INSTRUCTIONS

GEK-86659A
Supersedes GEK-86659

TLS1000 RELAY SYSTEM

SCHEME DESCRIPTION

GENERAL ELECTRIC

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SCHEME DESCRIPTION

INTRODUCTION

The TLS1000 System is a self-contained relaying system for transmission line protection that includes logic options for the following relaying schemes.

1. Stepped distance
2. Permissive transfer tripping
   a. Overreaching
   b. Underreaching
3. Hybrid
4. Blocking
5. Zone acceleration

The TLS1000 is available for both single pole and three pole tripping with all of the above schemes. By making suitable settings, the TLS may be used on lines with series capacitors, or on lines adjacent to series compensated lines.

The system contains the following functions:

1. First zone phase distance functions (M1)
2. Overreaching phase distance functions (MT)
3. First zone ground distance functions (MG1)
4. Overreaching ground distance functions (MTG)
5. Phase to phase current detectors (IØØ)
6. Phase current detectors - trip supervision (IØ TRIP)
7. Phase current detectors - block supervision (IØ BLOCK)
8. Phase blocking functions (MB)
9. Negative sequence blocking function (NB)
10. Phase out-of-step blocking (MOB)
11. Ground out-of-step blocking (MOBG)
12. Phase voltage level detectors (VØ)
13. Positive sequence current detector (I1)
14. Fault detector - current operated (FD)

DIRECTIONAL COMPARISON RELAYING

The TLS relay system will be described as it is used in the following types of directional comparison schemes:

1. Permissive tripping

    a. Overreaching
    b. Underreaching

2. Blocking

3. Hybrid

The channel considerations for the different schemes are discussed in the section, **"RELAY CHANNEL CONFIGURATIONS."** Each of the schemes is available in either a single pole tripping or a three pole tripping version. A list of the logic and elementary diagrams for each of these schemes is provided in Appendix I.

PERMISSIVE TRIPPING

The permissive tripping scheme is the simplest of the three schemes in that it uses 12 tripping elements (M1, MG1, MT, MTG) but does not use the blocking elements (MB, NB). The essential elements of this scheme are shown in the simplified logic diagram of Figure 1A.

The phase and ground directional distance overreaching functions, MT and MTG, reach beyond the remote terminal of the protected line to insure operation for faults anywhere on the protected line. The first zone phase and ground distance functions, M1 and MG1, are typically set for 90 percent of the positive sequence line impedance and trip directly for faults within their set reach. For a fault within the reach of the relay, one or more of the overreaching functions (MT, MTG) will operate. This will apply a signal to AND407 via OR201. AND407 is referred to as the "comparer" and is used to determine if the fault is within the protected line by comparing the output of the local tripping functions with the signal received from the remote terminal. In permissive overreaching transfer trip (POTT) schemes, an output from the overreaching functions will key the associated FSK channel to the trip frequency via OR205. In permissive underreaching transfer trip (PUTT) schemes, a permissive signal is sent when OR403 produces an output via an input from either of the first zone functions. The second input to AND407 is the output of the local receiver. The NOT output to AND407 is not used in this scheme.

For an internal fault, the overreaching fucntions at both terminals will operate and send a permissive trip signal to the remote terminal. This will apply a trip permission signal to OR405 via AND407, OR402, TL1, OR403 and AND417. The pickup delay of TL1 is used to provide security against false tripping on external faults due to spurious trip signals from the channel; the 50 millisecond reset time of TL1 prolongs the keying of the transmitter via OR403 and OR205 to insure that the remote terminal will have ample time to trip before the permissive trip signal is removed.

If an internal fault occurs within the reach of a zone 1 function (M1 or MG1), a trip permission signal will occur immediately via OR402, OR403, AND417 and OR405. The output from OR403 will also cause a permissive trip signal to be sent via OR205.

During an external fault, the tripping functions at the terminal nearer the fault will not operate because the fault is "behind" them. No tripping can occur at that terminal and the transmitter will not be keyed. The tripping functions at the remote end may see the fault, but tripping will not be allowed because there will be no permissive channel input at the comparer (AND407).

BLOCKING

The TLS relay system is supplied with blocking functions so that it may also be used in a directional comparison blocking scheme with AM (ON-OFF) power line carrier. This scheme includes both tripping and blocking elements and is shown in simplified form in Figure 1B.

In this scheme, no carrier is sent in standby or when the trip elements operate. The channel receiver input to the comparer (AND407) is therefore energized in the standby condition via NOT101. The operation of the blocking scheme for a fault within the protected zone is similar to that described for the permissive tripping scheme. When one of the overreaching tripping units (MT, MTG) operate, one input to the comparer (AND407) is supplied via OR201; in addition, the output of OR201 energizes the carrier stop output via AND209 and OR213. The will prevent any auxiliary functions (such as voice or checkback) from sending a blocking carrier signal during an internal fault. All three inputs to the comparer (AND407) will be satisfied since the blocking units will not operate and the blocking carrier will not be received for a fault within the protected zone. The 50 millisecond reset time of TL1 blocks carrier start and prolongs the carrier stop output to insure that the remote terminal will have ample time to trip.

During an external fault, the blocking units at the end nearest the fault are set to operate for any external fault for which the tripping functions at the remote terminal may operate. The tripping functions at the terminal closest to an external fault will not operate because the fault is "behind" them; the blocking units at this terminal will operate causing blocking carrier to be sent to the remote terminal. The tripping functions at the remote end may respond to the fault, but tripping will not be permitted because the carrier input will block the comparer via NOT101 and OR101.

HYBRID

The hybrid directional comparison scheme operates in a manner similar to the permissive tripping scheme, except that blocking functions are also used as shown in Figure 1C. The addition of the blocking units to the permissive tripping scheme allows the channel repeat and weak infeed tripping circuits to be incorporated.

When the hybrid scheme is used on a system with strong sources at each end, it will respond to an internal fault in the same manner as a permissive tripping scheme. On a system where one source is or may be weak, the hybrid scheme offers advantages that cannot be obtained with the permissive trip scheme. Assume a fault on the protected line that can be "seen" by the tripping units (MT, MTG) of the relay at the strong terminal, but not by the tripping units at the weak infeed end. The

relays at the strong infeed end will send a permissive trip signal to the relays at the weak infeed end. In a permissive scheme, the relays at the strong infeed terminal will not be able to trip because they will not receive a permissive trip signal from the relays at the weak infeed terminal. The relays at the weak infeed end will receive a permissive trip signal, but will not be able to trip because the tripping functions will not respond to the fault. In a hybrid scheme, the receipt of a permissive signal at the weak infeed end and the lack of an output from the blocking functions will allow the permissive signal to be repeated back to the relays at the strong infeed terminal via TL12, AND102, AND405 and OR205. When the repeated signal is received, the relays at the strong infeed terminal will produce a trip output. At the weak infeed terminal, where neither the tripping nor blocking functions have operated, a trip will be initiated via TL16 when the trip signal is received from the remote terminal, provided that the current is less than the IØ-Block setting and the voltage is less than 0.65 per unit.

When an external fault occurs within the reach of the overreaching tripping elements, the blocking functions will operate and block the local trip units, as well as blocking the repeat circuit at AND405, preventing the relays at either terminal from tripping.

SINGLE POLE TRIPPING

In a three pole tripping scheme, a TRIP PERMISSION output from OR405 will initiate three pole tripping of the associated circuit breaker(s). In a single pole tripping scheme, however, it is necessary to trip only the faulted phase for single line to ground faults, and to trip all three phases for multi-phase faults. A simplified phase selection circuit is shown in Figure 1.

The ground distance functions are designed to respond only to single line to ground faults (except for close-in phase to phase to ground faults where both ground units involved in the fault will operate). Therefore, for an internal phase A to ground fault, one input to AND408 will be supplied by the phase MG1 or MTG, while the TRIP PERMISSION signal will supply the other. Only the phase A pole of the circuit breaker will be tripped. Phase A may also be selected by the signal labelled "A open." This signal occurs when the voltage on phase A is less than 0.65 per unit and the current on phase A is less than the setting of the IA Block current detector. These open pole detectors are used to indicate when the associated phase is de-energized, and also to provide phase selection on weak infeed faults, as discussed subsequently.

An output from OR20 will select a three pole trip by applying an input to each of the phase selection circuits. The following conditions will apply an input to OR20 to select a three pole trip:

1. Operation of any first zone phase distance function (any M1).
2. Selection of more than one phase (two out of three logic).
3. Time delayed tripping - Zones 2 and 3 may be selected by the user to trip single pole or three pole. Zone 4, if used, will always trip three pole.
4. Operation of any overreaching phase distance function (any MT), or the combination of an MT function and the receiver output.
5. Receipt of a three pole trip channel.

Option links are available in the logic modules to select the combination of items 4 and 5 which are best suited for the application. General application rules are as follows:

1. Blocking Schemes with AM Channel:

   A three pole trip should be selected whenever any of the MT units operate

Switch	Position
101A-1	Closed
101A-2	Closed
101B-1	Open

2. Tripping/hybrid Schemes with a Single FSK Channel:

   A three pole trip should be selected by the receipt of the three pole trip channel or the operation of any MT. This allows a three pole trip in the case of a weak infeed condition where the MT units may not operate.

Switch	Position
101A-1	Closed
101A-2	Closed*
101B-1	Open

3. Tripping/hybrid schemes with shared/dual FSK channels - no possibility of intercircuit faults.

   A three pole trip should be selected by the receipt of the 3 pole trip channel or the operation of any MT. This allows a three pole trip in the case of a weak-infeed condition where the MT units may not operate.

Switch	Position
101A-1	Closed
101A-2	Closed
101B-1	Closed

4. Tripping/hybrid schemes with shared/dual channels where intercircuit faults are a consideration:

   A three pole trip should be selected by the operation of any MT AND an output from the three pole receiver. See the discussion in the section, **"INTERCIRCUIT FAULT PROTECTION."**

Switch	Position
101A-1	Open
101A-2	Closed
101B-1	Open

*Revised since last issue

RELAY-CHANNEL CONFIGURATIONS

In the earlier days of directional comparison relaying, most schemes used with power line carrier (PLC) were blocking schemes with an ON-OFF channel, and most schemes used over microwave (MW) were tripping schemes with a frequency-shift (FSK) channel. With only these two choices, a single term (tripping or blocking) was sufficient to describe the complete protective scheme.

A tripping scheme was attractive because it did not require any blocking relay functions, but relays at both terminals had to see the fault before either end could trip. In a blocking scheme, on the other hand, a relay at a high infeed terminal could trip fast without waiting for permission from the other end. Therefore, the characteristics of a blocking scheme are desirable in some applications and the characteristics of a tripping scheme are desirable in others.

The introduction of frequency shift channels on PLC with the unblocking mode of operation makes it possible to provide either a tripping or a blocking scheme over PLC or MW, depending on which frequency (trip or guard) is transmitted in standby. In addition, a third relay scheme, a "hybrid scheme" has been developed that offers some of the advantages of a blocking scheme (trip at one end with weak infeed at the other) but operates basically as a tripping scheme.

Because of this flexibility in channel arrangements and relay circuits, it is helpful to define a specific relay channel arrangement by a double term, with one term for the relay mode of operation and one term for the channel type and mode of operation. The following list of available combinations uses this double nomenclature.

In the tabluation of relay schemes and pilot channels given below, the following definitions of relay schemes are used:

Tripping Scheme - requires operation of the local trip functions and receipt of a trip signal from the remote terminals before tripping will be initiated. Scheme contains tripping functions only.

Blocking Scheme - requires operation of the local trip function and the absence of a blocking signal from the remote terminals before tripping will be initiated. Scheme contains both blocking and tripping functions.

Hybrid Scheme - requires operation of the local trip function and receipt of a trip signal from remote terminals before tripping will be initiated, but trip signal may be a "repeated" signal from remote terminal if neither trip nor block function has operated at that terminal. Scheme requires both blocking and tripping functions.

The various combinations of relay schemes and pilot channels are described below and the differences are summarized in Table 1.

1. Tripping scheme, FSK tripping channel:

Permissive overreaching transfer trip (POTT), transmitts guard frequency in

standby condition, relay trip functions key channel to trip frequency. Tripping blocked on loss of channel. Receipt of trip frequency gives trip permission to local relay.

2. Tripping scheme, FSK unblocking channel:

   Permissive overreaching transfer trip (POTT), transmits guard frequency in standby condition, relay trip functions key channel to trip frequency, permit trip for short duration if the signal is attenuated by a fault, then block tripping. Receipt of unblock signal* gives trip permission to local relay.

3. Blocking scheme, OFF-ON power line carrier:

   No signal transmitted in standby condition. Relay blocking functions start carrier transmission and relay tripping functions stop carrier transmission. Receiver output blocks tripping by local relay. Tripping functions initiate tripping independently at each terminal in absence of a blocking signal.

4. Blocking scheme, FSK tripping channel:

   Transmitter keyed to trip frequency in standby, relay blocking function at one terminal keys transmitter to guard frequency for external fault. Tripping blocked for loss of channel. Receipt of trip frequency gives trip permission to local relay.

5. Blocking scheme, FSK unblocking channel:

   Transmitter keyed to trip frequency in standby, relay blocking function at one terminal keys transmitter to guard frequency for external fault. Permit tripping for short duration if the signal is attenuated by a fault. Receipt of unblock signal gives trip permission to local relay.

6. Hybrid scheme, FSK tripping channel:

   Transmits guard frequency in standby condition. Relay tripping functions key transmitters to trip frequency. In addition, receipt of a trip frequency, plus no local blocking function output, will key the transmitter for a short duration (five cycles) to "repeat" trip signal back to transmitter location. Tripping is blocked for the loss of channel. Receipt of trip frequency gives trip permission to local relay.

6. Hybrid scheme, FSK unblocking channel:

   Transmits guard frequency in standby condition. Relay tripping functions key transmitters to trip frequency. In addition, receipt of a trip frequency plus no local blocking function output, will key the transmitter for a short duration (five cycles) to "repeat" trip signal back to transmitter location. Permits tripping for short duration if the signal is attenuated by a fault. Receipt of unblock signal* gives trip permission to local relay.

*An unblock signal can be the receipt of the trip signal from the remote terminal or the loss of signal (LOS) output from the local receiver.

The following application guidelines should be considered when selecting a relaying scheme and a channel.

1. The blocking scheme with OFF-ON carrier will trip the local breaker for any internal fault whether or not the remote tripping function operates and is suitable for applications with a weak infeed terminal. The channel is not continuously monitored, and is subject to overtripping if the channel fails. A failed channel can go undetected until tested manually or by an automatic checkback scheme.

2. Frequency shift (FSK) tripping channels would normally be used with microwave, and FSK unblocking channels with power line carrier to allow tripping on internal faults that cause excessive attenuation in the channel.

3. Where frequency shift channels are used, tripping schemes tend to be more secure because relay tripping functions at both ends of the line must see the fault. They are generally used where there are good sources of fault current at both ends of the line.

4. Where the source at one end of a line is much weaker than that at the other end, a blocking scheme will permit faster tripping of the heavy infeed end, since tripping is not delayed because of slow operation of the tripping function at the remote end.

5. For fast tripping of a weak infeed terminal, a hybrid scheme with a weak infeed trip circuit option is preferred.

6. If two FSK channels are used for direct transfer tripping for equipment failure, one of the two channels can be used for the directional comparison relaying. This would be a reason for choosing a tripping rather than a blocking scheme.

TABLE 1
CHARACTERISTIC FEATURES OF RELAY SCHEME CHANNEL COMBINATIONS

RELAY SCHEME	PILOT CHANNEL	RELAY FUNCTION		TRANSMIT ON STANDBY			TRIP PERMISSION FROM		REPEAT KEYING
		TRIP	BLOCK	TRIP	GUARD	ZERO	REC'D TRIP	UNBLOCK SIGNAL	
Tripping	FS Tripping	x			x		x		
Tripping	FS Unblock	x			x			x**	
Blocking	OFF-ON PLC	x	x			x		x*	
Blocking	FS Tripping	x	x	x			x		
Blocking	FS Unblock	x	x	x				x**	
Hybrid	FS Tripping	x	x		x		x		x
Hybrid	FS Unblock	x	x		x			x**	X

*Trip permission for no received carrier signal
**Trip permission for no received carrier signal for a short time on loss of signal or for the receipt of a trip signal.

RECLOSING CONTROL

RECLOSE INITIATION

As shown in Figure 2, output contacts are provided to initiate either a single pole reclosure or a three pole reclosure. Only one of these outputs may be energized at a given time. The single pole reclose initiation is not phase-identified; if phase-identified outputs are required for single pole reclose initiation, a phase-identified breaker failure initiation (BFI) contact should be placed in series with the RI-IØ contact as shown in Figure 3. The reclose initiation may be blocked in the relay logic by an output of OR407 depending upon the position of option link 121B-1. The inputs to OR407 that can block reclosing initiation are discussed in the next section.

LOCKOUT/BLOCK RECLOSING

An output from OR407 may be used to prevent reclosing in certain situations where reclosing is not desired. The reclose initiation contacts may be blocked in the relay logic via option link 121A-4 or externally to the relay scheme via the lockout relcosing contacts (LR), depending upon the reclosing scheme employed. Reclosing may be blocked for the following conditions:

1. An external trip signal via contact converter CC8.

2. A time delayed trip in Zone 4 time.

3. A sustained direct transfer trip signal. If an extended transfer trip signal is sent to differentiate between a line fault transfer trip for which reclosing is desired, and an equipment fault transfer trip for which reclosing is not desired, reclosing may be blocked after timer TL22 has timed out, indicating an equipment failure transfer trip. For a transfer trip, reclosing will be inhibited for the duration of the transfer trip signal as discussed in the paragraph, "Sequential Reclosing."

4. An option is available in the logic to block reclosing via option link 141E-6 whenever any MT unit operates, allowing reclosing only on SLG faults. This option is used in three pole tripping schemes where reclosing on multi-phase faults is not desired.

5. An option is available to block reclosing for Zone 3 time delayed tripping or Zones 2 and 3 time delayed tripping via option links 141F-1 and 141F-2.

141F-1	141F-2	RI Blocking
Open	Closed	Zones 2 and 3
Closed	Closed	Zone 3
O/C	Open	Neither Zone 2 or Zone 3

6. An option is available to block reclosing for a trip that occurs during an out-of-step condition via option link 131A-2. AND304 and AND305 prevent

this option from blocking reclosing for a SLG fault if a swing develops after the pole is opened. In addition, AND305 prevents the lockout reclosing relay from being energized during an out-of-step condition if no trip occurs.

If the reclose initiation is blocked by an output from OR407 for any of these conditions, an input is provided to OR20 to insure a three pole trip, regardless of fault type.

SEQUENTIAL RECLOSING/INHIBIT RECLOSING

The TLS relay system also includes an inhibit reclosing output that is intended to prevent reclosing as long as it is energized, but to allow the reclosing cycle to be started by the reclose initiation contacts. Reclosing will be permitted after the inhibit reclose contacts reset and the reclose time has elapsed. If the inhibit reclose contacts do not reset within the overall reclosing time, the recloser will proceed to lockout. This function is intended to be used with the Type TRS modular recloser, but may be used with any reclosing scheme, as appropriate.

The inhibit reclosing output is used to provide sequential reclosing for certain conditions. Sequential reclosing is intended to force the terminal most remote from a severe fault to reclose first and to prevent the terminal nearest to a severe fault from reclosing onto a permanent fault in order to minimize the effect on the power system of reclosing onto a permanent fault. After a sequential reclose signal is energized, it will prevent that terminal from reclosing until all three phase voltages on the line have returned to normal, indicating a successful reclosure at the remote terminal.

A simplified diagram of the inhibit reclosing logic used for sequential reclosing control is shown in Figure 4. The inhibit reclose output may be energized by a received transfer trip signal or by the sequential reclose circuit. The transfer trip input prevents a reclose as long as a transfer trip signal is being received. In the event of an equipment failure transfer trip from the remote terminal, the signal will last long enough to cause TL22 to pick up and energize the lockout reclosing output via OR409. The duration of a received transfer trip signal for a line fault will not cause TL22 to time out. In this case, reclosing will only be inhibited for the time that the transfer trip signal is being received.

A sequential reclose may be initiated via OR408 for one of the following conditions. Note that an output from OR408 seals itself in via AND413, AND414 and OR408, causing the inhibit reclosing output to remain energized until all three phase voltages return to normal and break the seal-in via AND413.

1. A nearby Zone 1 fault (any fault type) will initiate sequential reclosing via AND412 if any first zone distance unit (M1 or MG1) operates within 0.4 cycles of the time that the fault detector operates. If TL17 times out before the first zone unit operates, reclosing will be permitted. The time delay allows only the most severe faults from initiating a sequential reclose. This feature is enabled by option link 141E-2.

2. Additionally, sequential reclosing may be initiated for a multi-phase fault (any MT) or a three phase fault (all MTs). This feature is controlled by option links 141C-1 and 141C-3.

141C-1	141C-3	
Closed	Closed	Any MT
Closed	Open	All 3 MTs
Open	O/C	Neither

After a sequential reclose has been initiated, the inhibit reclose output will be sealed-in via AND413 and AND414 until all phase voltages return to normal. Note that if the relays at both terminals are set to initiate sequential reclosing for multi-phase or three phase faults, neither end will reclose because the line voltage will not return to normal.

THREE POLE TRIP ENABLE

In single pole tripping and reclosing schemes, a "Three Pole Trip Enable" signal must be supplied to the TLS relay by the associated reclosing scheme via contact converter CC5. This signal will select a three pole trip via OR20 causing a three pole trip for any type of fault. This input is typically energized for the following conditions:

1. Following a single pole trip, the three pole trip enable is energized for the reclaim time of the breaker in order that any subsequent tripping will be three pole regardless of fault type.

2. If the recloser is out of service, or if its DC supply voltage is removed, the three pole trip enable signal will cause the TLS to trip three pole for any fault because the reclosing scheme will not reclose an open pole.

LINE PICKUP

Line pickup, or close onto fault protection is included in all TLS relay systems. A simplified diagram of the line pickup circuit is shown in Figure 5. If the line pickup protection is not desired, it may be taken out of service by link 131A-4. The line pickup circuitry includes protection for three pole and single pole reclosing (when used).

When the protected line is de-energized, the three open pole detectors will operate, producing an output from AND406. After a security delay of 150 milliseconds, timer TL7 will produce an output that places the line pickup circuit in service. This signal will be maintained for five cycles after the first open pole detector resets or until it is fast reset via NOT301 and TL26 forty milliseconds after all three phase voltages return to normal. The second input to AND302 can be supplied by an overreaching distance unit (MT or MTG) or a positive sequence overcurrent unit (I_1). With line side potential, the distance relays will not operate for a bolted fault at the relay location, but will operate for a fault farther down the line. The I_1 unit is intended to provide protection for the bolted fault at the relay. The I_1 function produces an output whenever the positive sequence current is above its setting. Timer TL8 provides coordination between the pickup of the I_1 unit and the resetting of the undervoltage units in those applications where the I_1 unit is set less than the full load current and high speed reclosing is used at both ends of the line. If the coordinating time delay is not required, it may be bypassed by applying a permanent input to contact converter CC6,

thereby tripping via AND303. If, however, the application does require the coordinating time delay of TL8, a channel failure alarm contact from the associated power line carrier set may be connected to CC6. This assumes that the likely cause of a channel failure at the time of reclosing is the attenuation of the channel signal in an internal fault, thus, the time delay of TL8 may be bypassed.

It is possible to implement three pole line pickup protection when bus side potentials are used, but it requires the following:

A single phase source of line side potential is required to recognize that the transmission line is dead. This source of potential is applied to the TLS system via connection points provided in the system. Switch 131A-5 must then be set to the closed position which causes this potential to be applied to the input of NOT31 via an undervoltage level detector. During normal conditions, when the line is energized there will be no input to NOT31, thus timer TL7 will be reset via NOT31 and timer TL26. When the line is de-energized, the undervoltage detector will provide an input to NOT31, removing its output and consequently, the fast reset input from timer TL7 which will then be allowed to time out when it has an input applied.

CC11, CC12 and CC13 must be used to override the normal voltage detectors that will have full voltage applied when the line is dead because of the use of bus side potentials. To do this, switch 111A-2 must be set to the open position. In this position, an output from the respective contact converter is used to simulate an undervoltage function output. The input to these contact converters can come from an undervoltage detector associated with the single phase line side source, or breaker "b" switches may be used.

When these steps are taken, the line pickup circuitry will be activated as described, and direct tripping will be initiated when picking up a faulted line.

When the TLS relay system is equipped for single pole tripping, three single pole line pickup circuits are included in addition to the previously described three pole line pickup circuit. A simplified diagram of the circuit for phase A is shown in Figure 5; the operation of the scheme for a phase A reclose will be described. One input to AND13 will be supplied by TL9 one hundred and fifty milliseconds after the phase A open pole detector operates. This signal will be maintained for five cycles after the phase A open pole detector resets. The second input to AND13 is supplied by the phase A overreaching ground distance relay (MTG-A). The MTG-A unit is prevented from operating on the zero sequence current during the open pole period by IA-Trip current detector supervision. At the time the phase A breaker pole recloses, the MTG-A unit will have the proper polarizing signal due to the use of positive sequence voltage polarization; the MTG-A will operate for a phase A to ground fault anywhere on the protected line. Note that any line pickup trip will result in a three pole trip of the associated circuit breaker via OR304 and OR20, regardless of fault type.

CHANNEL REPEAT AND WEAK INFEED TRIPPING CIRCUITS

When the TLS relay system is applied in a hybrid tripping scheme, the channel repeat and weak infeed tripping features may be used. In all other schemes, these circuits should be taken out of service by connecting option link 141B-1 to plus DC logic voltage. A simplified diagram of the channel repeat and weak infeed tripping circuits is shown in Figure 6.

The repeat circuit will send a permissive signal to the remote end on the receipt of either a one pole or three pole signal, if the local blocking units have not operated. The keying of the repeat signal will be blocked at AND102 via TL12 after a permissive trip signal has been received for five cycles. If the local blocking units operate indicating an external fault, keying of the repeat signal will be blocked at AND405. In permissive tripping schemes where the blocking units are not used, the repeat function may still be used, but it must be supervised by the IØ-Block units as would be the case for an open breaker. Timer TL15 is used to extend the block unit for 50 milliseconds after the IØ-Block units have reset on clearing an external fault. When blocking units are used in the scheme, they are set to bypass TL15 by closing 141B-2 to block the repeat keying at AND405 directly.

A weak infeed trip circuit can be employed in conjunction with the channel repeat function. This feature, inserted by closing 141E-3, allows high speed clearing of the weak infeed end, even though little or no current may be flowing into the fault. In order for the weak infeed circuit to operate, the relay at the remote terminal must see the fault and initiate a permissive trip signal. If a permissive trip signal is received, and a blocking unit has not operated, an output from AND405 in the repeat circuit will energize one of the inputs to AND406. In addition, the output from AND405 will send a permissive trip signal to the remote terminal permitting the relays at that end to trip. Timer TL23 is intended to remove the weak infeed circuit from service by blocking the weak infeed tripping circuit at AND406 during the open pole period following a single pole trip for increased security because the "open pole" circuit will be energized for the open pole period. If a second phase becomes faulted during the open pole period, TL23 will be fast-reset, returning the weak infeed circut to service. Depending upon the specific application, the third input required to produce a weak infeed trip is the operation of any of the open pole detectors or any of the undervoltage detectors, depending upon the position of option link 141B-3. Once an output is obtained from AND405, it must be present for the pickup delay of timer TL16 in order to produce a weak infeed trip. The time delay of TL16 must be set greater than the maximum incorrect trip output from the channel that might be expected due to errors in the channel. In addition, if the weak infeed circuit is connected to the undervoltage detectors, TL16 should be set long enough to provide sufficient time to clear an external fault to prevent false tripping should an unblocking channel logic output occur, due to a flashover in the PLC coupling equipment (tuning pack, wave trap, etc.).

PT FUSE FAILURE ALARM

A circuit is included in the TLS relay system to detect a failure of a fuse in the potential device associated with the relay. A simplified diagram of this circuit is shown in Figure 7. The PT fuse failure alarm circuit will produce an output when the following conditions are met:

1. Any phase undervoltage unit has operated
2. Any phase current is above the IØ-Trip level detector setting
3. The fault detector unit has not operated

Once the fuse failure circuit has operated, it is sealed-in via AND416 and OR411 until all phase voltages are again healthy. A normally open contact of the fuse failure alarm relay may be connected to contact converter CC9 to block the TLS relays from misoperating on loss of potential. If a fuse failure occurs when the current is less than the IØ-Trip level detector, the fuse failure alarm will not operate. However, since the distance units are also supervised by the IØ-Trip units, they cannot misoperate and these is no danger of a false trip. If the current should then increase above the pickup level, the fuse failure alarm will operate before the distance unit. The fuse failure alarm circuit is blocked from operation during the time any pole is open.

FAULT DETECTOR

A fault detector function is included in the TLS relay system for supervision of the trip outputs. This feature is intended to reduce the possibility of the relays misoperating due to either potential failure or component failure. This function is a sensitive, high speed, current disturbance detector that operates from negative sequence current or a change in positive sequence current, as shown in Figure 8. It will provide a steady-state output for unbalanced faults and a transient output for three phase faults. Once the fault detector has operated, it will remain sealed-in via OR209, AND207 and OR210 until the latter of either the distance relay (MT or MTG) resetting, or the trip bus resetting.

The I_1 circuit is used to detect the change in positive sequence current, thus eliminating the desensitizing effects of load current. The adaptive level detector is designed to automatically increase its pickup level, after a time delay, when a continuous input is applied. This feature is intended to prevent the fault detector from picking up on negative sequence currents caused by unbalances in the load current. A long time constant on the adapting feature allows the circuit to function properly on low level fault currents.

If the fault detector supervision is not desired, an option is available to remove it via closing option links 121B-3 and 121B-4. If the fault detector supervision is used, option link 121B-1 may be used to allow external trips via CC7 or CC8, even if the fault detector has not operated. Similarly, option link 121B-2 may be used to allow tripping during out-of-step conditions, if desired.

OUT-OF-STEP BLOCKING

A circuit to block the TLS relay from tripping during an out-of-step condition is included in the system. A simplified diagram of the out-of-step blocking circuit is shown in Figure 9. The MOB characteristic timers receive one input block per cycle from each of the three coincidence logic circuits of the overreaching distance units (MT and MTG). Both phase and ground MOB characteristic timers are included.

The nature of a power swing is such that the locus of the swing impedance will first enter the MOB characteristic and at some later time will enter the MT characteristic. On the other hand, for a fault condition the impedance will suddenly appear within the MT characteristic so the MT and MOB will both operate at about the same time. The out-of-step blocking logic makes use of the difference to recognize that a swing rather than a fault has occurred.

As a swing progresses, one input will be applied to AND201 when either MOB-Ø or MOB-G produces an output. The second input to AND201 will already be present because neither the MT nor MTG will be picked up and therefore, NOT201 will be producing an output. If MT does not produce an output before the pickup time of TL6, this timer will produce an output indicating that an out-of-step condition exists. The output of TL6 seals-in the second input to AND201 via OR203 preventing a later operation of MT or MTG from resetting the MOB output as the swing progresses. Thus, out-of-step blocking will be set up and maintained until 50 milliseconds after the swing exits the MOB characteristic.

The MOB-G function is used when single pole tripping is applied on parallel lines. It is used to block the ground function in one phase of the unfaulted line from operating if a swing should occur when the same phase of the faulted line is open following a single pole trip. MOB-G is not required in three pole tripping schemes; therefore, it is effectively disabled by settings its characteristic timer to the same settings used on the ground MTG functions.

The out-of-step blocking output serves a variety of functions in the TLS scheme logic as noted below:

1. The first zone direct trip units (M1 and MG1) may be blocked by the out-of-step signal at AND402 via option link 141A-3.

2. Zone 2 time-delayed tripping may be blocked at AND403 via option link 141A-8.

3. Zone 3 time-delayed tripping may be blocked at AND404 via option link 141A-2.

4. Permissive tripping may be blocked at the comparer, AND407, via option link 141A-5.

5. Keying a permissive trip signal may be blocked at AND204 and AND205 via option link 121A-3.

6. The weak infeed trip function may be blocked at AND406 via option link 141A-7.

7. If tripping when the MT unit operates during a swing is desired, the out-of-step blocking signal may be used to supply the trip bus supervision normally supplied by the fault detector via option links 121B-2 and 121B-4.

8. If the relays are allowed to trip during a swing, but reclosing is not desired, reclosing may be blocked via option link 131A-2 as discussed in the section, **"RECLOSING CONTROL."**

BLOCKING UNITS/ZONE 4 TRIPPING

When the TLS system is applied in a directional comparison blocking scheme, or a hybrid tripping scheme, the blocking functions must be used. The blocking functions consist of three single phase mho distance functions (MBs) and one negative sequence directional function (NB). A simplified diagram of the logic associated with the blocking functions is shown in Figure 10.

For an internal fault, the tripping functions will operate faster than the blocking functions (which may operate due to offset) and prevent operation of the NB and MBs via OR10. Note that the trip functions will have priority over the blocking functions, even if the blocking functions were operated before the tripping functions. In this case, the blocking output at AND302 will continue for the dropout time of TL24 and TL25 to provide transient blocking coordination for fault current reversals, etc. Because the negative sequence blocking function (NB) may pick up under load with one pole open, any MT or MTG operation will take immediate priority over NB during the open pole period via OR10, AND12, OR301 and AND301. A three phase fault or a first zone fault also take immediate priority over NB.

An option is also provided via link 131A-3 to include a Zone 4 time-delayed tripping feature whenever MB has been operated for an appropriate time.

DIRECT TRANSFER TRIPPING

When the TLS relay system is applied in a permissive or hybrid scheme with two communications channels, either on a shared or dedicated basis, the direct transfer trip feature included in the TLS logic may be used. A simplified logic diagram is shown in Figure 11.

In this application, a local three pole trip results in both transmitters 1 and 2 being keyed via AND203 and TL18, provided switch 121A-7 is closed. Only transmitter 1 is keyed for permissive tripping. The relay logic utilizes either receiver 1 or receiver 2 for its permissive trip signal to the comparer. This allows a permissive trip to occur when a transfer trip has been sent, even if channel 1 has failed for some reason. AND101 produces an output whenever channels 1 and 2 are received simultaneously. If the system uses only a single channel that is dedicated to the pilot relaying scheme, it is still possible to direct transfer trip through the scheme logic, but switch 111B-4 must be closed, and the direct transfer trip input must be connected to CC2. The direct transfer trip output (AND101 or CC2) initiates a three pole trip via TL13 and inhibits reclosing via OR409 as discussed in the section, **"RECLOSING CONTROL."** Timer TL13 is intended to prevent an incorrect transfer trip signal due to an erroneous output from one channel while the other is being received. An output from TL13 also blocks, via AND203, the keying of a transfer trip back to the originating end. Timer TL22 is used to discriminate between a pilot transfer trip and an equipment transfer trip and to block reclosing, as described in the **RECLOSING CONTROL** section.

Switch 111B-3, when closed, allows a transfer trip signal to:

a. initiate a trip via TL13 provided switch 111A-1 is open
b. block reclosing via timer TL22

Both of these features are disabled when 111B-3 is open.

INTERCIRCUIT FAULT PROTECTION

The protection of double circuit lines presents an interesting problem when single pole tripping is required. Consider, for example, the system shown in Figure 12. For the fault condition shown, the fault will appear as a BCG fault to the relays on both lines at station A. At station B, the fault will appear as a BG fault to the relays on line 1 and as a CG fault to the relays on line 2. Note that as the fault location moves towards the center of the ine, the fault will appear as a single line to ground fault to the relays at both stations. If suitable precautions are not taken, single pole tripping will be initiated on both lines at station B, while three pole tripping will be initiated on both lines at station A.

The distance functions in the TLS relay system are designed such that only the BC phase units will operate at station A, while at station B, only the B phase ground unit will operate on line 1 and only the C phase ground unit on line 2. However, this feature by itself does not solve the problem.

A complete solution involves the use of multiple communications channels. The first solution requires two information channels which could, for instance, be supplied by two Type 40 tone channels or by one Type 45, three frequency FSK channel. The two channel solution provides correct single pole clearing, as described below, but involves sequential tripping of the breaker remote from the fault.

This solution involves the use of two communications channels as shown in simplified form in Figure 13. Briefly, the following will occur for the fault condition shown in Figure 12. At station A, the phase BC MT functions will operate and send a three pole trip signal to station B via OR8 and AND205. At station B, the phase B MTG will operate in the protection associated with line 1 and the phase C MTG will operate in line 2. They will send single pole trip signals to the relays at station A via OR206 and AND204. A permissive trip signal will be applied to the comparer via OR101 at both stations. Single pole tripping of the faulted phases will be initiated at station B. No tripping will be initiated at station A at this time, because there has been no phase selection. The MT units are permitted to select a three pole trip only if a three pole trip signal is being received from station B (AND21). As soon as the fault is cleared at station B, the phase BC units at station A will reset and the proper ground units will operate and initiate single pole tripping. The permissive trip signal keying from station B will be extended beyond the time the breaker clears by TL1 (trip integrator).

A second solution which provides high speed clearing at both terminals, requires four information channels which could, for instance, be supplied by one Type 40 tone channel and one Type 45 three frequency FSK channel. The channel interface circuits are shown in simplified form in Figure 14. For the fault condition shown in Figure 12, the phase BC MT will operate at station A and send a three pole trip signal (f4) to station B via OR8 and AND205. At station B, the phase B MTG will operate in the protection associated with line 1, and the phase C MTG will operate in line 2. They will each send a phase identified single pole trip signal to the relays at station A via OR205, AND204 and the TX relay associated with the faulted phase.

The relays at station B will receive a permissive three pole trip signal (f4) which will energize the comparer via CC3 and OR101. Single pole tripping of the

faulted phase will be initiated at station B. At station A, the protection associated with line 1 will receive a phase B permissive single pole trip signal (f2). This signal will energize the comparer via CC1 and OR101; it will also provide phase selection via CC12 and OR2. This will result in single pole tripping of phase B on line 1 and in a similar manner, phase C on line 2. Note that the MT units are only allowed to select a three pole trip if a permissive three pole trip signal is received, indicating that the relays at both terminals are seeing an interphase fault. As noted earlier, the use of four channels results in high speed clearing at both terminals and does not require sequential tripping of the terminal remote from the fault.

TIME-DELAYED TRIPPING/ZONE SWITCHING

The TLS relay system includes timers for use in time-delayed backup or stepped distance applications. The basic relay schemes employ two dedicated zones of distance relaying - M1/MG1 and MT/MTG. An option is also included to extend the reach of the first zone phase and ground distance units via switch 141C-2 when the Zone 2 timer produces an output. Refer to Figure 1. This feature allows the basic TLS system to be used in three zone applications with no additional hardware. Single pole or three pole tripping is selected independently for both Zone 2 and Zone 3 tripping. Reclosing may also be blocked for either or both zones.

When the optional blocking units are included in the TLS system, a Zone 4 timer is also provided for time delay tripping as shown in Figure 10. An output from the Zone 4 timer will result in a three pole trip with no reclosing, regardless of the fault type.

TARGET LAMPS

A single pole tripping scheme is equipped with 13 LED target lamps as shown in Table IV. All LEDs are sealed-in and supervised by the relay trip busses except for the out-of-step blocking and three pole trip selected lamps. Note that the A, B and C lamps indicated the trip busses that were energized, rather than the fault type. In other words, a BC fault will result in all three lamps being lit and a BG fault will result in only the B lamp. Note that if the switched zone feature is used, a trip in Zone 2 time will result in the I and II lamps, while a trip in Zone 3 time will result in the II and III lamps. In three pole tripping schemes, the 3P lamp (three pole trip selected lamp) is omitted and all phase targets (A, B and C) are connected in parallel.

TABLE II
TLS TARGET LAMPS

LAMP	DESCRIPTION
A	ØA Trip Bus
B	ØB Trip Bus
C	ØC Trip Bus
I	Zone 1 Trip
II	Zone 2 Trip
III	Zone 3 Trip
IV	Zone 4 Trip
CT	Pilot Trip
LP	Line Pickup Trip
WI	Weak Infeed Trip
TT	Direct Transfer Trip
MOB	Out-of-step Blocking
3P	Three Pole Trip Selected

DATA LOGGING MONITORING

The basic single pole tripping TLS relay system includes 12 normally open contacts for monitoring the logic of the relay system. The 12 points are listed in Table III.

TABLE III
STANDARD DLA POINTS

1	Any MT (OR50)
2	Any MTG (OR53)
3	Any M1 (OR51)
4	Any MG1 (OR54)
5	Local Permissive Trip (OR201)
6	Received Permissive Trip (OR101)
7	Local Blocking (OR302)
8	Three Pole Trip Select (OR20)
9	Time Delayed Trip (OR401)
10	DTT (TL13)
11	Weak Infeed Trip (TL16)
12	Line Pickup Trip (OR304)

LOGIC SWITCHES

The TLS1000 System is provided with a series of switches that must be set to establish the scheme logic. The following pages list these switches, the modules that they are located on, and the proposed settings for Blocking (B), Permissive Tripping (P) and Hybrid (H) type relaying schemes. Comments are given where required to aid in making an appropriate setting. Where no comments are provided, it is only necessary to select the setting given for the particular scheme that is to be implemented. Note that the ULM101 module is not provided in three-pole tripping schemes. Thus, the settings described for switches located on the ULM101 module can be ignored unless single-pole tripping is used.

SWITCH NO.	B	P	H	COMMENTS
101A-1 (ULM101)	O	O	O	Used in single-pole tripping schemes. See section on single-pole
-2	O	O	O	tripping to determine setting.
-3	C	C	C	See section on single-pole tripping for more details.
-4	C	C	C	
-5	C	C	C	Open in single-pole tripping schemes applied to double-circuit
-6	C	C	C	lines.
-7	C	C	C	Open in single-pole tripping schemes if it is required to trip single-pole following a zone 3 trip.
-8	C	C	C	Open in single-pole tripping schemes if it is required to trip single-pole following a zone 2 trip.
101B-1(ULM101)	C	C	C	See section on single-pole tripping, for more details.
-2	O	O	O	Open - Single-pole trip for SLG faults, three-pole trip for multi-phase faults. Close - Three-pole trip for all faults.
-3	O	O	O	Close when two channel are used (1 Pole.13 Pole).*
111A-1(ULM111)	O	O	O	Close to direct transfer trip through TLS logic.
-2	C	C	C	Open if bus side potentials are employed and line pickup protection is required. See section on line pickup.
-3	C	O	O	
-4	O	O	O	
111B-1(ULM111)	O	O	O	Close if zone acceleration is used.
-2	O	O	O	
-3	O	O*	O*	*Close to direct transfer trip through TLS logic.
-4	O	O	O	Close if TLS logic is used for direct transfer trip and if input is connected to CC2.

*Revised since last issue

SWITCH NO.	B	P	H	COMMENTS
121A-1(ULM121)	O	O	O	Open for 60 Hz. Close if system frequency is 50 Hz.
-2	C	C*	C	*Open if scheme is permissive underrreaching.
-3	O	O	O	Close if XMTR keying is to be blocked during out-of-step.
-4	C	C	C	Open if RI output is required for all trip conditions. Refer to text for details.
-5	O	O	O	Close to invert K1 contacts (XMTR No. 1 keying)
-6	O	O	O	Close to invert K2 contacts (XMTR NO. 2 keying)
-7	O	O*	O*	*Close to operate K1 and K2 when trip output is produced. Used to key direct transfer trip XMTRS.
-8	O	O	O	Not used.
121B-1 (ULM121)	C	C	C	Allows external trip without fault dectector via CC7 or CC8. Open to disable external trip unless fault detector operates.
-2	O	O	O	Close to allow MOB to override fault detector - Use the closed position when it is desired to trip during an out-of-step condition.
-3	O	O	O	Close this switch to override fault detector.
-4	C	C	C	Enables positions 1, 2 and 3 of this switch when closed. Open to disable these three positions.
121C-1 (ULM121)	C*	O	O	*Blocking with off-on channel
-2	C*	O	O	*Blocking with off-on channel
T101A-1(UTM101)	O	O	O	
-2	O	O	O	Close all three switches if MG1 is operated in the reactance mode.
-3	O	O	O	
-4	O	O	O	Close when single-pole tripping is used on double-circuit lines.

SWITCH NO.	B	P	H	COMMENTS
131A-1(ULM131)	C	C	C	
-2	C	C	C	Close - 1 Block RI output during out-of-step. Open - Allow RI output during out-of-step.
-3	O	O	O	Open - Block zone 4 timing. Close if zone 4 timing is required.
-4	C	C	C	Close - Line pickup in service. Open if line pickup protection is not required.
-5	O	O	O	Close if bus side potentials are used and line pickup is required. See section on line pickup.
-6	O	O	O	Not used.
141A-1(ULM141)	C	C	C	Zone three enabled when closed; Open to disable zone 3 protection.
-2	C	C	C	Zone three blocked during out-of-step; Open to remove MOB supervision of zone 3.
-3	C	C	C	Zone one blocked during out-of-step; Open to remove MOB supervision of zone 1.
-4	C	C	C	Zone two enabled when closed; Open to disable zone 2 protection.
-5	C	C	C	Pilot trip blocked during out-of-step; Open to allow pilot trip during out-of-step.
-6	O	O	O	Close if series capacitors are located directly behind TLS system, either in protected line or adjacent lines.
-7	C	C	C	Weak infeed trip blocked during out-of-step. Open to allow weak infeed trip during out-of-step.
-8	C	C	C	Zone two blocked during out-of-step. Open to remove MOB supervision of Zone 2.

SWITCH NO.	B	P	H	COMMENTS
141B-1(ULM141)	0	0	C*	*Open to block repeat of received signal.
-2	0	0	C*	*Open only if additional delay required in blocking repeat of signal.
-3	0	0	0	
141C-1(ULM141)	0	0	0	Close to enable 141C-3.
-2	C	C	C	Close - Trip via zone 2 timer. Open - Switch zone 1 reach via zone 2 timer.
-3	0	0	0	Open - Enable sequential reclose for all MT. Closed - Enable sequential reclose for any MT.
141D-1(ULM141)	0	0	0	Close only if independent zone 3 is supplied.
-2	0	0	0	Close only if extra coordinating time delay is required; i.e., if extremely slow channel is used.
141E-1(ULM141)	C	C	C	Open when independent third zone supplied and is not to be used as part of pilot protection.
-2	C	C	C	Open to block any zone 1 function from establishing sequential reclose output.
-3	0	0	C*	Close - weak infeed trip in service. *Open to block weak infeed tripping.
-4	0	0	0	Not used.
-5	0	0	0	Not used.
-6	0	0	0	Close to block RI for any MT operation.

SWITCH NO.	B	P	H	COMMENTS
141F-1(ULM141)	O	O	O	Open - Block RI for zone 2 or zone 3 trip. Close - Block RI for zone 3 trip only, permit RI for zone 2.
-2	C	C	C	Close - Enables 141F-1 output. Open to disable 141F-1 output.
-3	O	C	O	

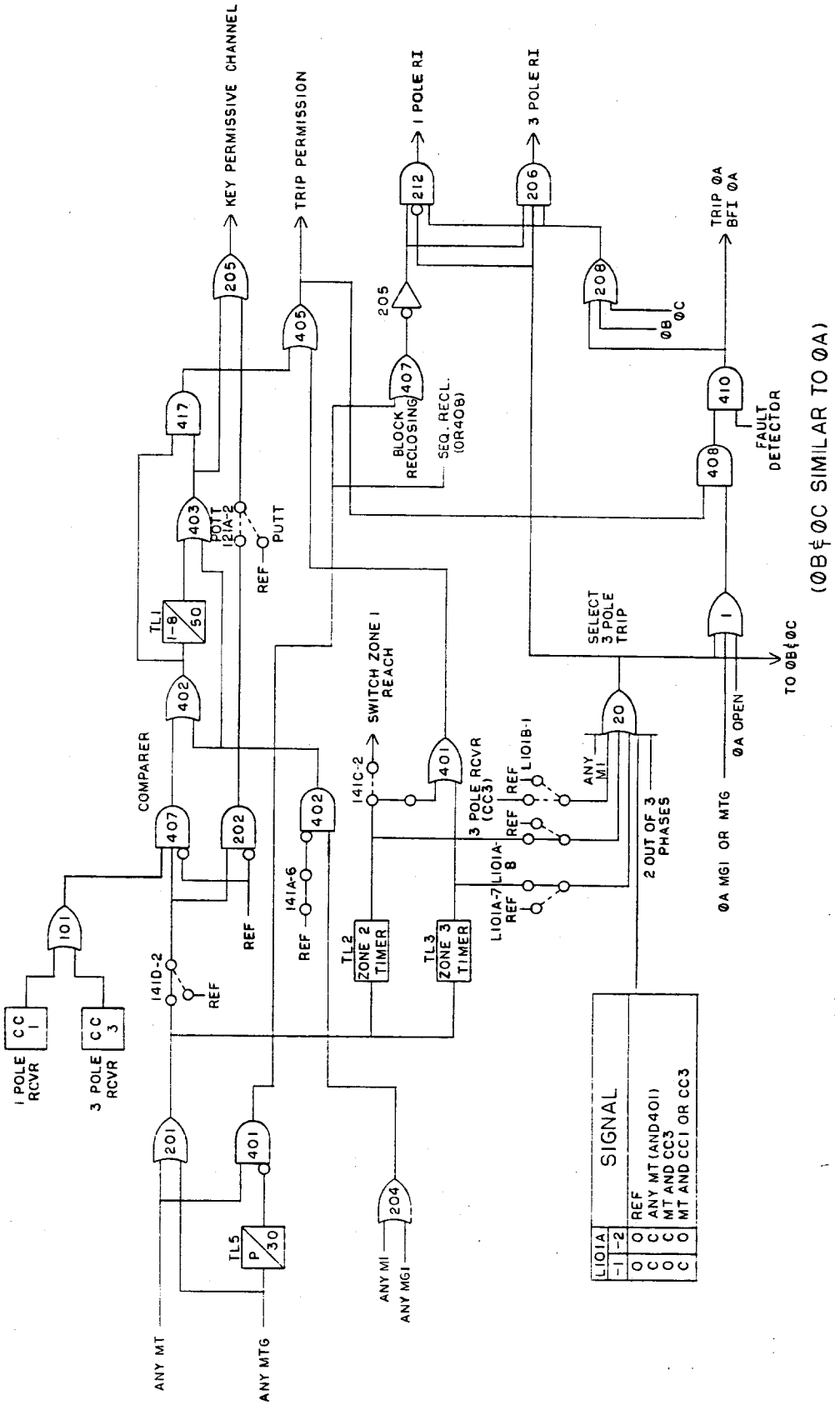


FIGURE 1A (0179C7190, Sh 1) - TLS SIMPLIFIED PERMISSIVE TRIPPING LOGIC

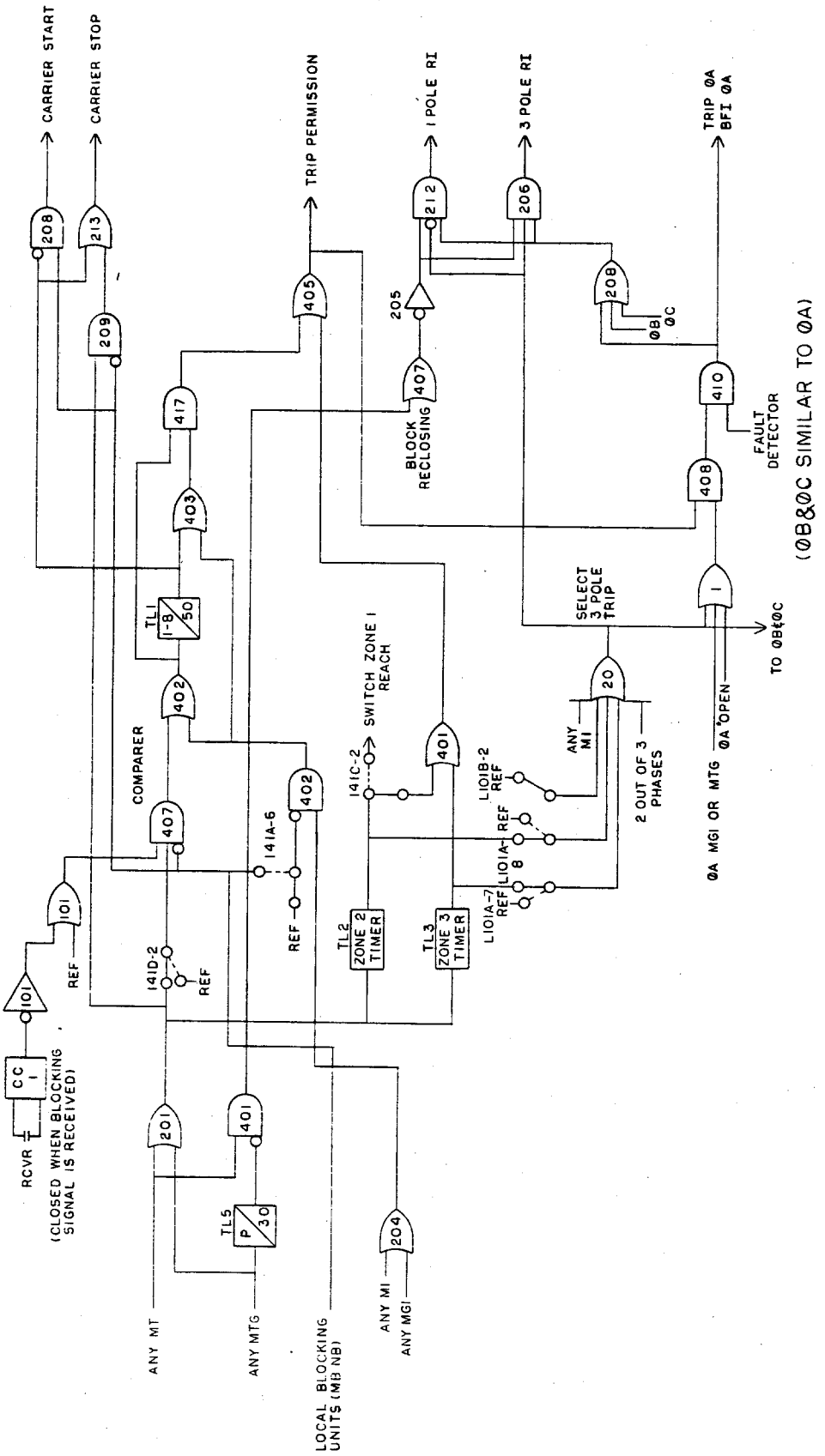


FIGURE 1B (0179C7190, Sh 2) - TLS SIMPLIFIED DIRECTIONAL COMPARISON BLOCKING LOGIC, AM CHANNEL

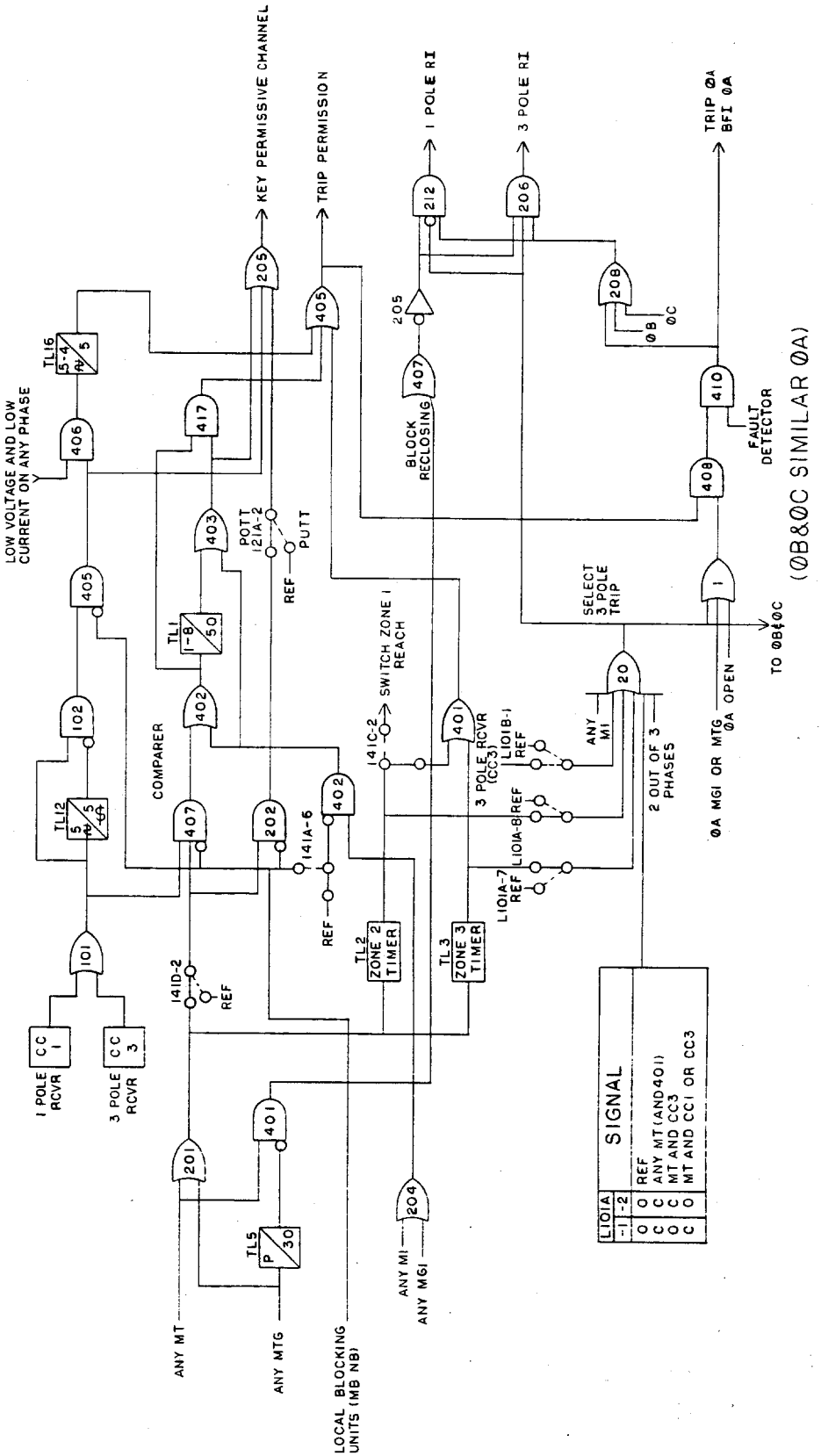


FIGURE 1C (0179C7190, Sh 3) - TLS SIMPLIFIED HYBRID DIRECTIONAL COMPARISON LOGIC

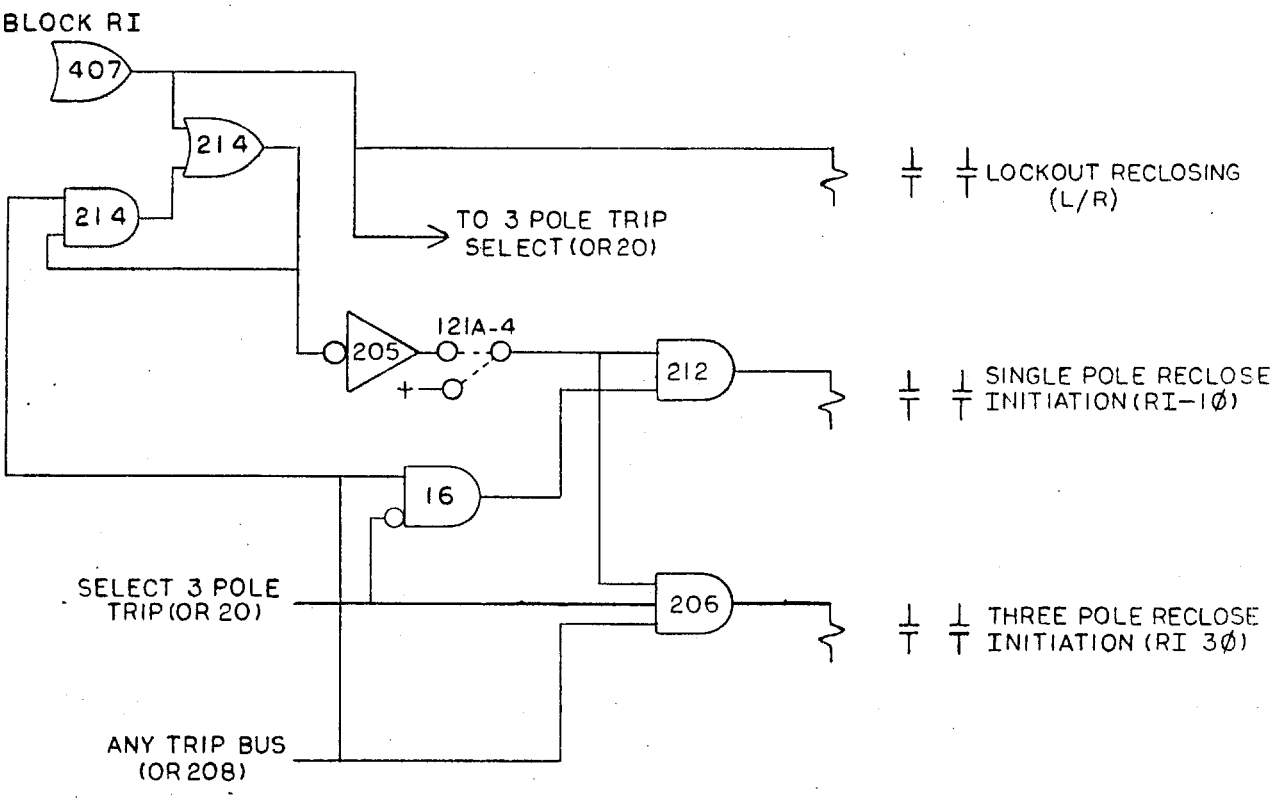


FIGURE 2 (0285A9259, Sh 1) - TLS RECLOSE INITIATION CIRCUIT

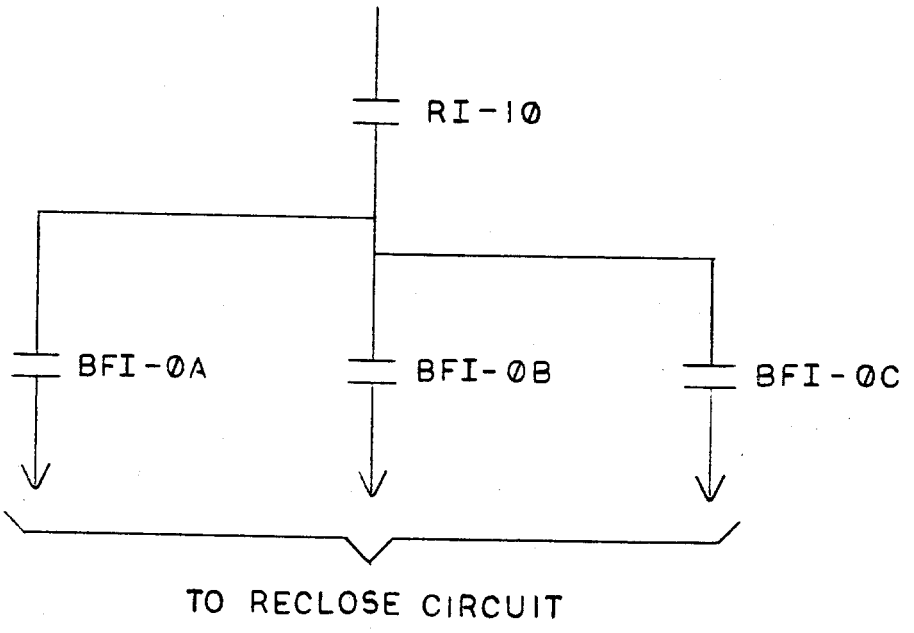


FIGURE 3 (0285A9259, Sh 2) - PHASE IDENTIFIED SINGLE POLE RECLOSE INITIATION

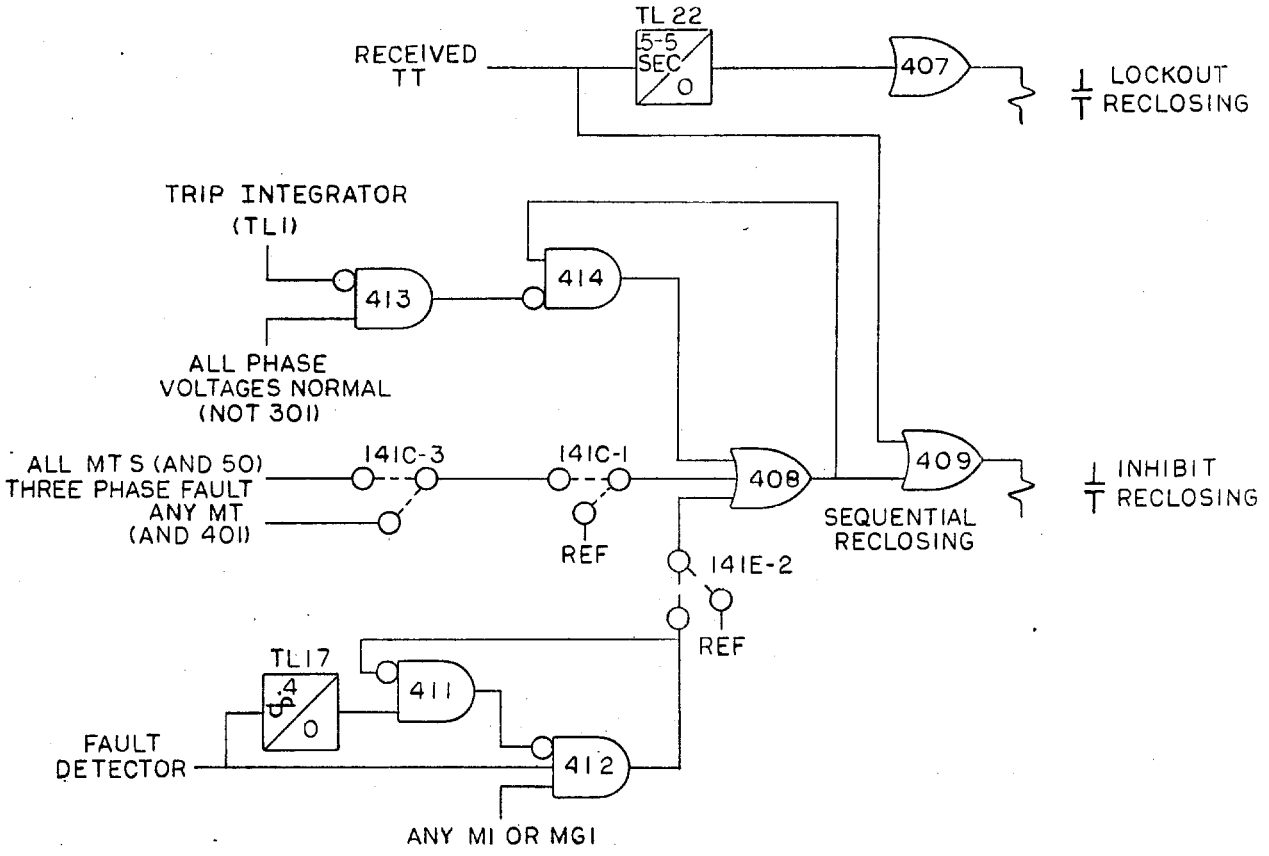


FIGURE 4 (0285A9259, Sh 3) - INHIBIT RECLOSING CIRCUIT

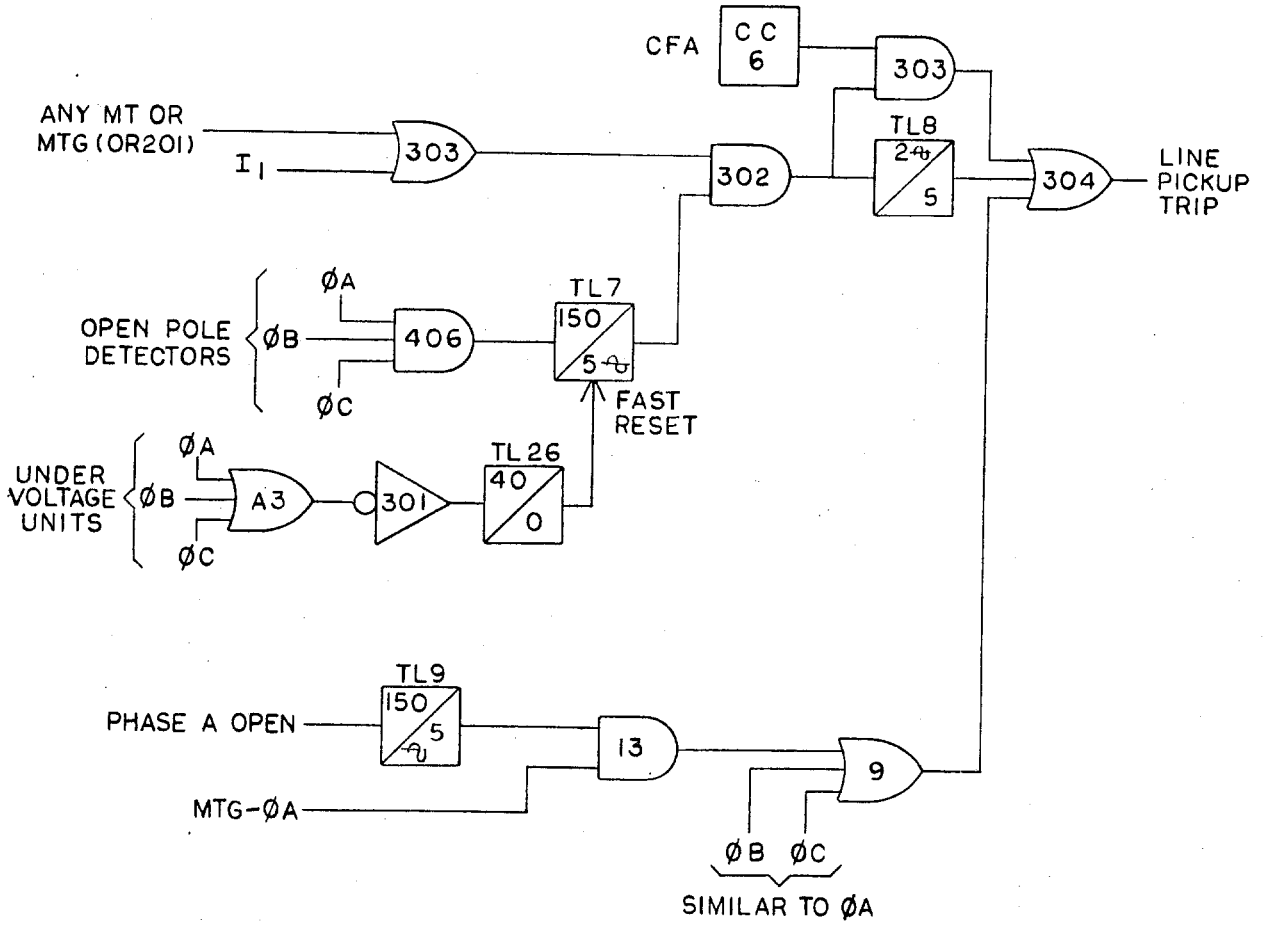


FIGURE 5 (0285A9259, Sh 4) - SIMPLIFIED LINE PICKUP CIRCUIT

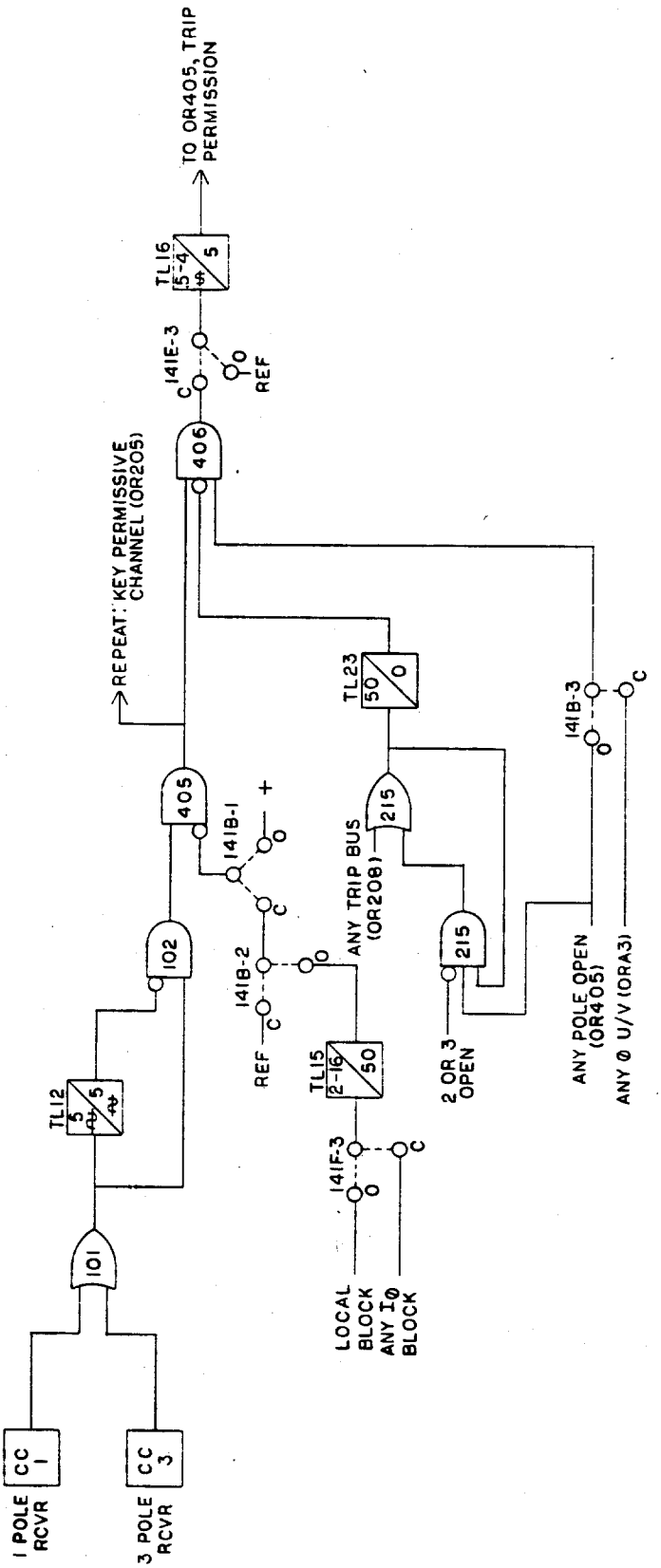


FIGURE 6 (0184B6313) - CHANNEL REPEAT AND WEAK-INFEED CIRCUITS

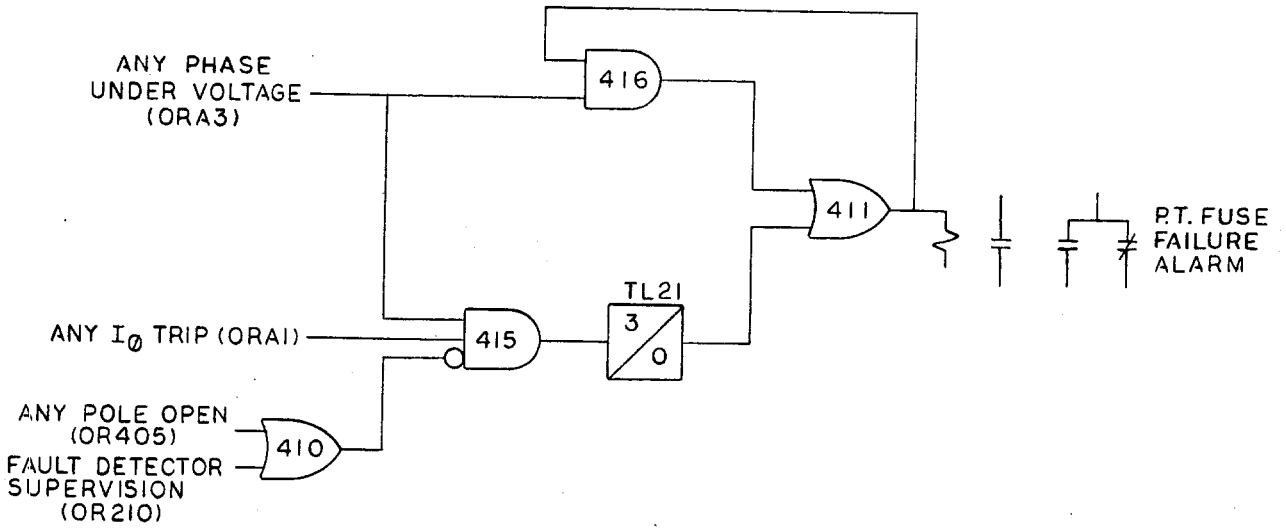


FIGURE 7 (0285A9259, Sh 5) - P.T. FUSE FAILURE ALARM CIRCUIT

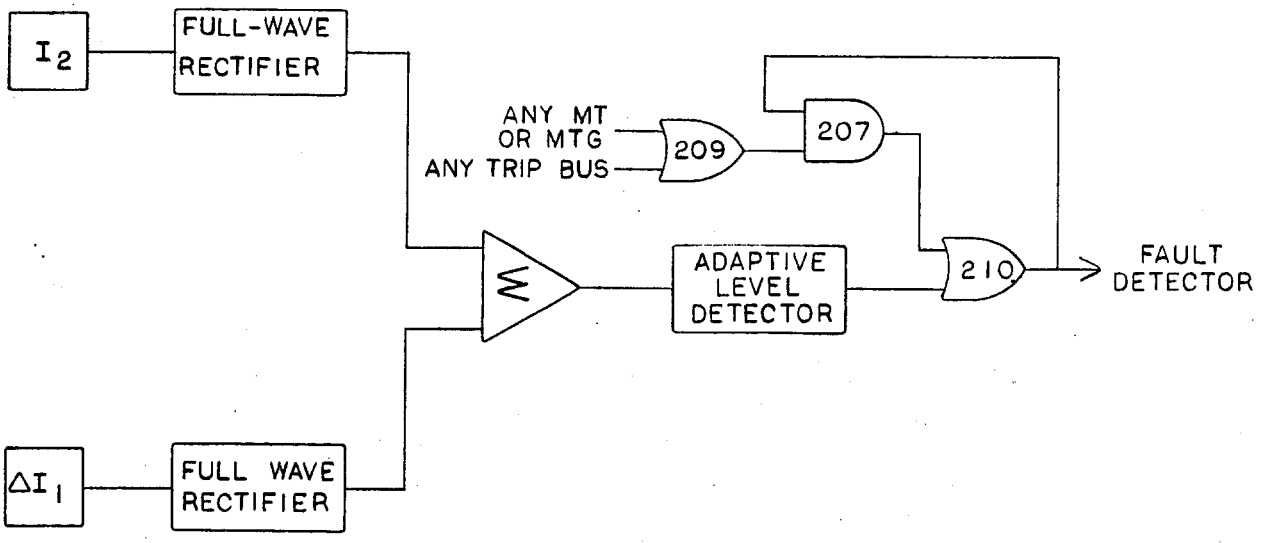


FIGURE 8 (0285A9259, Sh 6) - FAULT DETECTOR CIRCUIT

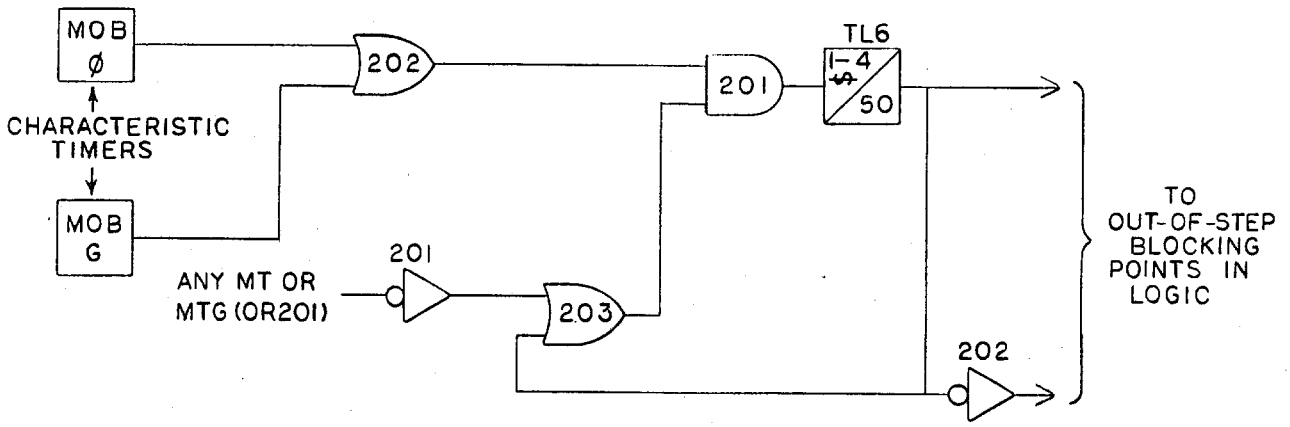


FIGURE 9 (0285A9259, Sh 7) - OUT-OF-STEP BLOCKING

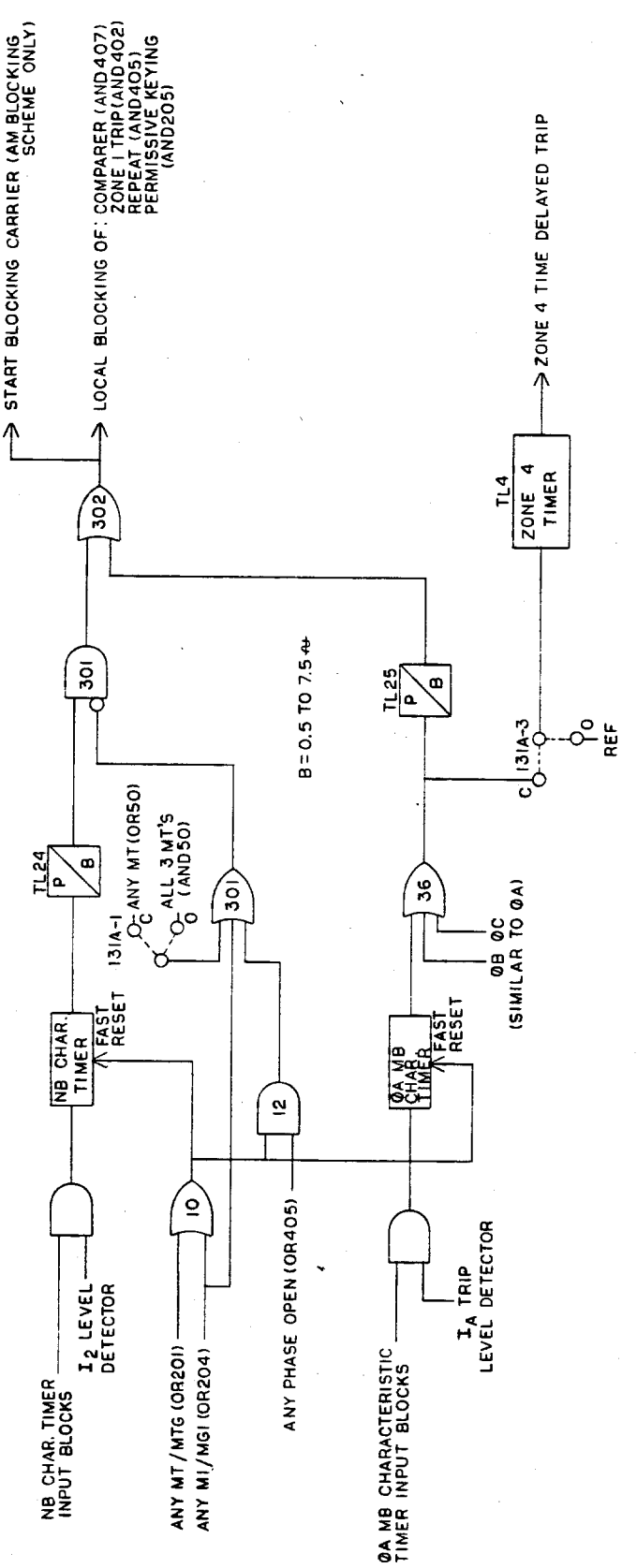


FIGURE 10 (0184B6314) - BLOCKING FUNCTIONS

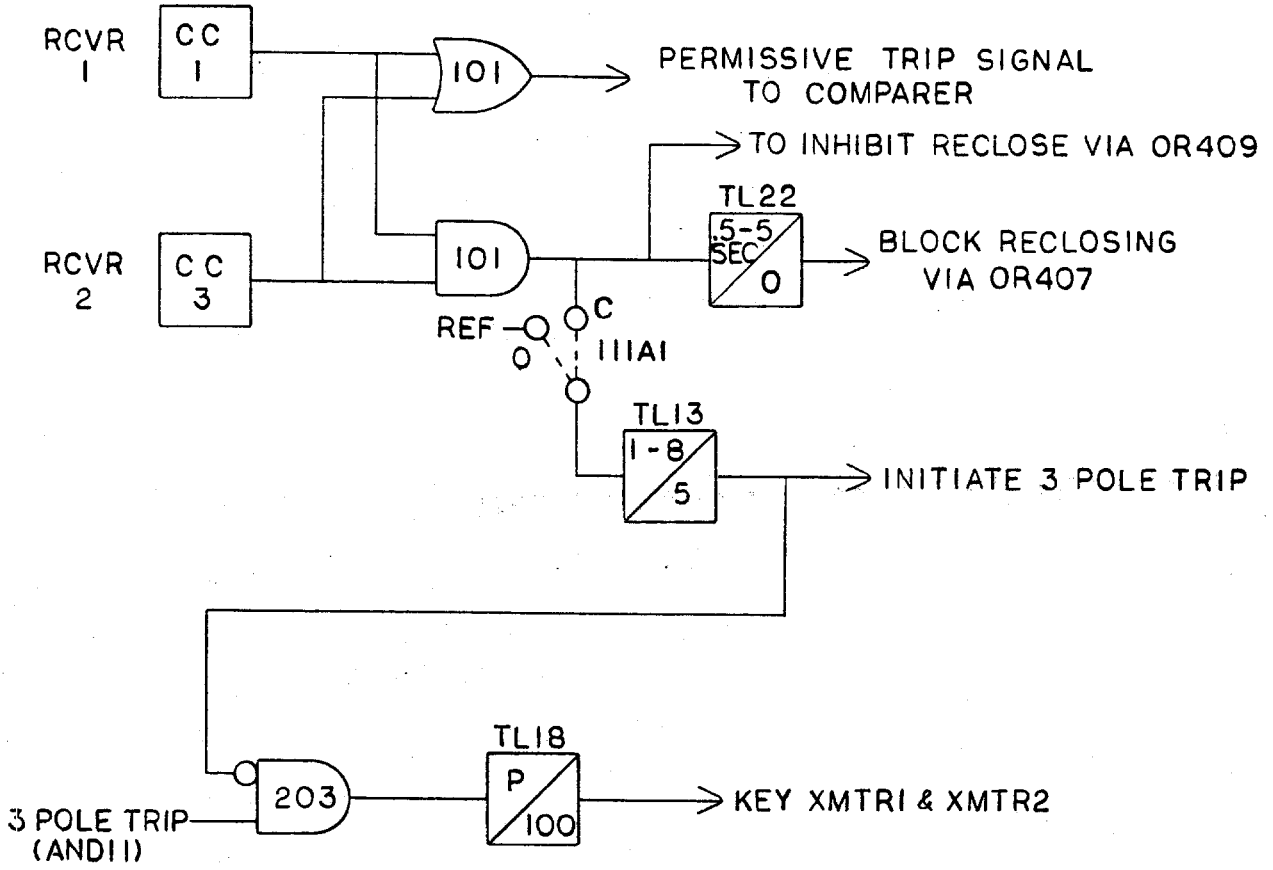


FIGURE 11 (0285A9259, Sh 8) - DIRECT TRANSFER TRIP LOGIC

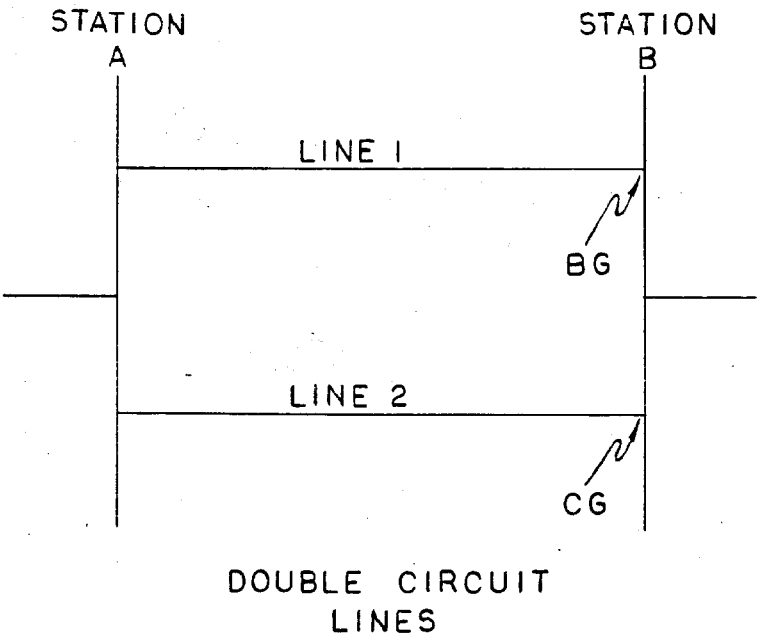


FIGURE 12 (0285A9259, Sh 9) - INTERCIRCUIT FAULT ON DOUBLE CIRCUIT LINE

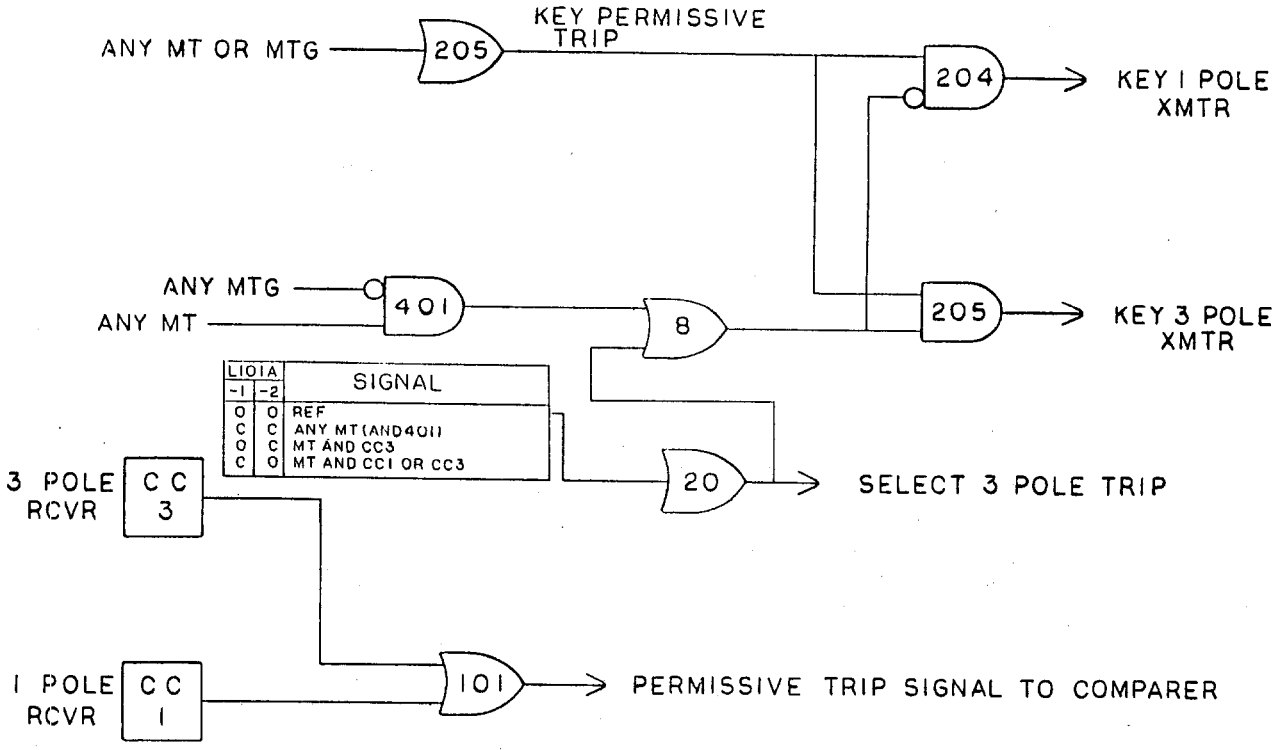
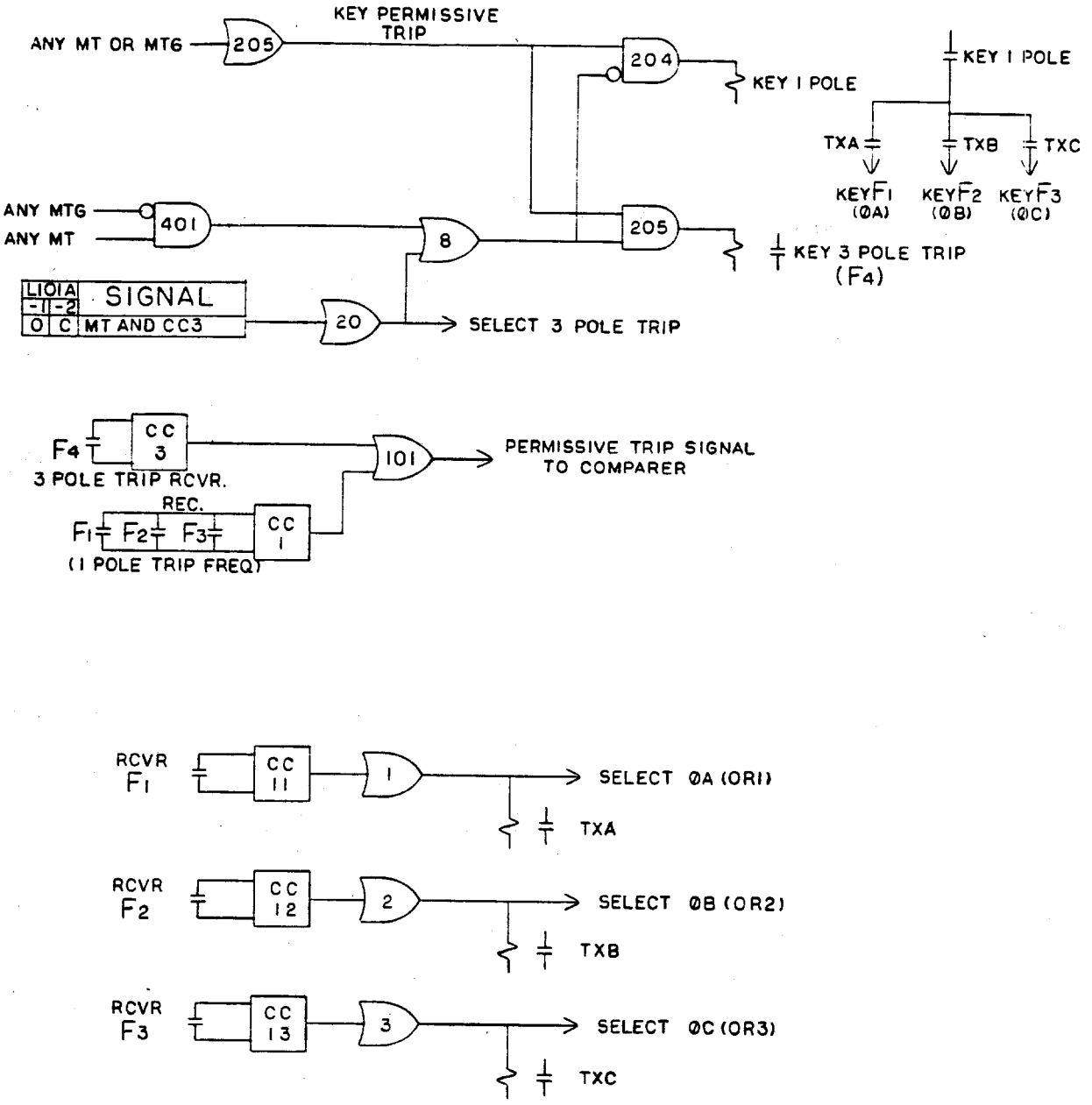


FIGURE 13 (0285A9259, Sh 10) - CHANNEL KEYING/PHASE SELECTION FOR INTERCIRCUIT FAULTS



FREQUENCY ALLOCATION	
F1	ØA SELECTED
F2	ØB SELECTED
F3	ØC SELECTED
F4	3 POLE TRIP SELECTED

FIGURE 14 (0184B6315) - CHANNEL KEYING/PHASE SELECTION FOR INTER CIRCUIT FAULTS, FOUR CHANNEL SCHEME

Meter and Control
Business Department

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(10/89) (A)

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