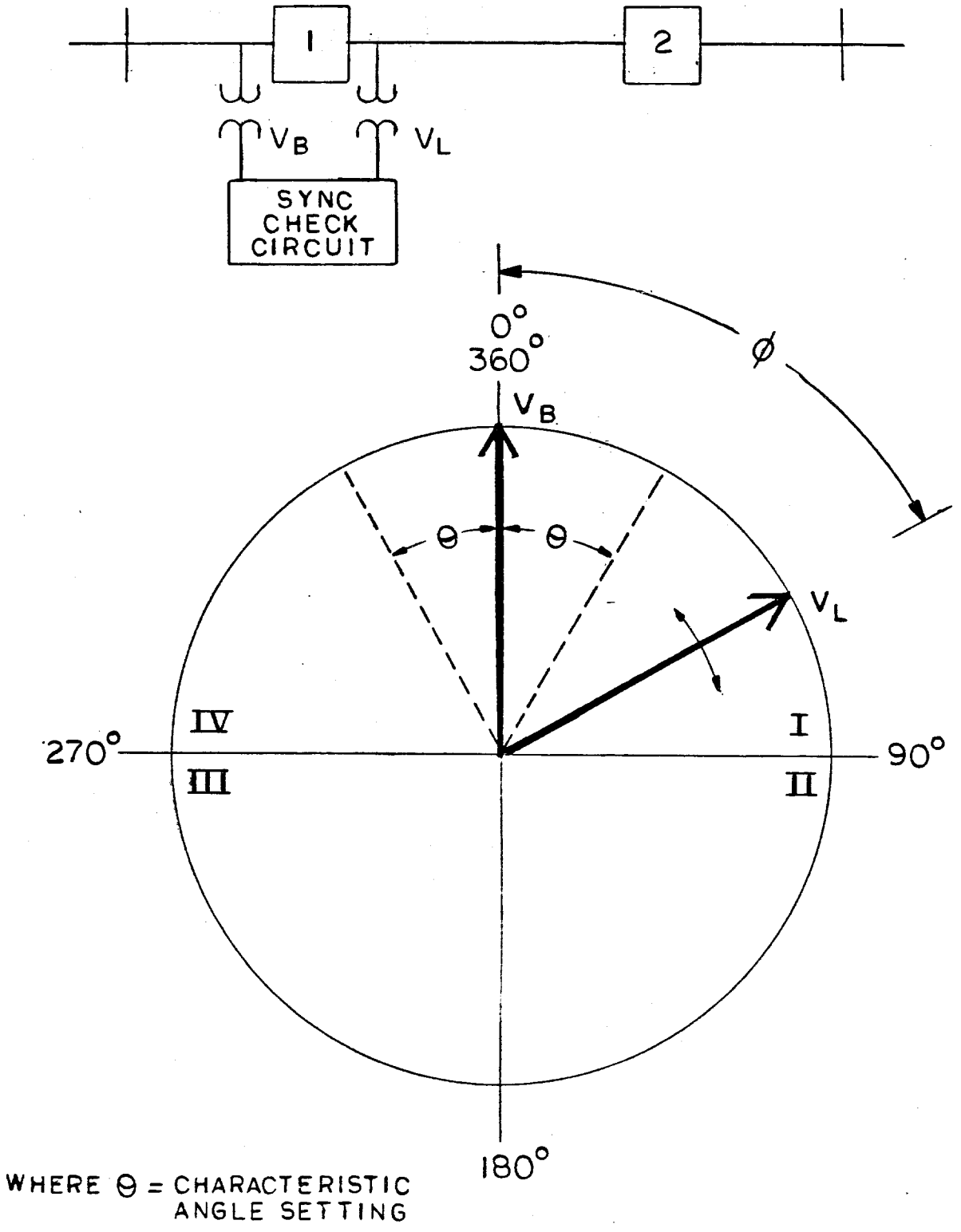

Figure 5 (0285A8201-0) System and Phasor Diagram
for Synchronism Check Discussion

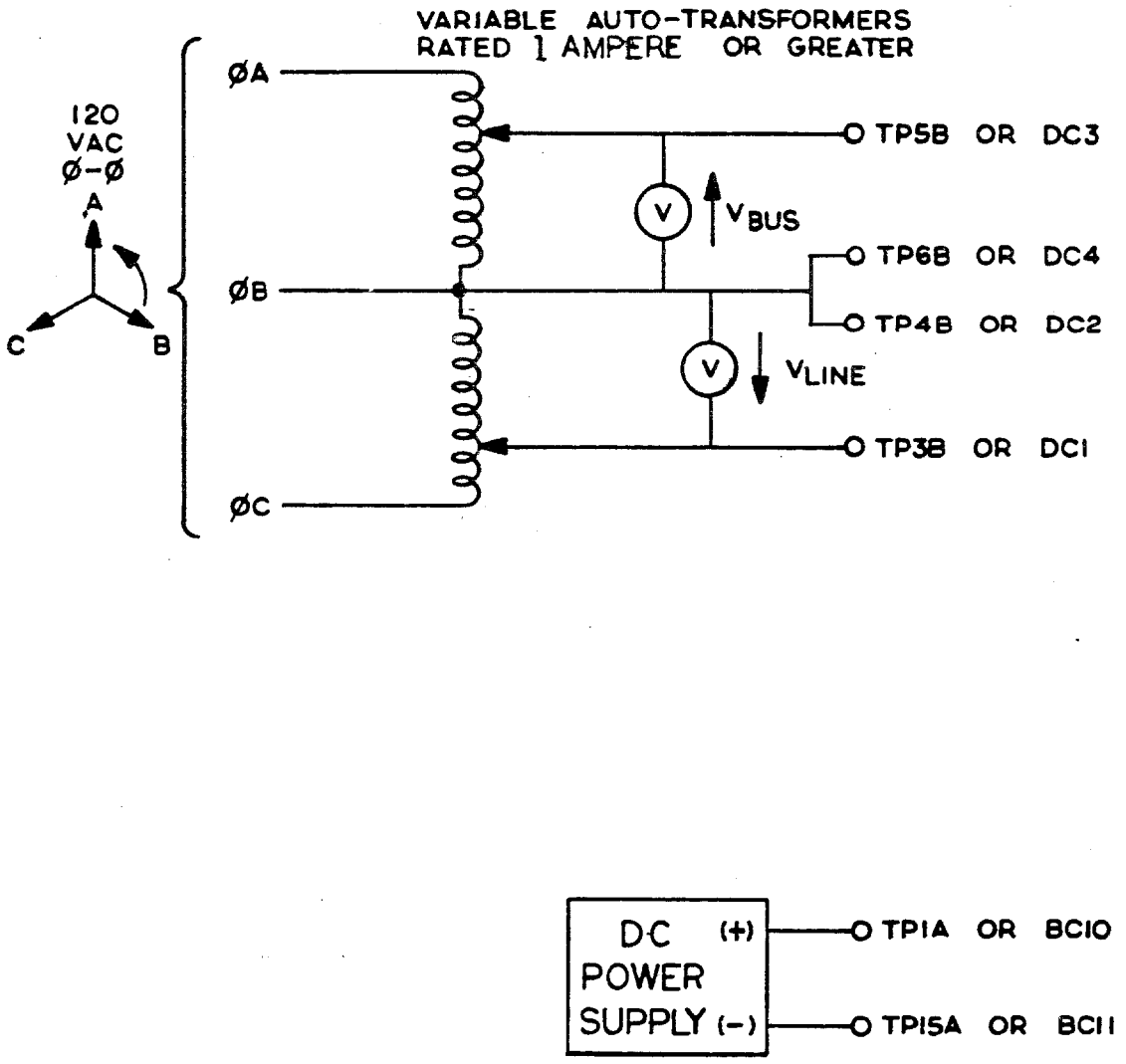

Figure 6 (0285A7581-1) Test Circuit for Synchronism Check Voltage Level Tests

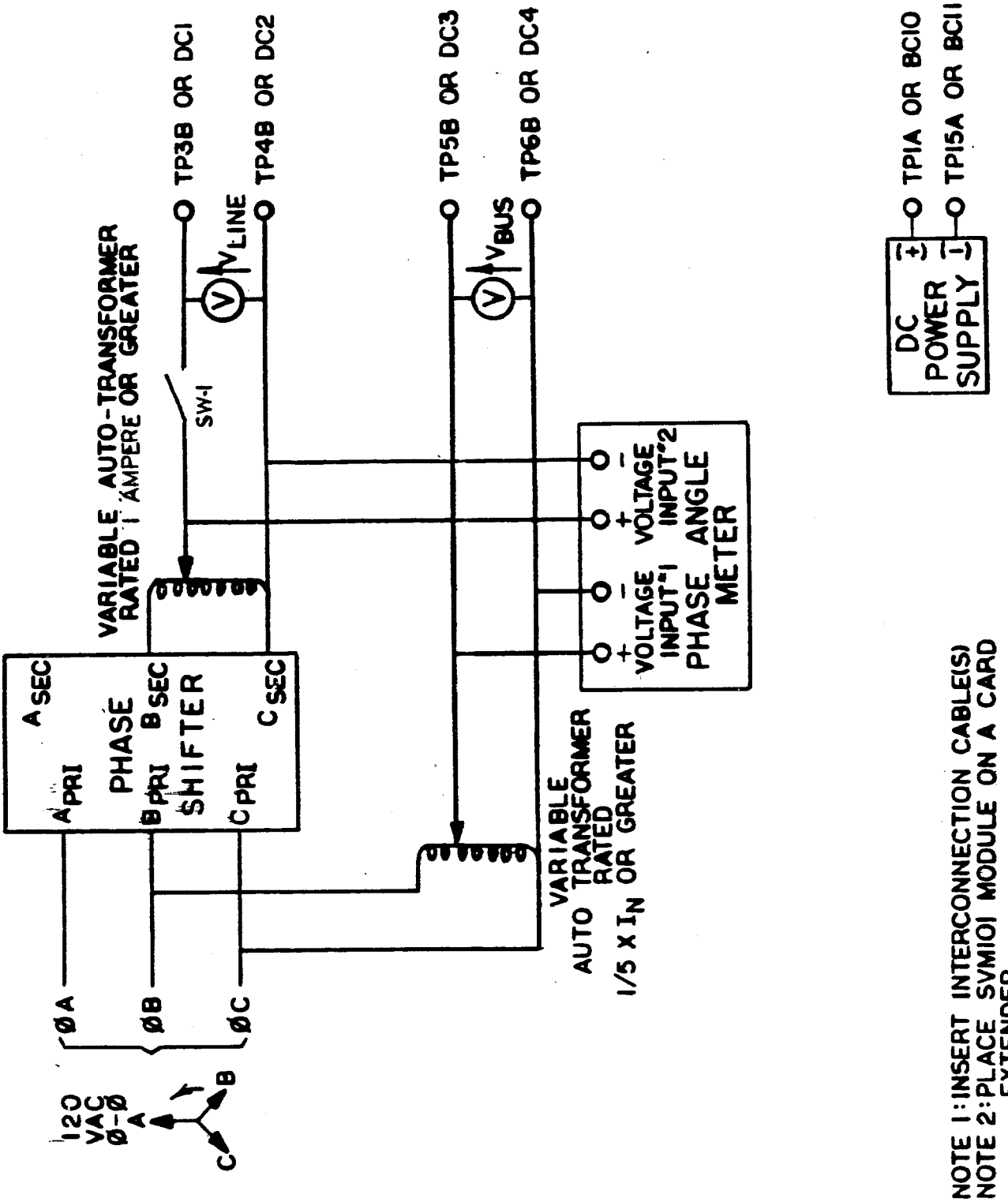

Figure 7 (0285A7580-1) Test Circuit for Synchronism Check Angle and Slip Tests

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10/84