TLS1B

DIGITAL RELAY SYSTEM

Instruction Manual

Manual P/N: GEK-100559

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES CONTD.

LIST OF TABLES

MODULAR RELAY SYSTEM

TLS1B

INTRODUCTION

The TLS1B is a comprehensive relaying system for transmission-line protection. It can be used on series-compensated, as well as uncompensated, lines. Single-pole tripping is also included.

The system is packaged in an eight-rack-unit (8 RU) modular case containing insertable printed-circuit cards, the input magnetics for potential and current, and the high-current output relays.

A continuous monitor module is available as an option for all models. Relay or SCR tripping outputs may also be specified.

The TLS system may be set by the user for any of the following distance relaying schemes (refer to the SCHEME DESCRIPTION section of this manual).

1. Stepped distance
2. Permissive overreaching transfer trip
3. Permissive underreaching transfer trip
4. Directional comparison blocking
5. Hybrid tripping

All of the above schemes, except for the stepped-distance scheme, require a communication channel. When a pilot scheme is used, the stepped-distance scheme may also be used to provide backup protection.

The TLS systems also include other standard features that may be selected by the user, such as:

1. Out-of-step blocking
2. Fault-detector supervision of the trip bus
3. Line pickup (close onto fault) protection
4. PT fuse-failure alarm
5. Sequential reclosing control
6. Channel repeat (echo)
7. Weak-infeed tripping
8. Direct transfer trip

The various relaying schemes and features are discussed in detail in the SCHEME DESCRIPTION section of this manual. Note that all of these features are not compatible with every scheme. For example, the channel repeat, weak-infeed trip, and direct transfer trip cannot be used with the directional-comparison-blocking scheme.

MODEL NUMBER BREAKDOWN

The following table shows the model number structure and can aid in determining the schemes and options desired.

TLS1 B * * * * * * * *

Digit Number	Code	Description
5	B	8 rack unit case
6	1	1 ampere rated current
	5	5 ampere rated current
7	5	50 hertz rated frequency
	6	60 hertz rated frequency
8	B	Blocking scheme with AM channel
	H	Hybrid scheme with FSK channel
	P	Permissive scheme with FSK channel
	S	Stepped distance scheme
	X	Special customer logic
9	0	48 volt DC rated
	1	125 volt DC rated
	2	250 volt DC rated
10, 11	CC	One tripping zone of distance protection with blocking units
	CD	Two tripping zones of distance protection (switched third zone) with blocking units
	CE	Three tripping zones of protection with blocking units *
12	1	Solid state tripping output (SCR)
	2	Relay tripping outputs
13	A	No options
	B	Continuous monitor
	C	Single pole breaker failure, positive sequence over-voltage unit, and two auxiliary timers
	D	Continuous monitor, single pole breaker failure, positive sequence over-voltage unit, and two auxiliary timers
	X	Special customer options
14	B	Revision level

* Cannot be used with option C or D (digit 13).

SCHEME DESCRIPTION

FORWARD REACHING FUNCTIONS

Variable mho characteristics are used to provide the phase and ground distance protection used in the TLS1B system. These characteristics are derived using a multi-input comparator as shown in Figure SD-1. The phase angle measurement is made by comparing the coincidence time of all of the phasors applied to the comparator. If all of the phasors are coincident for a time corresponding to the characteristic timer angle setting, or conversely, if all of the phasors are separated by less than the characteristic timer angle setting, the function will provide an output.

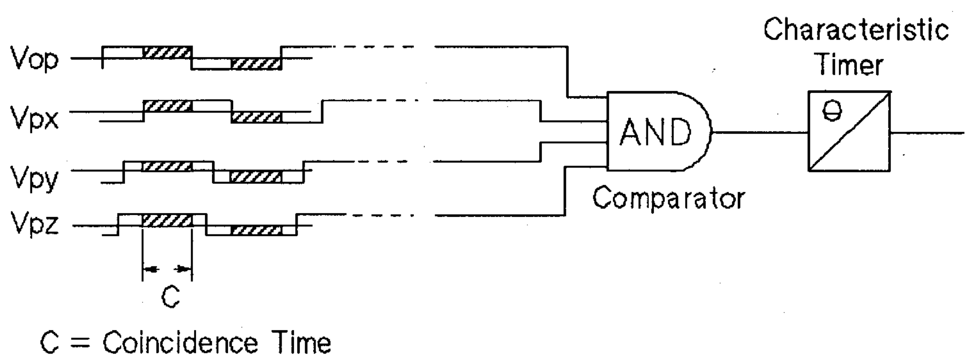


Figure SD-1 Multi-input Phase Angle Comparator

The multi-input comparator provides the basic variable mho/lens/tomato characteristics shown in Figure SD-2. The characteristic timer can be adjusted to give the shapes shown in the Figure.

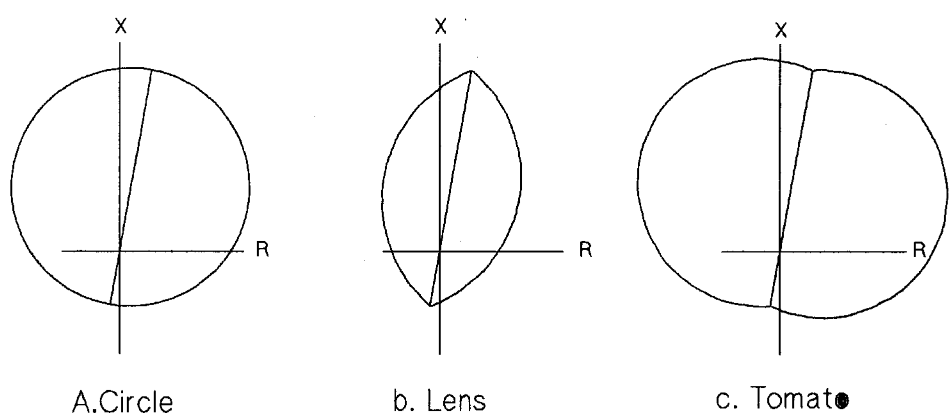


Figure SD-2 Variable Mho/Lens/Tomato Characteristics

PHASE DISTANCE FUNCTIONS

The following signals are used:

Operating Signal:

$$Vop = I\phi\phi * ZR1 - V\phi\phi$$

Polarizing Signals:

$$Vpx = (V\phi\phi 1 - I\phi\phi 1 * ZR1')_m$$

$$Vpy = I\phi\phi * ZR1$$

Where: $\phi\phi$ = AB, BC or CA
1 = positive sequence
ZR1 = Reach of the forward reaching phase distance functions
ZR1' = forward offset = (OFFSET)*ZR1, where the factor (OFFSET) can be set to 0, 0.1, 0.2, 0.3 or 0.4
m = memory

Table SD-1 lists the characteristics that are formed from these signals. The phase distance functions are always applied with all three characteristics in service.

TABLE SD-1 PHASE DISTANCE FUNCTION CHARACTERISTICS

CHARACTERISTIC	SIGNALS USED
Variable mho	Vop and Vpx
Reactance	Vop and Vpy
Directional	Vpx and Vpy

GROUND DISTANCE FUNCTIONS

The following signals are used:

Operating Signal:

$$Vop = (I\phi - I0)ZR1 + K0*I0*ZR0 - V\phi$$

Polarizing Signals:

$$Vpx = (V\phi 1 - I\phi 1 * ZR1')_m$$

$$Vpy = I\phi 2 * ZR1$$

$$Vpz = I\phi 0 * ZR1$$

Where: ϕ = A, B or C
0 = zero sequence

2 = negative sequence
ZR1 = Reach of the forward reaching ground distance functions
ZR1' = forward offset = (OFFSET)*ZR1, where the factor (OFFSET) can be set to 0, 0.1, 0.2, 0.3 or 0.4
K0 = zero sequence current compensation.

Listed in Table SD-2 are the characteristics that are formed with these signals:

TABLE SD-2 GROUND DISTANCE FUNCTION CHARACTERISTICS

CHARACTERISTIC	SIGNALS USED
Variable mho	Vop and Vpx
Negative Sequence Reactance	Vop and Vpy
Zero Sequence Reactance	Vop and Vpz
Directional	Vpx and Vpy
Directional	Vpx and Vpz
Negative/Zero Sequence Phase Selector	Vpz and Vpy

The ground zone 1 distance functions can be operated in the reactance mode by disabling the Vpx polarizing signal. When the ground zone 1 functions are operated in the reactance mode, they must be supervised by the ground distance overreaching (MTG) functions.

REVERSE REACHING (BLOCKING) FUNCTIONS

The following signals are used to derive the ground distance blocking functions.

Operating Signal:

$$Vop = -I\phi * ZR1 - K0 * I0 * ZR0 - V\phi g + KV1(V\phi 1 - I\phi 1 * ZR1')_m$$

Polarizing Signal:

$$VP = (V\phi 1 - I\phi 1 * ZR1')_m$$

Where:

ZR1 = Reach of the reverse looking blocking functions
KV1 = 0, 0.15, 0.3 or 0.45
K0 = zero sequence current compensation
ZR1' = reverse offset = OFFSET*ZR1, where the factor OFFSET = 0(OUT) or 0.1(IN)

These functions will operate for all fault types, however, they may be slow to operate for some phase-to-phase faults. To provide for this contingency, a second blocking function is provided. Negative sequence quantities operating through an amplitude comparator are used in this function to produce a negative sequence directional characteristic. The following signals are used in the negative sequence directional blocking functions:

Operating Signal:

$$Vop = V2 + KI2Z*I2*NB$$

Restraining Signal:

$$VR = I2*NB$$

Where:

KI2Z = current compensation offset factor

NB = reach factor

FAULT DETECTOR

A fault detector function is used to provide supervision of the trip outputs, and is intended to reduce the possibility of misoperation due to either potential or component failure. The function is a sensitive, high speed current operated function, that uses negative sequence current or the change of positive sequence current. It has an adaptive pickup level that is increased automatically, after a time delay, when a continuous input is applied to it. This feature is intended to prevent operation of the fault detector on negative sequence current caused by unbalances in the load current. The function will perform properly on low level fault currents because the adaptive feature is provided with a long time constant.

LINE PICKUP (CLOSE INTO FAULT)

Line pickup circuitry (close into a fault protection) is included in all TLS1B systems. Circuitry is provided for three pole and single pole tripping schemes.

The line pickup circuitry is implemented via current and voltage functions that operate through the logic to initiate tripping when energizing a line. Basically, the current and voltage functions are used to form open pole detectors to determine that the line is dead by sensing the lack of voltage and current. If a dead line condition persists for nine cycles, the logic is arranged to permit direct tripping by a positive sequence overcurrent function provided for this purpose. If there is no fault when the breaker is closed, the positive sequence overcurrent function will not operate, and the line pickup protection will be removed from service when all three phase voltages return to normal.

Similar type logic is used when single pole tripping is required, but in this case line pickup will only be energized during the period that the faulted phase is open. If a breaker is reclosed into a fault, three pole tripping will be initiated through the operation of the ground distance function associated with the faulted phase. If there is no fault, the line pickup circuitry will be removed from service following restoration of the phase voltage.

If the line pickup protection is not desired, it can be taken out of service via an option link.

OUT-OF-STEP BLOCKING

Out-of-step blocking is provided on both the phase and ground overreaching functions. The ground functions are provided with out-of-step blocking to prevent operation of the ground overreaching functions in applications involving single pole tripping and parallel lines. With one pole open in one of the lines, it is possible for the ground distance function on the same phase in the parallel line to operate during a swing before the phase out-of-step blocking can be set up.

The ground out- of-step blocking is set to prevent this. If single pole tripping is not employed, the ground out-of-step blocking is not required and is taken out of service by setting the MOBG characteristic the same as the MTG characteristic.

PT FUSE FAILURE

Circuitry is included in the TLS1B system to detect failure of a fuse in the potential supply of the system. The alarm circuit operates when all three of the following conditions are met.

1. Loss of any or all phase voltages.
2. Any phase current above the $I\phi$ TRIP level detector setting.
3. No output from the fault detector.

The fuse-failure-alarm output is sealed in once it operates, and remains sealed in until all phase voltages return to normal. The output from the fuse failure alarm may be used to block tripping, sound an alarm, etc. The alarm will not operate if the phase current is not above the $I\phi$ TRIP pickup, but the distance units cannot produce any tripping for this loss of potential because they are supervised by $I\phi$ TRIP. If the current should then increase above the pickup level, the fuse failure circuit will operate before the distance functions, thus preventing any trip outputs. Note that the fuse failure alarm circuit will be blocked during a single pole trip when such tripping is employed.

APPLICATION

The TLS1B protective relaying system can be used to provide fast, reliable protection on long or short lines, compensated or uncompensated lines, double-circuit lines, etc. In all of these applications, Single-pole tripping is also included.

Three independent forward zones of protection are provided. Each forward zone uses three functions for phase faults (one for each phase pair) and three functions for ground faults (one for each phase). Two types of blocking functions are used in the TLS1B system. They are required in the hybrid and blocking type schemes and in all applications with series capacitors. A variation of a positive sequence polarized mho ground distance function is used as the first type of blocking function. Three such functions are used - one for each phase. The second type of blocking function uses negative sequence quantities operating into an amplitude comparator to form a directional function.

SCHEMES

The following pilot relaying schemes can be selected:

1. Permissive overreaching transferred trip/unblocking
2. Permissive underreaching transferred trip
3. Hybrid (weak infeed and channel repeat)
4. Directional comparison blocking

The channel interface for each of the pilot relaying schemes is provided through contact inputs and outputs.

SERIES COMPENSATED LINES

The TLS1B system can be applied on lines with series compensation or on lines adjacent to compensated lines.

One of the basic problems that can occur on a compensated line is that the voltage at the relay can be reversed from the normal position because of the series capacitor. Consider the situation shown in Figure CS-5 in the CALCULATION OF SETTINGS section.

For a fault at F, the voltage applied to a relay with its potential source located on the line side of capacitor C will reverse if the protective gaps do not operate to remove the capacitors from service. On a steady-state basis, the effect of the reversal on a distance function that uses this voltage for polarization is to cause the fault to appear to be internal to the line rather than external as it actually is. If the function has its potential source on the bus side of C an internal fault just in front of C will appear as an external fault (steady-state). If the function has a memory circuit in the voltage polarizing signal, it will perform correctly on a dynamic basis regardless of the location of the potential source; i.e., the voltage will not reverse immediately because of the memory action.

The distance functions in the TLS1B system use positive sequence voltage as the polarizing quantity and are provided with memory circuits. The positive sequence voltage will reverse for three phase faults, but on many systems it will be less likely to reverse for unbalanced faults. Therefore, the functions must be relied on to operate dynamically for three phase faults. For unbalanced faults, they will respond correctly on a dynamic basis, and in many cases will also provide a correct steady-state response. Thus, the distance functions in the TLS1B system will respond correctly to initiate high speed tripping (direct or pilot) regardless of the fault type or fault location relative to the series capacitor and potential source location.

Although the TLS1B distance functions with their potential source located as shown in Figure CS-5 will provide a correct dynamic response for a fault at F, this response may not be long enough to prevent tripping in the event of inordinately long breaker times in the adjacent line sections. To overcome this limitation, the blocking functions must be used in all applications involving series capacitors. The blocking functions will operate correctly dynamically, and possibly steady-state, to establish a blocking condition; and they are provided with adjustment in the dropout time to allow their output to last long enough to allow fault clearing by the breakers in the adjacent line sections.

Because the capacitive reactance of the series capacitor cancels the inductive reactance of the line, zone 1 functions cannot be set to protect 90 percent of the line when the capacitors are located in front of the relay location - either in the line itself or in adjacent line sections. It is also recommended that zone 1 functions not be set to reach 90 percent of the compensated line impedance; i.e., [0.9(ZL - XC)]. This is so because of the low frequency transients that are introduced by the series capacitors which can cause a zone 1 function to overreach significantly. The zone 1 functions in the TLS1B system can be used to initiate direct tripping on series compensated lines, but they must be operated in the combined distance/overcurrent mode, and set accordingly. See the CALCULATION OF SETTINGS section for further details.

SINGLE POLE TRIPPING

The TLS1B system can be used to initiate single pole tripping when such operation is required. Only a few modifications are required in the settings.

One problem arises because the phase distance functions can operate for some single line to ground faults. If this were allowed to happen, a three pole trip would be initiated when a single pole trip is really required. To prevent this from happening the following is done:

1. The first zone phase functions have zero sequence overcurrent restraint built in. This restraint is such that the function will be prevented from operating for single line to ground faults, but the effect will be minimized on double line to ground faults. This restraint must be switched in when single pole tripping is implemented.

2. The logic is set up so that the ground distance overreaching functions take priority over the phase distance overreaching functions during single line to ground faults. Thus, the phase distance overreaching functions will be prevented from initiating a three pole trip. No special settings are required to implement this feature.

The first zone ground distance functions are provided with zero sequence current supervision. On systems using three pole tripping this supervision is set at the minimum level to provide the most sensitive protection. When single pole tripping is used, the setting for this supervision should be based on the minimum zero sequence current for a fault at the end of the line remote from the function. This setting is proposed to prevent overreaching by the first zone ground distance functions in the unlikely event that a phase to phase fault were to occur on an adjacent line at the same time that a pole was open (during a single pole trip) in the line being protected by the zone 1 functions.

It was noted earlier that the ground distance functions use signals derived from the negative and zero sequence current. These two signals form an excellent phase selector in addition to combining with the operating signal to form the negative and zero sequence reactance characteristics described earlier. This type of phase selection assures that only the ground distance function associated with the faulted phase will operate during single line to ground faults. Provisions are included for removing these inputs, so it must be assured that these signals are in when single pole tripping is required.

RECLOSING CONTROL

Reclose initiate outputs are provided for three pole reclosing and single pole reclosing (when used). Option links are provided in the logic to block the reclose initiate outputs for any, or all, of the following conditions.

1. Operation of an external contact (via a contact converter)

2. Following a zone 3, or zone 2 and 3 time delayed trip.

3. Following a zone 4 time delayed trip.

4. Following an operation of any one of the MT functions, thus blocking reclosing for all multi-phase faults, but allowing reclosing for single line to ground faults (used in three pole tripping schemes).

5. Following a trip initiated by an out-of-step swing.

SEQUENTIAL RECLOSING

Sequential reclosing logic is provided in the TLS1B system. It is provided to control an independent recloser/reclosing system, and it may be used to prevent reclosing into a severe fault. The reclosing logic is arranged to recognize the severity of the fault by operation of certain of the tripping functions, and to provide an inhibit output to block reclosing at the terminals where those functions have operated. The inhibit output will persist until the line voltage returns to normal to indicate that the line is healthy. If a severe fault is not indicated, reclosing will be permitted at that terminal, and if successful, the voltage on the line will return to normal to remove any inhibit outputs that may have been produced. If none of the fault detectors indicate a severe condition, high speed reclosing will be initiated at all terminals of the line. If a severe condition is indicated at all line terminals, then reclosing will be inhibited at all line terminals.

For the latter condition, reclosing will have to be performed manually, or a long time delay is often recommended to produce an automatic reclose and so minimize the shock to the system.

An inhibit output may be initiated for the following conditions:

1. Operation of any of the first zone functions within 0.4 cycle of the time that the fault detector operates.

2. Operation of any of the phase distance functions, thus inhibiting reclosing for all multi-phase faults on the line.

3. Operation of all three phase distance functions, thus inhibiting reclosing for all three phase faults.

Option links are provided whereby these features can be inserted/removed from service.

WEAK INFEED CONDITIONS

A weak infeed condition exists whenever the fault current for an internal fault on the transmission line falls below the standard settings for the overcurrent trip supervision functions, $I\phi$ TRIP and $I\phi\phi$. It is possible to initiate a trip for this condition, but a blocking or hybrid type of scheme must be used, and one end of the line must have a strong feed.

Blocking Scheme

If a blocking scheme is used, the weak infeed terminal will have to be tripped by a direct transferred trip from the strong terminal following a trip there.

Hybrid Scheme

If a hybrid scheme is selected, overcurrent and undervoltage functions located at the weak terminal are used in conjunction with no output from the blocking functions to initiate tripping on receipt of a permissive trip signal from the strong terminal.

Some thought must be given to the settings of the overcurrent tripping and blocking functions when either scheme is employed for weak infeed conditions. With the standard settings, the overcurrent blocking functions are set as sensitively as possible at each terminal, and the overcurrent tripping functions are set less sensitively to assure coordination. This may not be acceptable for a weak infeed condition. Consider the following:

1. The current at the weak terminal is either greater than the setting of the tripping functions or less than the setting of the blocking functions for various source conditions; i.e., the current will never be between the setting of the tripping and blocking functions. For this case, the standard settings may be used. Either scheme will trip normally when the current is greater than the setting of the tripping functions. When the current is less than the setting of the blocking functions, the weak terminal must be direct transferred tripped when a blocking scheme is used, or weak infeed tripping will be initiated when a hybrid scheme is used.

2. The current at the weak terminal can fall in between the settings of the tripping and blocking functions. For this condition, the standard settings cannot be used because the blocking functions may operate at the weak terminal to block tripping at the strong as well as the weak terminal. To overcome this condition, the following settings are proposed.

STRONG TERMINAL:		WEAK TERMINAL:	
I_ϕ TRIP	= 0.30*IN	I_ϕ TRIP	= 0.15*IN
$I_{\phi\phi}$	= 0.30*IN	$I_{\phi\phi}$	= 0.15*IN
I_ϕ BLOCK	= 0.10*IN	I_ϕ BLOCK	= 0.20*IN
I2LD	= 0.05*IN	I2LD	= 0.15*IN

With these settings, the tripping functions are set to coordinate with the blocking functions at the remote terminal of the line just as in the standard settings. However, the blocking functions at the weak terminal are set above the tripping functions at the same terminal thus eliminating the situation where the blocking functions could operate to block tripping for a weak feed condition. It must be noted that the tripping functions at the strong terminal must of necessity be set less sensitively (with higher settings) than those proposed in the standard settings. Consequently, conditions at the strong terminal must be sufficient to support the settings there for all operating conditions.

At least one terminal must be a strong terminal for these settings to work. If the situation can reverse, so that the strong terminal becomes the weak terminal and vice versa for varying system conditions, it is proposed that two hybrid schemes be used with one scheme at each line terminal set up for weak conditions and one set up for strong conditions.

OPERATING TIME

The operating time of the distance functions is proportional to the operating signal (IZ - V) because large operating signals will either bypass the normal filtering in the function, or pass through the filtering much quicker than will signals of lower levels; i.e., the filtering becomes more effective as the signal level decreases in magnitude. Thus larger operating signals will tend to produce faster operating times than will signals of lesser magnitude.

Since the operating signal is dependent on current, voltage and reach setting, its magnitude will change as follows:

1. It will become larger as the fault is moved towards the relay location because the current will increase and the voltage will decrease; i.e. as the fault becomes more severe to the system.
2. It will become larger as the source impedance behind the relay location decreases. Here too, the fault appears more severe to the system as the change occurs.
3. It will become larger as the reach is increased.

The fastest operating time will therefore occur for the most severe faults and it can be optimized by using the largest possible reach setting consistent with the application requirements.

The overall average operating time for any type of fault will be dependent on the number of functions that operate for a given fault type. For three-phase faults, all three of the phase functions (AB, BC and CA) will operate, and the average operating time will be approximately equal to the minimum operating time of any one of the functions. This is so because the effect of incidence angle is nearly eliminated by the fact that the fault will occur at an incidence angle that is favorable to at least one of the three phase functions. For near end phase-to-phase-to-ground faults (ϕ-ϕ-G), three functions will also operate - two ground functions and one phase function - so here too, the average operating time will be approximately equal to the minimum operating time of any one of the three functions. On the other hand, only one function will operate for phase-to-phase (ϕ-ϕ), remote phase-to-phase-to-ground and phase-to-ground (ϕ-G) faults, so the average operating time will fall somewhere between the minimum and maximum operating time for that single function.

The time curves of Figure SD-3 show the average time for a ϕ-ϕ fault, therefore, the following should observed when using these curves. For three phase and near end ϕ-ϕ-G faults, the operating time will be about two milliseconds less than the time shown. For ϕ-ϕ and ϕ-G faults, the operating time will be equal to the time shown plus or minus about two milliseconds.
The times given are for electronic outputs. When contact outputs are used, add four milliseconds to the given times.

TLS1B SCHEME DESCRIPTION

The TLS1B 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

The TLS1B is available for both single pole and three pole tripping with all of the above schemes. By making suitable settings, the TLS1B 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. Zone 2 Overreaching phase distance functions (M2)
3. Zone 3 Overreaching phase distance functions (MT)
4. First zone ground distance functions (MG1)
5. Zone 2 Overreaching ground distance functions (MG2)
6. Zone 3 Overreaching ground distance functions (MTG)
7. Phase to phase current detectors ($I\phi\phi$)
8. Phase current detectors - trip supervision ($I\phi$ TRIP)
9. Phase current detectors - block supervision ($I\phi$ BLOCK)
10. Phase blocking functions (MB)
11. Negative sequence blocking function (NB)
12. Phase out-of-step blocking (MOB)
13. Ground out-of-step blocking (MOBG)
14. Phase voltage level detectors (V0)
15. Positive sequence current detector (I1)
16. Fault detector - current operated (FD)

DIRECTIONAL COMPARISON RELAYING

The TLS1B 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."

PERMISSIVE TRIPPING

The permissive tripping scheme is the simplest of the three schemes in that it uses 18 tripping elements (M1, MG1, M2, MG2, MT, MTG). The blocking elements (MB, NB) are used to establish blocking to prevent tripping during fault clearing, during current reversals, or during voltage reversals that can occur on series compensated lines. The essential elements of this scheme are shown in the simplified logic diagram of Figure SD-4.

The phase and ground directional distance overreaching functions, M2, MT, MG2 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 (M2, MT, MG2, or MTG) will operate. Either the second zone functions, M2 and MG2 or both the second and third zone functions, M2, MT, MG2 and MTG, can be used as the permissive elements in the scheme (via Link 141E-1). The permissive unit will apply a signal to AND407 via OR412. 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. Link 121A-2 is used to select either a POTT (closed), or a PUTT (opened) scheme. 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 functions 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, but the blocking functions will operate, to establish transient blocking. 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 TLS1B 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 SD-5.

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 (M2, MT, MG2, or MTG) operate, one input to the comparer (AND407) is supplied via OR412; 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 SD-6. The blocking units allow 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 (M2, MT, MG2, or 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 I -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

If the TLS1B system is applied 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 Figures SD-4, SD-5, and SD-6.

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 operation of any MT.

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

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 tabulation 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.

1. Tripping scheme, FSK tripping channel:

   Permissive overreaching transfer trip (POTT), transmits 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 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. Tripping is blocked for the loss of channel. 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.

RECLOSING CONTROL

Reclose Initiation

As shown in Figure SD-7, 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-1ϕ contact as shown in Figure SD-8. The reclose initiation may be blocked in the relay logic by an output of OR407 depending upon the position of option link 121A-4. 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 reclosing 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 line fault 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 M2 or 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	Zone 3 only
Closed	Closed	Zone 2 or 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 TLS1B 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 SD-9. 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 M2 or 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 TLS1B 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 TLS1B 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 TLS1B relay systems. A simplified diagram of the line pickup circuit is shown in Figure SD-10. 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 a Zone 2 distance unit (M2 or MG2) or a positive sequence overcurrent unit (I1). 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 I1 unit is intended to provide protection for the bolted fault at the relay. The I1 function produces an output whenever the positive sequence current is above its setting. Timer TL8 provides coordination between the pickup of the I1 unit and the resetting of the undervoltage units in those applications where the I1 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 due to an internal fault, thus, the time delay of TL8 may be bypassed.

When the TLS1B 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 SD-10; 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 TLS1B 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 opening option link 141B-1. A simplified diagram of the channel repeat and weak infeed tripping circuits is shown in Figure SD-11.

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 I -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 Iϕ-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 circuit 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 TLS1B 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 SD-12. 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 Iϕ-Trip level detector setting
3. The fault detector unit has not operated, or none of the breaker poles are open

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 TLS1B relays from misoperating on loss of potential. If a fuse failure occurs when the current is less than the I_ϕ-Trip level detector, the fuse failure alarm will not operate. However, since the distance units are also supervised by the I_ϕ-Trip units, they cannot misoperate and there 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 TLS1B 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 SD-13. 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 Δ I1 circuit is used to detect the change in positive sequence current, thus eliminating the 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, CC8, or a received direct transfer trip, 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 TLS1B 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 SD-14. 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-ϕ 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 TLS1B 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."
9. If link 121B-5 is closed, MOBG will be blocked if either receiver input is active.

BLOCKING UNITS/ZONE 4 TRIPPING

When the TLS1B 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 SD-15.

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 TLS1B 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 TLS1B logic may be used. A simplified logic diagram is shown in Figure SD-16.

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 SD-17. 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 line, 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 TLS1B 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 SD-18. Briefly, the following will occur for the fault condition shown in Figure SD-17. 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 SD-19. For the fault condition shown in Figure SD-17, 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 TLS1B relay system includes timers for use in time-delayed backup or stepped distance applications. All of the relay schemes employ three dedicated zones of distance relaying - M1/MG1 M2/MG2 and MT/MTG. 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.

A Zone 4 timer is also provided for time delay tripping via the blocking functions as shown in Figure SD-15. 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 SE-2. 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 SD-3 TLS1B TARGET LAMPS

LAMP	DESCRIPTION
A	Phase A Trip Bus
B	Phase B Trip Bus
C	Phase C 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
IN SERV	Relay in Service/Trip Bus Enabled

DATA LOGGING MONITORING

The basic single pole tripping TLS1B relay system includes 12 normally open contacts for monitoring the logic of the relay system. An additional 12 points are available as an option for a total of 24 outputs. The 24 points are listed in Table SD-5.

TABLE SD-4 STANDARD DLA POINTS

1	Fault Detector, FD
2	Out of Step Block, MOB (TL6)
3	Trip Permission (OR405)
4	Zone 1 Trip, M1 or MG1 (OR204)
5	Local Permissive Trip, M2, MT MG2 or MTG (OR412)
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)
13	M1 AB
14	M1 BC
15	M1 CA
16	MG1 A
17	MG1 B
18	MG1 C
19	MT AB
20	MT BC
21	MT CA
22	MTG A
23	MTG B
24	MTG C

LOGIC SWITCHES

The TLS1B 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.

A logic switch is open (O) when the switch handle is moved to the left; it is closed (C) when the switch handle is moved to the right.

TABLE SD-5 TLS1B LOGIC LINK SELECTION

S = Step distance, B = Blocking, P = Permissive, H = Hybrid

ULM101 MODULE (SPT&R schemes only)

Switch	S	B	P	H	Comment
L101A-1	O	O	O	O	See logic description for other settings
L101A-2	O	O	O	O	"
L101A-3	C	C	C	C	"
L101A-4	C	C	C	C	Open only for double circuit lines and SPT
L101A-5	C	C	C	C	Open only for double circuit lines and SPT
L101A-6	C	C	C	C	Open only for double circuit lines and SPT
L101A-7	C	C	C	C	Open only if a single pole trip is desired for Zone 3
L101A-8	C	C	C	C	Open only if a single pole trip is desired for Zone 2
L101B-1	C	C	C	C	Close to allow RCVR 2 (CC3) to select 3 pole trip
L101B-2	O	O	O	O	Close for 3 pole tripping for all fault types
L101B-3	O	O	O	O	Close when single pole & three pole channels are used

ULM112 MODULE

Switch	S	B	P	H	Comment
L111A-1	O	O	O	O	Close to direct transfer trip via TLS1B
L111A-2	C	C	C	C	Must be closed to use CC11, CC12, and CC13
L111A-3	O	C	O	O	Close to invert RCVR 1 (CC1) output
L111A-4	O	C	O	O	Close to invert RCVR 2 (CC3) output
L111B-1	O	O	O	O	Close if zone acceleration is desired
L111B-2	O	O	O	O	Close to use CC4 input as permissive trip signal
L111B-3	O	C	C	C	Open to defeat DTT
L111B-4	O	O	O	O	Close for transfer trip via TLS1B and CC2

ULM121/122 MODULE

Switch	S	B	P	H	Comment
L121A-1	O	O	O	O	Close if rated frequency is 50 Hz
L121A-2	O	C	C	C	Open for permissive underreaching scheme
L121A-3	O	O	O	O	Close to block XMTR keying during out of step
L121A-4	C	C	C	C	Close to block RI output for reclose lockout
L121A-5	O	O	O	O	Close to key XMTR 1 with NC contact
L121A-6	O	O	O	O	Close to key XMTR 2 with NC contact
L121A-7	O	O	O	O	Close to key both channels for transfer trip
L121A-8	O	O	O	O	Close: OSB blocks M1, Block MG1 unless any pole open
L121B-1	C	C	C	C	Allows external trip via CC7 or CC8 without fault detector supervision. Close for FD supervision
L121B-2	O	O	O	O	Close to allow tripping during out of step.
L121B-3	O	O	O	O	Close to remove fault detector supervision.
L121B-4	C	C	C	C	Close to enable L121B-1, L121B-2,and L121B-3
L121B-5	C	O	C	C	Close to block MOBG if receiver is active (ULM122 only)(Revision B TLS1)
L121C-1	O	C	O	O	Closed for blocking with AM channel Open for permissive or hybrid schemes
L121C-2	O	C	O	O	Closed for blocking with AM channel Open for permissive or hybrid schemes

ULM131 MODULE

Switch	S	B	P	H	Comment
L131A-1	C	C	C	C	Open to block NB for all 3 MT's rather than any MT
L131A-2	C	C	C	C	Open to permit RI output during out of step
L131A-3	C	O	O	O	Close for Zone 4 time delayed tripping
L131A-4	C	C	C	C	Open if line pickup protection is not desired
L131A-5	O	O	O	O	Must be opened if line pickup is used
L131A-6	O	O	O	O	NOT USED

ULM141 MODULE

Switch	S	B	P	H	Comment
L141A-1	O	C	C	C	Open to disable Zone 3 time delayed tripping
L141A-2	O	C	C	C	Open to permit Zone 3 tripping during out of step
L141A-3	C	C	C	C	Open to permit Zone 1 tripping during out of step
L141A-4	C	C	C	C	Open to disable Zone 2 time delayed tripping
L141A-5	O	C	C	C	Open to permit pilot tripping during out of step
L141A-6	C	O	O	O	Close to supervise Zone 1 with blocking units Must be closed for series compensated systems
L141A-7	O	C	C	C	Open to permit weak infeed tripping during out of step
L141A-8	O	C	C	C	Open to permit Zone 2 tripping during out of step
L141B-1	O	O	O	C	Close to enable echo circuit
L141B-2	O	C	C	C	Open only if time delay required to block echo
L141B-3	O	O	O	O	Close for weak infeed tripping with any phase UV
L141C-1	O	O	O	O	Close to inhibit reclose for MT operation
L141C-2	C	C	C	C	Open for switched Zone 2 scheme
L141C-3	O	*	*	*	Open to inhibit reclose for 3 MT's Close to inhibit reclose for any MT NOTE: L141C-1 must be closed to inhibit reclose
L141D-1	C	C	C	C	Closed when 3 independent zones are supplied
L141D-2	O	O	O	O	Close to enable coordinating timer TL14
L141E-1	C	C	C	C	Open when 3 independent zones are supplied and the third zone is not used for pilot tripping
L141E-2	O	O	O	O	Close to inhibit reclose for zone 1 operation
L141E-3	O	O	O	C	Close to enable weak infeed tripping
L141E-4	O	O	O	O	NOT USED
L141E-5	O	O	O	O	Close for 3 terminal lines with permissive or hybrid trip scheme logic
L141E-6	O	O	O	O	Close to block RI for any MT operation
L141F-1	O	O	O	O	Open to block reclose for zone 3 trip Close to block reclose for a zone 2 or a zone 3 trip
L141F-2	C	C	C	C	Close to permit reclose for zone 2 or zone 3 trips
L141F-3	O	C	O	O	TL15 input select - repeat logic

UTM101 MODULE

Switch	S	B	P	H	Comment
T101A-1	O	O	O	O	Close if MG1 is used as a reactance unit
T101A-2	O	O	O	O	"
T101A-3	O	O	O	O	"
T101A-4	O	O	O	O	Close for SPT on double circuit lines

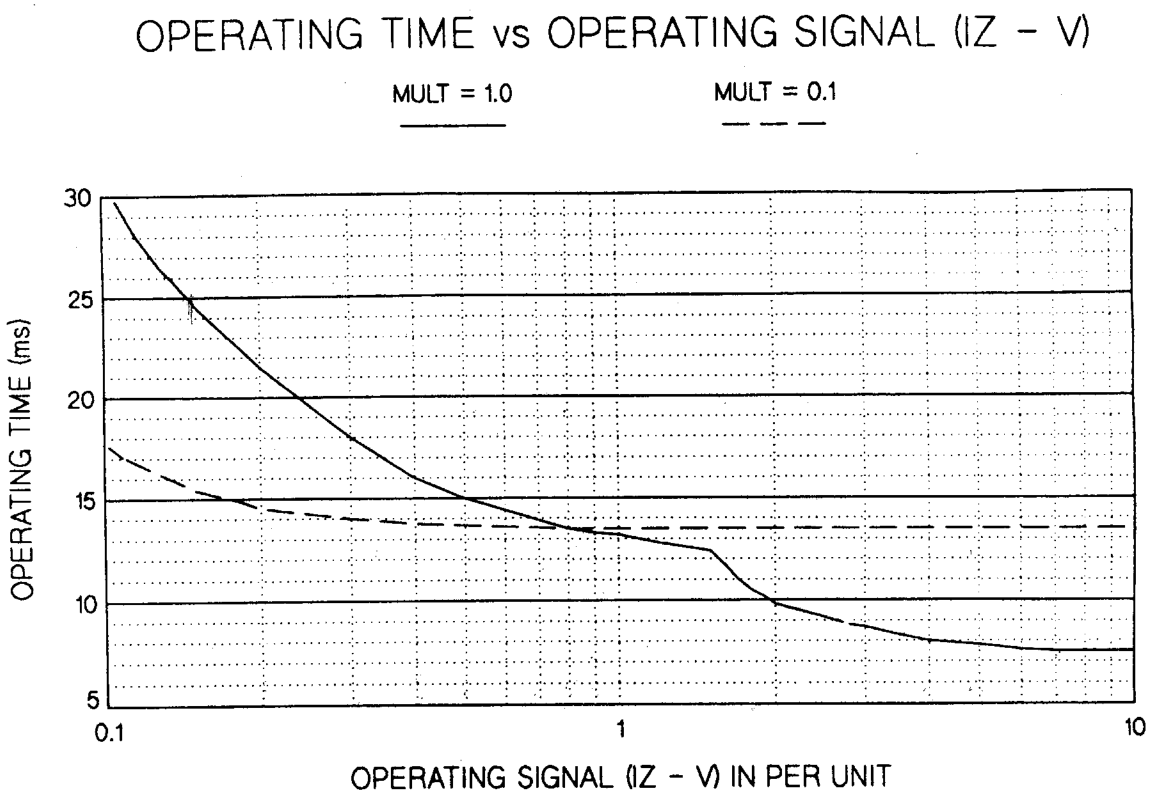


Figure SD-3 (0286A1891) Distance Function Operating Time

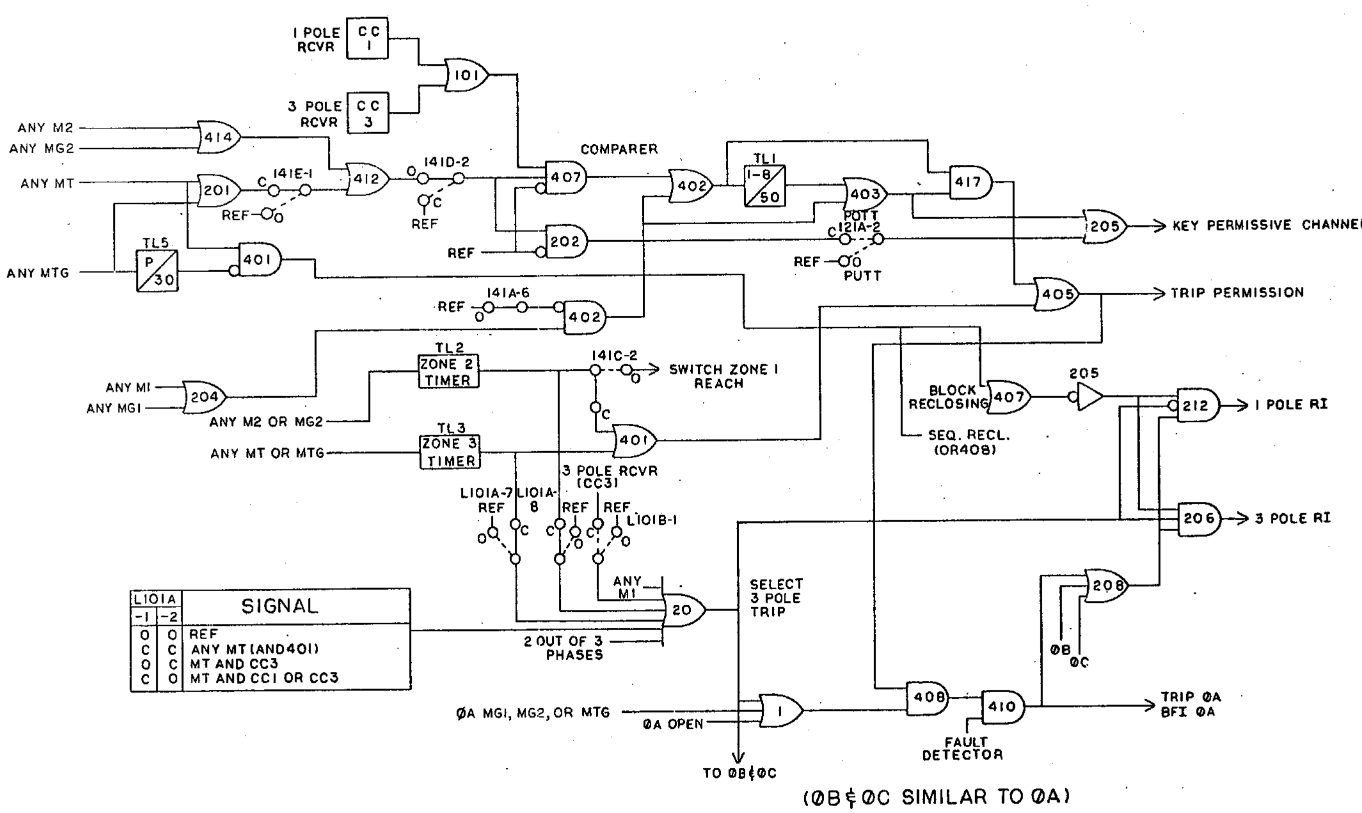


Figure SD-4 (0179C7544 Sh.1) Simplified Permissive Tripping Logic

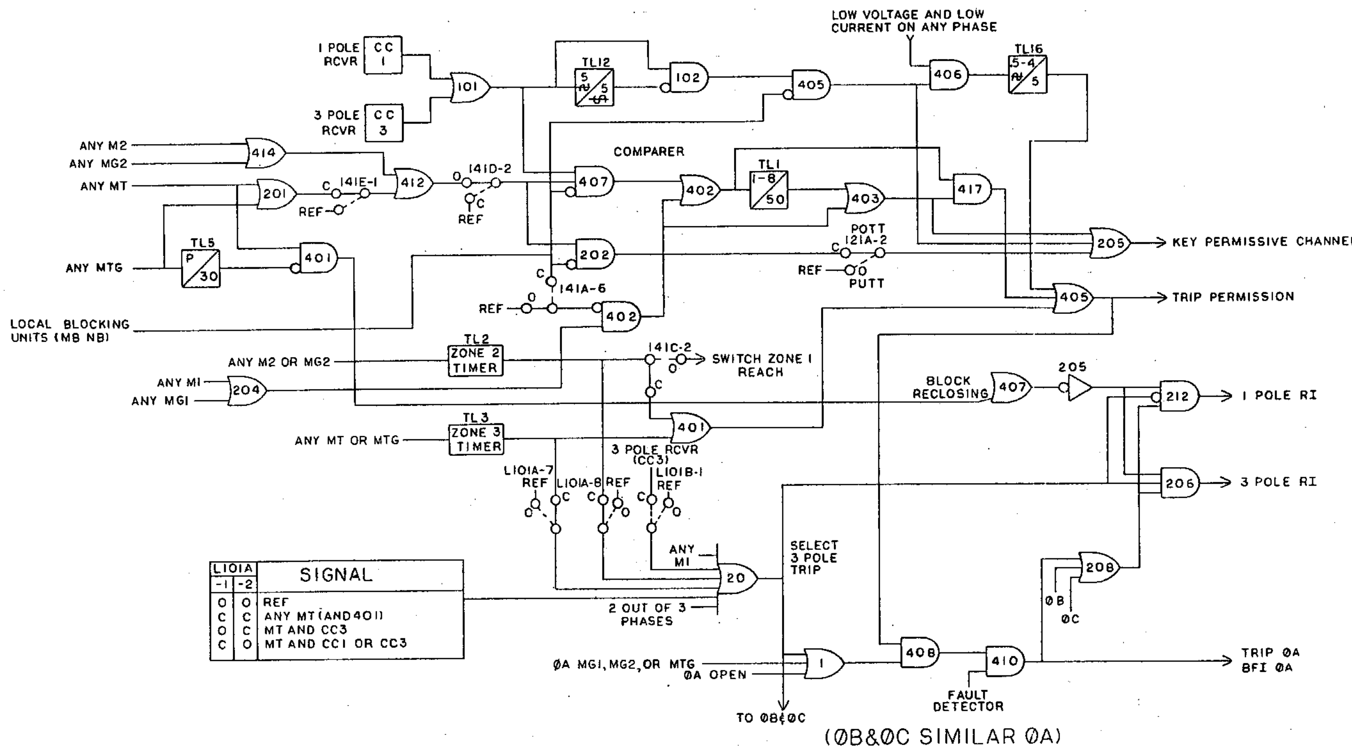


Figure SD-5 (0179C7544 Sh.3) Simplified Hybrid Directional Comparison Logic

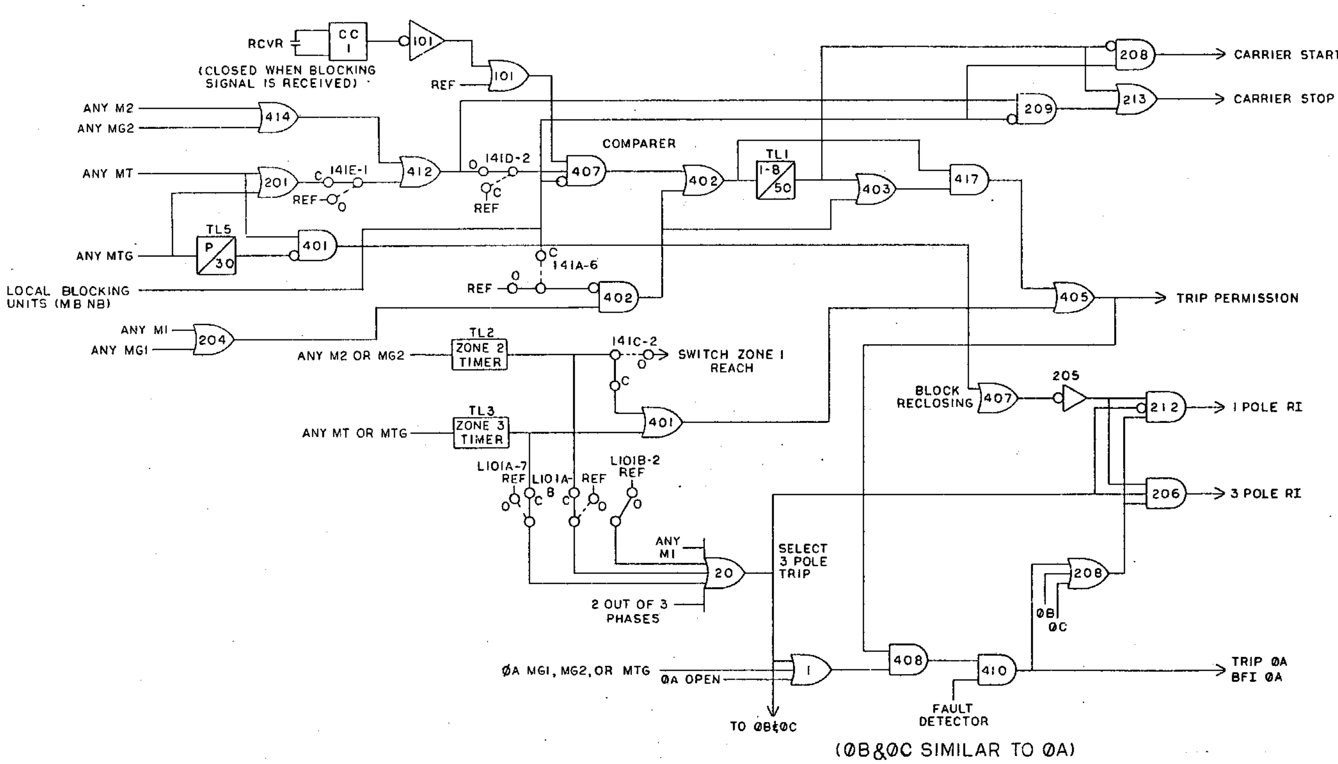


Figure SD-6 (0179C7544 Sh.2) Simplified Directional Comparison Blocking Logic

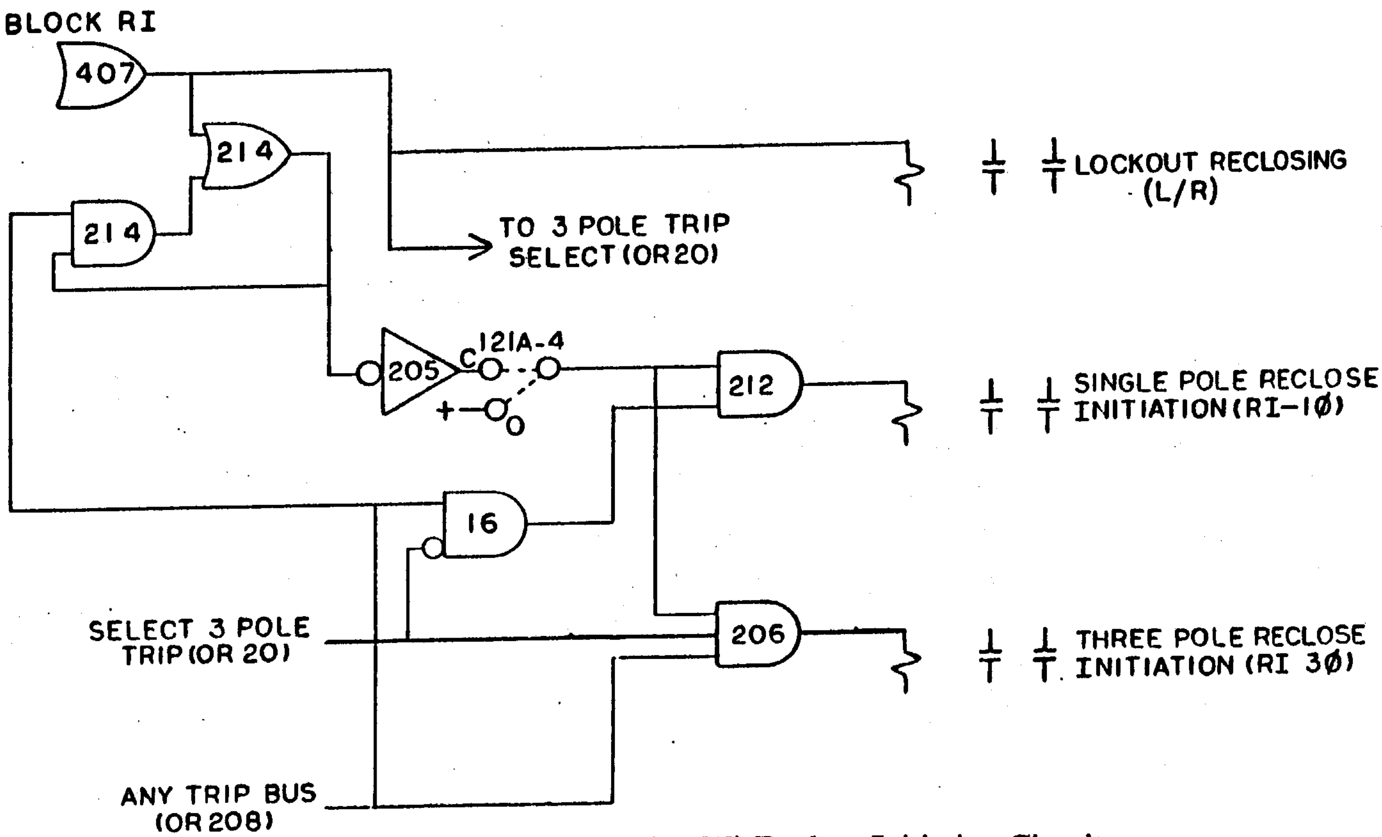


Figure SD-7 (0285A9259, Sh.1 [1]) Reclose Initiation Circuit

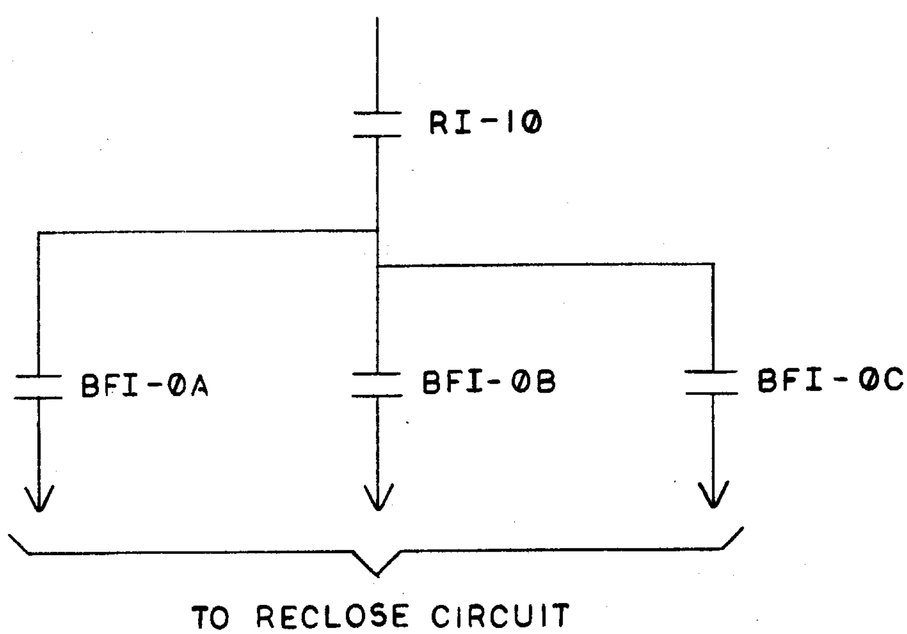


Figure SD-8 (0285A9259, Sh.2) Phase Identified Single Pole Reclose Initiation

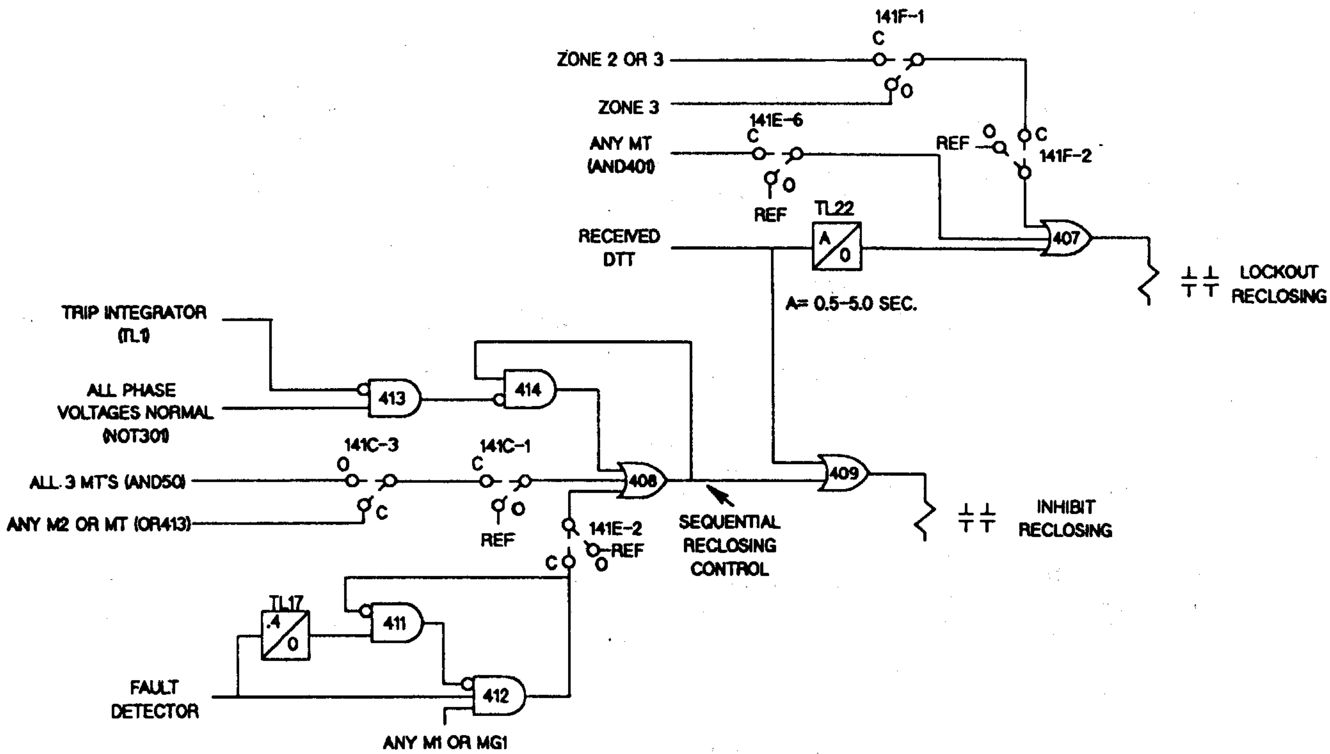


Figure SD-9 (0285A5366) Inhibit Reclosing Circuit

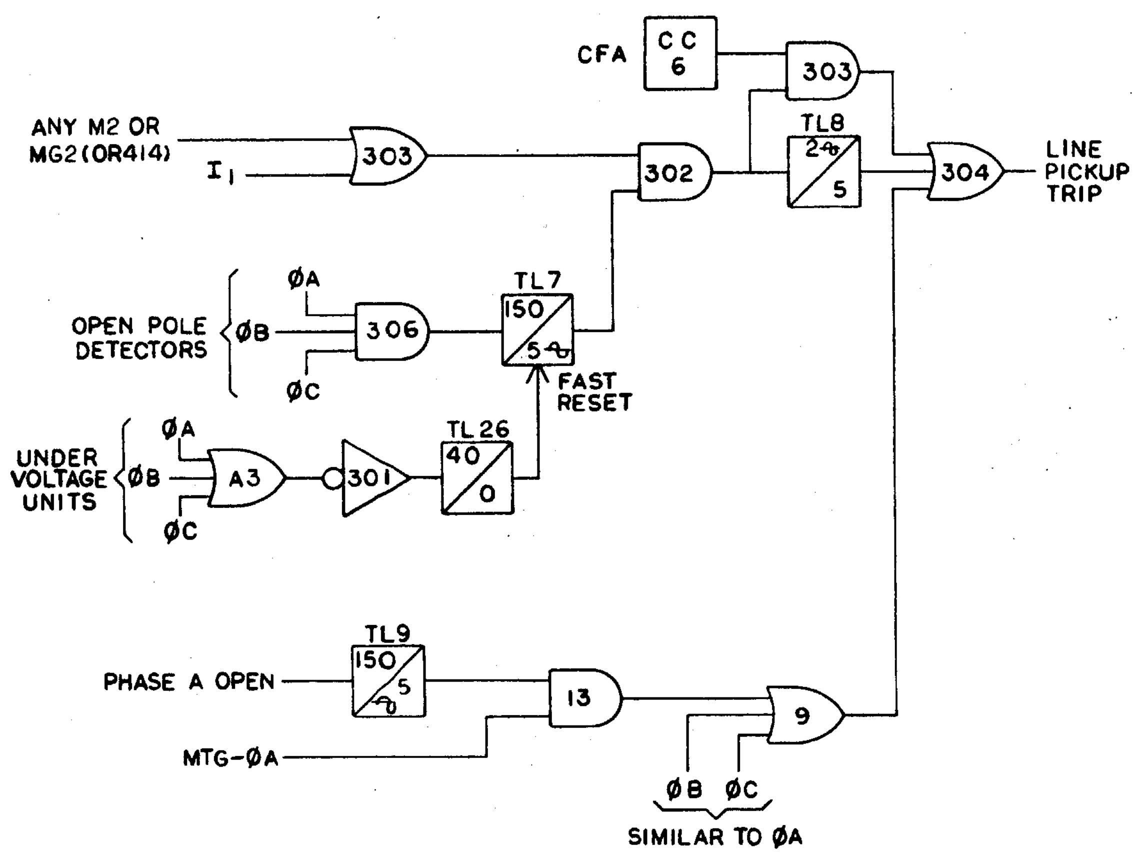


Figure SD-10 (0285A5365) Simplified Line Pickup Circuit

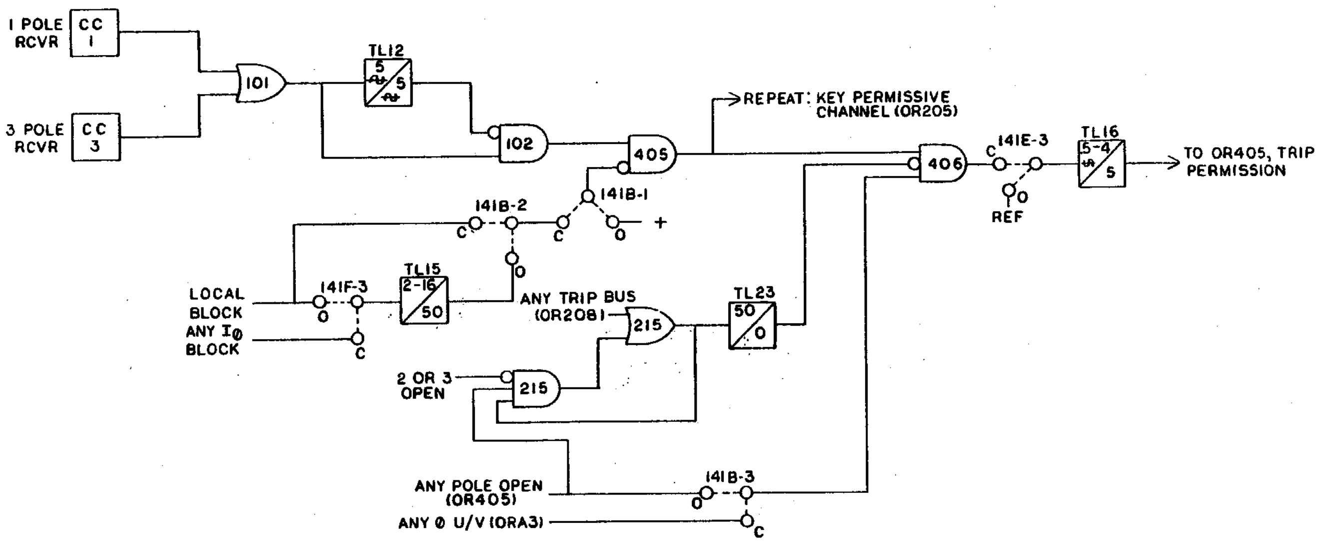


Figure SD-11 (0184B6313 [1]) Channel Repeat and Weak Infeed Circuits

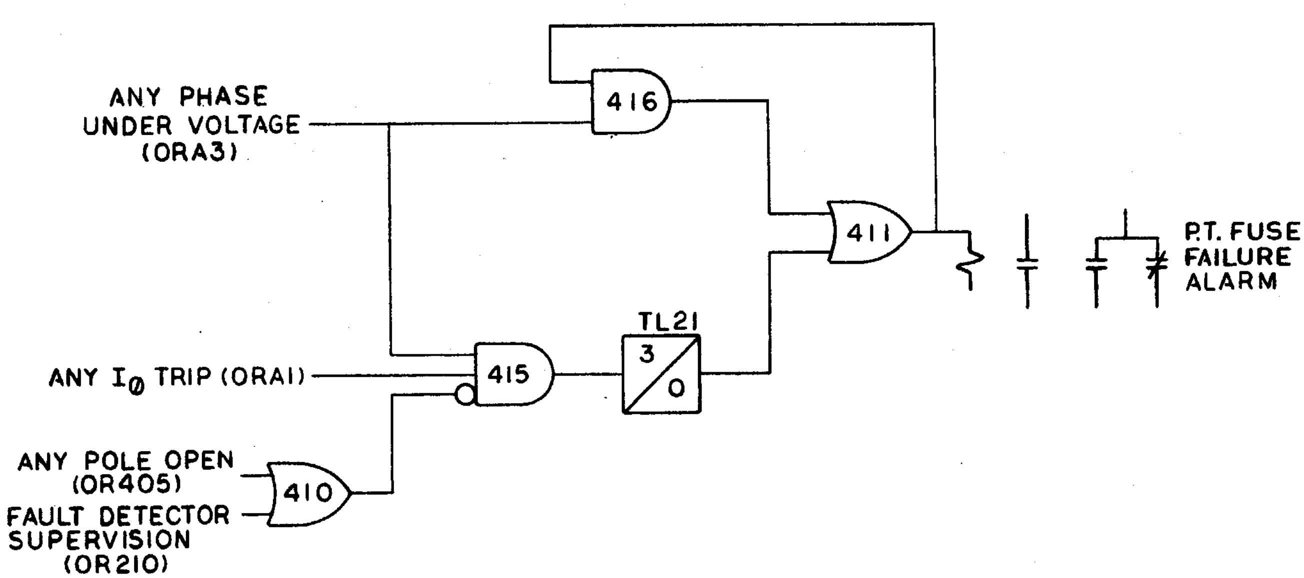


Figure SD-12 (0285A9259, Sh.5) PT Fuse-Failure Alarm Circuit

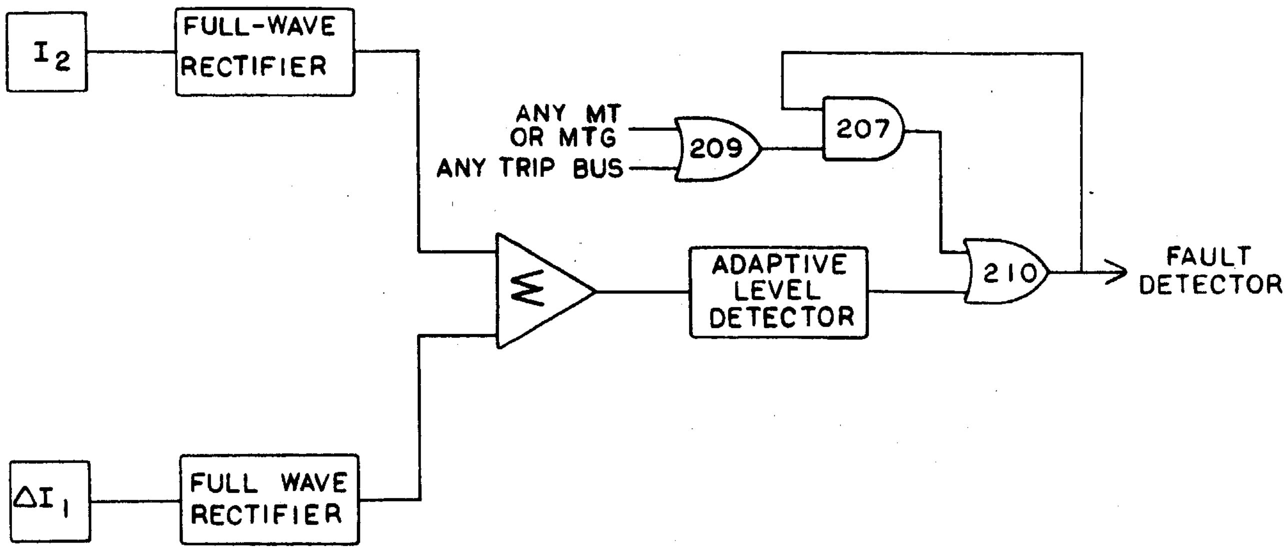


Figure SD-13 (0285A9259, Sh.6) Fault Detector Circuit

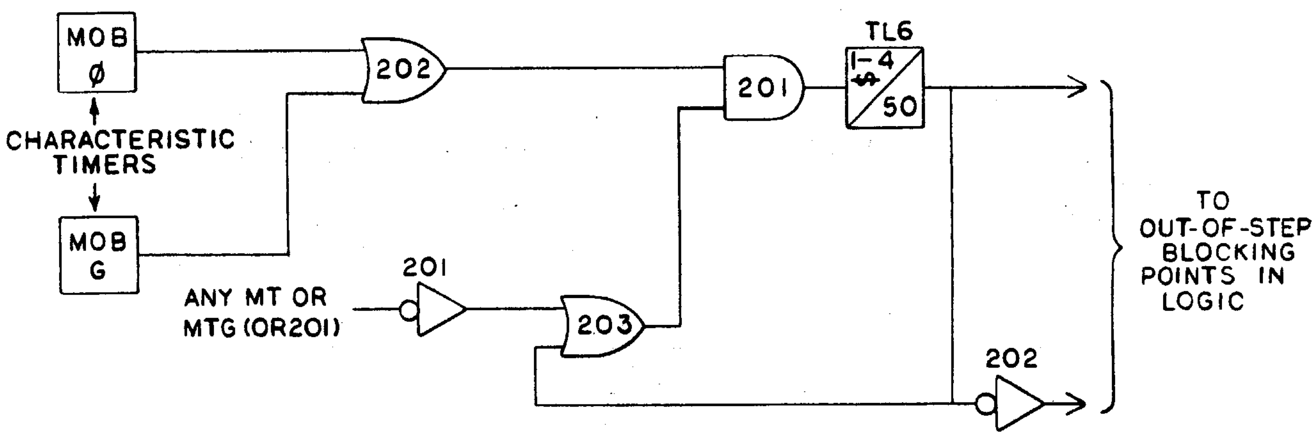


Figure SD-14A (0285A9259, Sh.7) Out of Step Blocking Circuit (Revision A TLS1)

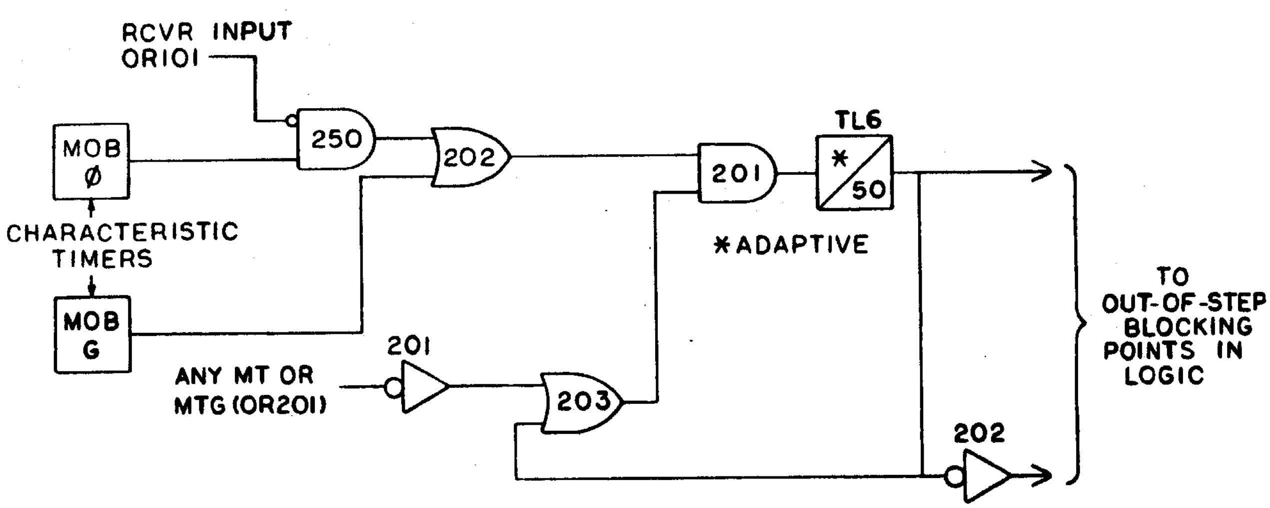


Figure SD-14B (0256A3596) Out of Step Blocking Circuits (Revision B TLS1)

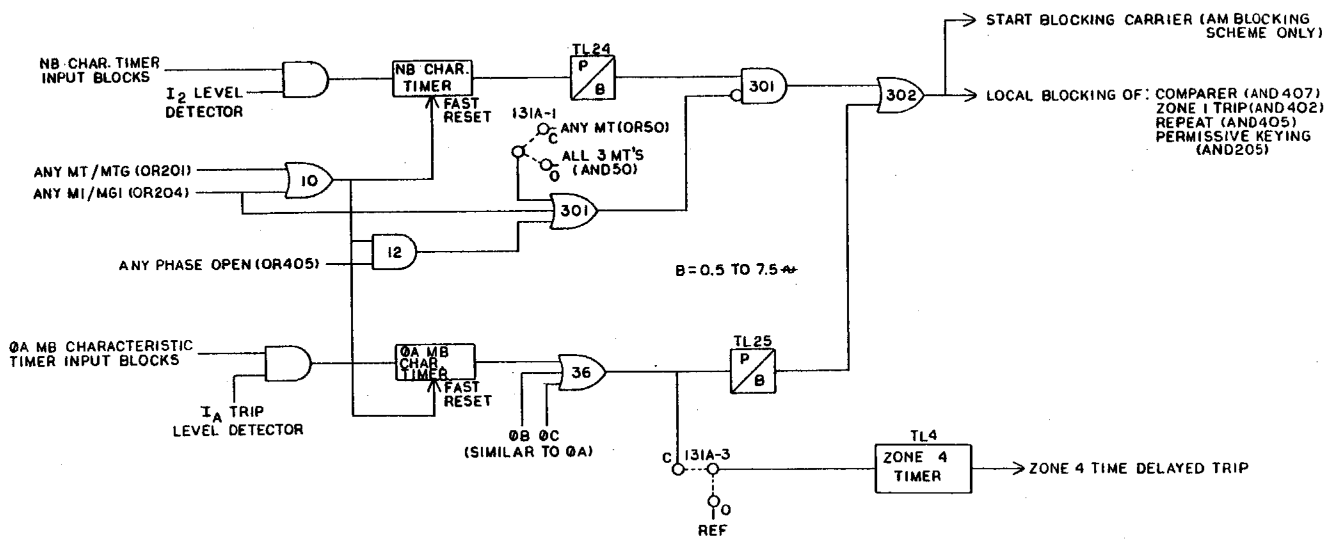


Figure SD-15 (0184B6314) Blocking Units

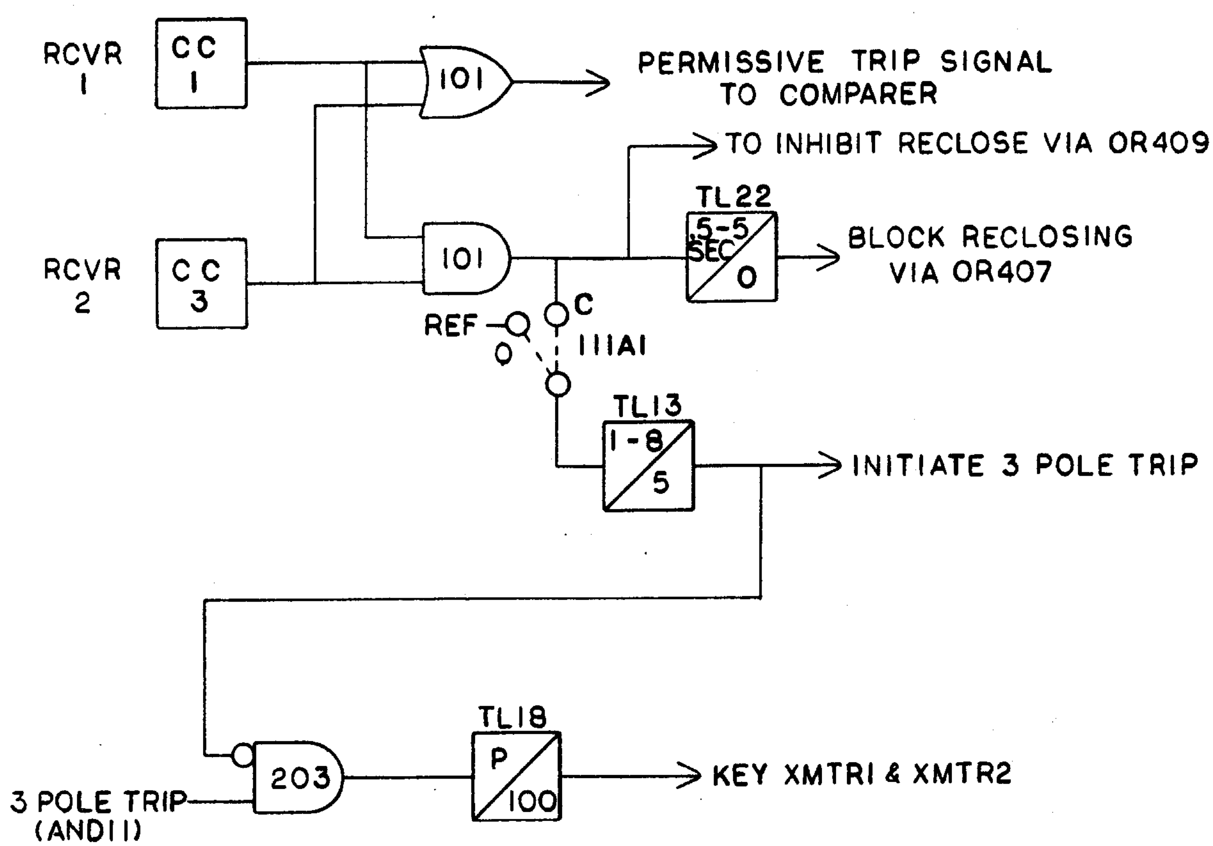


Figure SD-16 (0285A9259, Sh.8) Direct Transfer Trip Logic

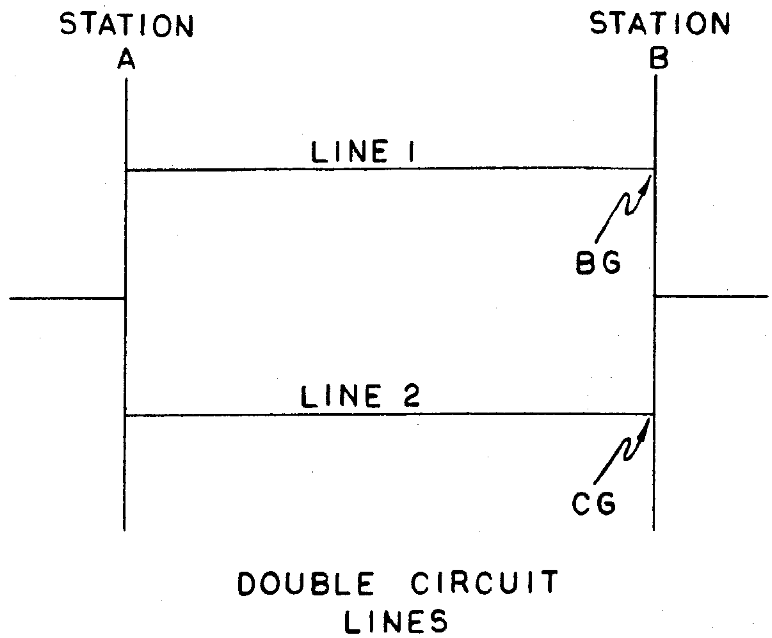


Figure SD-17 (0285A9259, Sh.9) Intercircuit Fault on Double Circuit Line

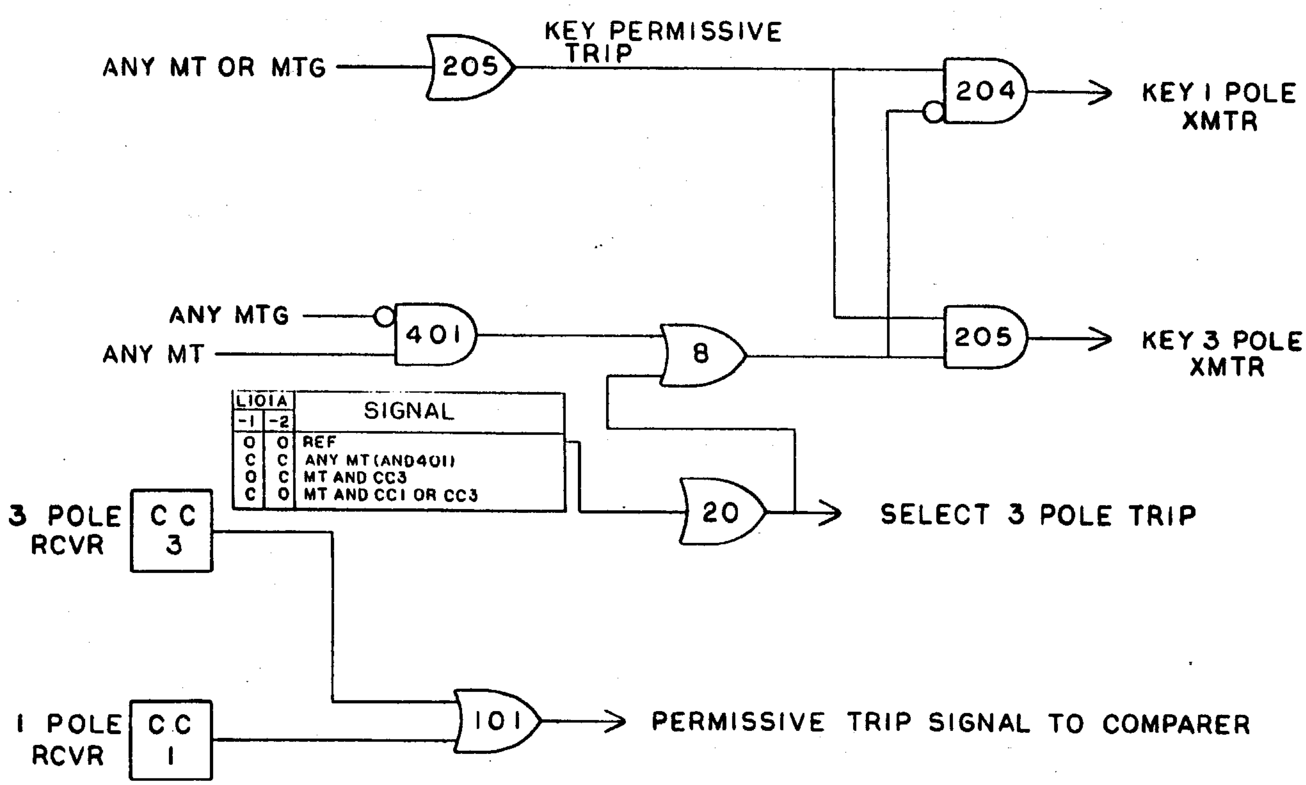
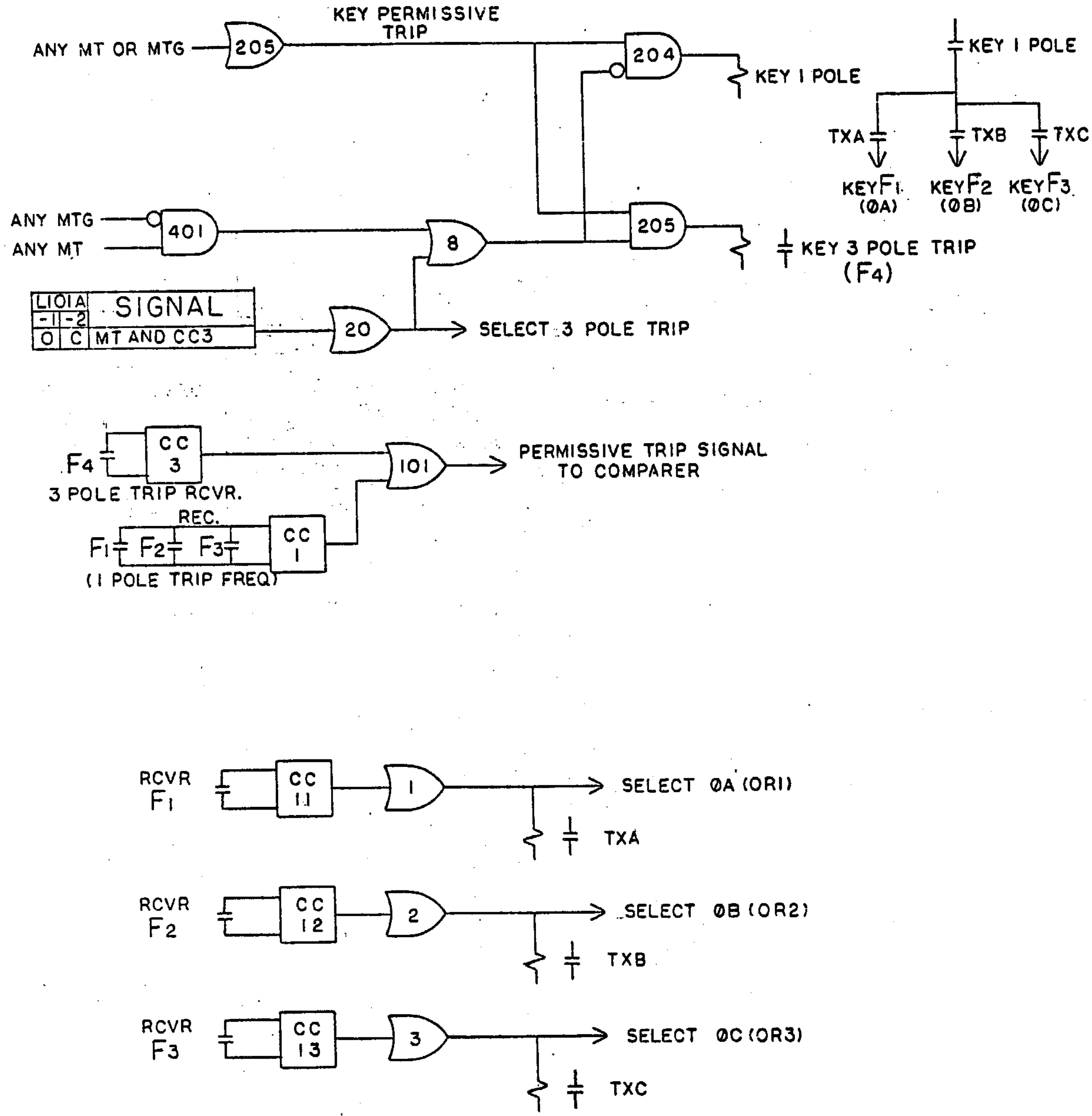


Figure SD-18 (0285A9259, Sh.10) Channel Keying/Phase Selection for Intercircuit Fault



FREQUENCY ALLOCATION	
F_1	ØA SELECTED
F_2	ØB SELECTED
F_3	ØC SELECTED
F_4	3 POLE TRIP SELECTED

Figure SD-19 (0184B6315) Channel Keying/Phase Selection for Intercircuit Fault, 4-Channel System

CALCULATION OF SETTINGS

This first part of this section addresses the use of the TLS1B system on a two-terminal uncompensated transmission line, and covers all of the settings required to implement three-pole tripping or single-pole tripping. The second part discusses the settings that must be changed when the scheme is applied on a line with series compensation.

The designation for each setting as it appears on the respective module is indicated by underlining and boldface (e.g., **ZR1**). The module on which the setting is to be made is given in boldface (e.g. **AFM101**). When a module reference is given with two designations separated by a slash (e.g. **AFM101/104**), the first designation applies to 60 Hz systems whereas the second designation applies to 50 Hz systems. The term "In" is used throughout this section and refers to the rated current of the system which can be 1 or 5 amperes. Check the specific model number for rating.

The following settings must be made:

ISM101/102

IT (0.1 to 1.0)*In amperes in 0.05 steps

The IT function is used to supervise the phase and ground distance functions, and establishes the level for which tripping will occur. In blocking and hybrid schemes it must be set higher than the IB function at the remote terminal of the line. Use the following setting:

In blocking and Hybrid schemes:

IT = 0.15 per unit

In all other schemes:

IT = 0.1 per unit

IB (0.1 to 1.0)*In amperes in 0.05 steps

The IB function is used to supervise the ground distance blocking functions, and establishes the level for which blocking will occur.

In all schemes:

IB = 0.1 per unit

φZ1 (50° to 85°) in 5° steps

φZ1 sets the positive sequence angle of maximum reach. Use a setting that is just larger than the angle of the positive sequence impedance of the transmission line. Use 85° for line angles greater than 85°.

φZ0 (50° to 85°) in 5° steps

φZ0 sets the zero sequence angle of maximum reach. Use a setting that is just larger than the angle of the zero sequence impedance of the transmission line. Use 85° for line angles greater than 85°.

AFM101/104

r	(1 to 25)*5/In ohms in 0.1 steps (front panel)
MULT	0.1, 0.25 or 1 (front panel)
MULT	(on board, set to same value as MULT on front panel)

The r and MULT settings located on the front panel are used to establish the reach of the zone 1 phase and ground distance functions. The zone 1 reach should be set equal to 90 percent or less of the positive sequence impedance of the transmission line. Select an r and MULT so that [r*MULT] is equal to the desired reach. Table CS-1 can be used to select an appropriate MULT setting from which r can be determined.

The MULT setting located on the board of this module is used to establish a clipping level of the I0ZR1 signal in the ground distance functions and should be set to the same setting as the MULT setting on the front panel.

TABLE CS-1 REACH MULTIPLIER (MULT) SELECTION
ZONE 1 FUNCTIONS

DESIRED REACH		REACH MULTIPLIER (MULT)
(6.25 to 25)*5/In		Use MULT = 1.0
(2.5 to 6.5)*5/In	IF > 9/ZR1	Use MULT = 0.25
	IF < 9/ZR1	Use MULT = 1.0
(1.0 to 2.5)*5/In	IF > 9/ZR1	Use MULT = 0.25
	IF < 9/ZR1	Use MULT = 1.0
(0.25 to 1.0)*5/In	IF > 2.25/ZR1	Use MULT = 0.1
	IF < 2.25/ZR1	Use MULT = 0.25
(0.1 to 0.25)*5/In		Use MULT = 0.1

In = rated current, 1A or 5A
IF = minimum fault current for three phase fault at the remote end of the line

ZR1 = M1/MG1 reach = r*MULT

NOTE: Maximum sensitivity will be achieved if the lowest MULT is used, but better operating time will be obtained for heavier faults if the highest MULT is used (see operating time curves in Figure SD-3 of the DESCRIPTION section of this book). Select the highest MULT if sensitivity is not a problem. Sensitivity can be calculated using the equations given in the SPECIFICATIONS section.

<u>A FIL</u> (IN or OUT)

The A FIL setting is used to insert or remove the A filter in the zone 1 ground distance functions. Use the following setting:

A FIL = IN

<u>B FIL</u> (IN or OUT)

The B FIL setting is used to insert or remove the B filter in the zone 1 ground distance functions. Use the following setting:

B FIL = IN

<u>0 SUP</u> (0.1 to 1.5 per unit volts) in 0.03 per unit volt steps

The 0 SUP setting is used to establish the level of operation for the operating signal of the zone 1 ground distance functions. Use the following setting:

$$0\ SUP = \frac{0.1}{MULT}$$

Where: MULT is the MULT setting made on this the AFM101/104 module as described above.

<u>K0</u> (1 to 7) in 0.1 steps

K0 establishes the zero sequence current compensation for the zone 1 ground distance functions. Use the following setting for lines without zero sequence mutual coupling:

$$K0 = \frac{0.95 * Z0L}{Z1l}$$

Where: Z1L = positive sequence impedance of transmission line

Z0L = zero sequence impedance of transmission line

If zero sequence mutual coupling with other lines exists, refer to GE publication GET-6657, "Review of Ground Relaying Concepts for Transmission Line Protection" which includes a discussion of mutual coupling.

<u>∠ZR0</u> (0°, 25°, 50° or 75°)

The ∠ZR0 setting subtracts from the ϕZ0 setting made on the ISM module and is used to set the zero sequence angle of maximum reach for the zone 1 ground distance where the zero sequence impedance angle is less than 50° (such as in cable circuits). Use the following setting:

For line angles greater than or equal to 50°,

∠ZR0 = 0

For line (cable) angles less than 50°,

$\angle ZR0 = \phi Z0 - \phi Z0L$

Where: $\phi Z0L$ = angle of the zero sequence impedance of the transmission line

S (IN or OUT)

Set S = OUT

AFM102/105

r (2 to 50)5/In ohms in 0.2 steps (front panel)
MULT 0.1, 0.25 or 1 (front panel)
MULT (on board)

The r and MULT settings located on the front panel are used to establish the reach of the Zone 2 overreaching phase and ground distance functions, M2 and MG2. If the Zone 2 functions are chosen as the primary pilot relaying elements, the reach should never be set less than 125 percent of the positive sequence impedance of the transmission line. Select an r and MULT so that [r*MULT] is equal to the desired reach. Table CS-2 can be used to select an appropriate MULT setting from which r can be determined.

The MULT setting located on the board of this module is used to establish a clipping level of the I0ZR1 signal in the ground distance overreaching functions and should be set to the same setting as the MULT setting on the front panel.

A FIL (IN or OUT)

The A FIL setting is used to insert or remove the A filter in the overreaching ground distance functions. Use the following setting:

A FIL = IN

K0 (1 to 7) in 0.1 steps

K0 establishes the zero sequence current compensation for the overreaching ground distance functions. Use the following setting:

$$K0 = \frac{Z0L}{Z1l}$$

Where: Z1L = positive sequence impedance of transmission line

Z0L = zero sequence impedance of transmission line

Table CS-2 REACH MULTIPLIER (MULT) SELECTION
Zone 2 Overreaching Functions

DESIRED REACH		REACH MULTIPLIER (MULT)
(12.5 to 50)∗5/In		Use MULT = 1.0
(5.0 to 12.5)∗5/In	IF > 9/ZRT IF < 9/ZRT	Use MULT = 0.25 Use MULT = 1.0
(2.0 to 5.0)∗5/In	IF > 9/ZRT IF < 9/ZRT	Use MULT = 0.25 Use MULT = 1.0
(0.5 to 2.0)∗5/In	IF > 2.25/ZRT IF < 2.25/ZRT	Use MULT = 0.1 Use MULT = 0.25
(0.2 to 0.5)∗5/In		Use MULT = 0.1

In = rated current, 1A or 5A

IF = minimum fault current for three phase fault at the remote end of the line

ZR2 = M2/MG2 reach = r*MULT

NOTE: Maximum sensitivity will be achieved if the lowest MULT is used, but better operating time will be obtained for heavier faults if the highest MULT is used (see operating time curves in Figure SD-3 of the SCHEME DESCRIPTION section of this book). Select the highest MULT if sensitivity is not a problem. Sensitivity can be calculated using the equations given in the SPECIFICATION section.

B FIL (IN or OUT)

The B FIL setting is used to insert or remove the B filter in the overreaching ground distance functions. Use the following setting:

B FIL = IN

0 SUP (0.1 to 1.5 per unit volts) in 0.03 per unit volt steps

The 0 SUP setting is used to establish the level of operation for the operating signal of the overreaching ground distance functions. Use the following setting:

$$0\ SUP = \frac{0.1}{MULT}$$

Where: MULT is the MULT setting made on this the AFM102/105 module as described above.

∠ZR0 (0°, 25°, 50° or 75°)

The ∠ZR0 setting subtracts from the φZ0 setting made on the ISM module and is used to set the zero sequence angle of maximum reach for the overreaching ground distance functions where the zero sequence impedance angle is less than 50°. Use the following setting:

For line angles greater than or equal to 50°,

$\angle ZR0 = 0$

For line angles less than 50°,

$\angle ZR0 = \phi Z0 - \phi Z0L$

Where: $\phi Z0L$ = angle of the zero sequence impedance of the transmission line

NOTE: If the function is being used to protect a short cable followed by longer transmission lines wherein the cable angle and the line angles are significantly different, $\angle ZR0$ should be set equal to the line angle rather than to the cable angle.

S (IN or OUT)

Set S = OUT

AFM103/106

r (3 to 75)5/In ohms in 0.3 steps (front panel)
MULT 0.1, 0.25 or 1 (front panel)
MULT (on board)

The r and MULT settings located on the front panel are used to establish the reach of the Zone 3 overreaching phase and ground distance functions, MT and MTG. If the Zone 3 functions are chosen as the primary pilot relaying elements, the reach should never be set less than 125 percent of the positive sequence impedance of the transmission line. Select an r and MULT so that [r*MULT] is equal to the desired reach. Table CS-3 can be used to select an appropriate MULT setting from which r can be determined.

The MULT setting located on the board of this module is used to establish a clipping level of the I0ZR1 signal in the ground distance overreaching functions and should be set to the same setting as the MULT setting on the front panel.

A FIL (IN or OUT)

The A FIL setting is used to insert or remove the A filter in the overreaching ground distance functions. Use the following setting:

A FIL = IN

Table CS-3 REACH MULTIPLIER (MULT) SELECTION
Zone 3 Overreaching Functions

DESIRED REACH		REACH MULTIPLIER (MULT)
(18.7 to 75)*5/In		Use MULT = 1.0
(7.5 to 18.7)*5/In	IF > 9/ZRT	Use MULT = 0.25
	IF < 9/ZRT	Use MULT = 1.0
(3.0 to 7.5)*5/In	IF > 9/ZRT	Use MULT = 0.25
	IF < 9/ZRT	Use MULT = 1.0
(0.75 to 3.0)*5/In	IF > 2.25/ZRT	Use MULT = 0.1
	IF < 2.25/ZRT	Use MULT = 0.25
(0.3 to 0.75)*5/In		Use MULT = 0.1

In = rated current, 1A or 5A

IF = minimum fault current for three phase fault at the remote end of the line

ZRT = MT/MTG reach = r*MULT

NOTE: Maximum sensitivity will be achieved if the lowest MULT is used, but better operating time will be obtained for heavier faults if the highest MULT is used (see operating time curves in Figure SD-3 of the SCHEME DESCRIPTION section of this book). Select the highest MULT if sensitivity is not a problem. Sensitivity can be calculated using the equations given in the SPECIFICATION section.

B FIL (IN or OUT)

The B FIL setting is used to insert or remove the B filter in the overreaching ground distance functions. Use the following setting:

B FIL = IN

0 SUP (0.1 to 1.5 per unit volts) in 0.03 per unit volt steps

The 0 SUP setting is used to establish the level of operation for the operating signal of the overreaching ground distance functions. Use the following setting:

$$0\ SUP = \frac{0.1}{MULT}$$

Where: MULT is the MULT setting made on this the AFM102/105 module as described above.

K0 (1 to 7) in 0.1 steps

K0 establishes the zero sequence current compensation for the overreaching ground distance functions. Use the following setting:

$$K0 = \frac{Z0L}{Z1l}$$

Where: Z1L = positive sequence impedance of transmission line

Z0L = zero sequence impedance of transmission line

/ZR0 (0°, 25°, 50° or 75°)

The /ZR0 setting subtracts from the ϕZ0 setting made on the ISM module and is used to set the zero sequence angle of maximum reach for the overreaching ground distance functions where the zero sequence impedance angle is less than 50°. Use the following setting:

For line angles greater than or equal to 50°,

/ZR0 = 0

For line angles less than 50°,

/ZR0 = ϕZ0 - ϕZ0L

Where: ϕZ0L = angle of the zero sequence impedance of the transmission line

NOTE: If the function is being used to protect a short cable followed by longer transmission lines wherein the cable angle and the line angles are significantly different, /ZR0 should be set equal to the line angle rather than to the cable angle.

S (IN or OUT)

Set S = OUT

AFM201/202

A FIL (IN or OUT)

The A FIL setting is used to insert or remove the A filter in the overreaching zone 2 phase distance functions. Use the following setting:

A FIL = IN

B FIL (IN or OUT)

The B FIL setting is used to insert or remove the B filter in the overreaching zone 2 phase distance functions. Use the following setting:

B FIL = IN

0 SUP (0.1 to 1.5 per unit volts in 0.03 per unit volt steps)

The 0 SUP setting is used to establish the level of operation for the operating signal of the overreaching zone 2 phase distance functions. Use the following setting:

$$0\ SUP = \frac{0.1}{MULT}$$

Where: MULT is the MULT setting made on the front of the AFM102/105 module.

S (IN or OUT)

Set S = OUT

AFM211/212

A1 FIL (IN or OUT)

The A1 FIL setting is used to insert or remove the A filter in the zone 1 phase distance functions. Use the following setting:

A1 FIL = IN

B1 FIL (IN or OUT)

The B1 FIL setting is used to insert or remove the B filter in the zone 1 phase distance functions. Use the following setting:

B1 FIL = IN

0(1) SUP (0.1 to 1.5 per unit volts in 0.03 per unit volt steps)

The 0(1) SUP setting is used to establish the level of operation for the operating signal of the zone 1 phase distance functions. Use the following setting:

$$0(1)\ SUP = \frac{0.1}{MULT}$$

Where: MULT is the MULT setting made on the front of the AFM102/105 module.

AT FIL (IN or OUT)

The AT FIL setting is used to insert or remove the A filter in the overreaching zone 3 phase distance functions. Use the following setting:

AT FIL = IN

BT FIL (IN or OUT)

The BT FIL setting is used to insert or remove the B filter in the overreaching zone 3 phase distance functions. Use the following setting:

BT FIL = IN

0(T) SUP (0.1 to 1.5) per unit volts in 0.03 per unit volt steps

The 0(T) SUP setting is used to establish the level of operation for the operating signal of the overreaching zone 3 phase distance functions. Use the following setting:

$$0(T)\ SUP = \frac{0.1}{MULT}$$

Where: MULT is the MULT setting made on the front of the AFM103/106 module.

S1 (IN or OUT)

Set S1 = OUT

ST (IN or OUT)

Set ST = OUT

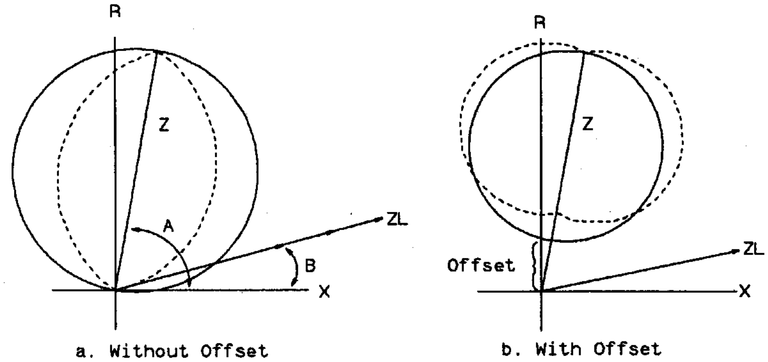
UTM101

M1	(64° to 127°) in 1° steps
MG1	(64° to 127°) in 1° steps
MT	(64° to 127°) in 1° steps
MTG	(64° to 127°) in 1° steps

UTM102

M2	(64° to 127°) in 1° steps
MG2	(64° to 127°) in 1° steps

The characteristic timer setting is dependent on the reach that is set on the distance functions with both settings being dependent on the maximum load flow across the line.



Z = Relay reach
A = Relay angle of maximum reach
ZL = Load impedance
B = Angle of load impedance
Offset = OFFSET*Z
Where, OFFSET = offset factor in per unit (0, 0.1, 0.2, 0.3, 0.4)

Figure CS-1 Zone I Characteristics

Refer to Figure CS-1 which shows that the shape of the characteristic must be changed to keep the load impedance from encroaching as the load flow or the reach of the function is increased. At light loads and/or for short reaches, a circular characteristic may be used. As the load and/or reach is increased, it will be necessary to use a lenticular shaped characteristic (without offset).

For extremely heavy loads and/or extremely long reaches, it will be necessary to introduce offset into the characteristic. When offset is used, it may be possible to use a circular or tomato characteristic as shown in Figure CS-1, provided the constraint described below is met.

The reach and characteristic timer setting that can be used for a given amount of load flow can be determined by calculating the width of the load block (coincidence time in degrees between Vpol and Vop) applied to the characteristic timer. With this factor known, the timer setting must be set 40 degrees greater than this coincidence time. The procedure outlined below is based on maintaining this margin.

Setting Procedure

1. Use the MT/MTG reach setting selected earlier.

2. Determine the minimum load impedance (using maximum steady-state load current) that the function will see.

3. Make the following calculations to determine the characteristic timer setting to be used on the function. Start with zero offset by setting OFFSET = 0.

$$C = \frac{(1 - OFFSET)*|Z|*Sin|A - B|}{|Z - ZL|} \quad (1)$$

$$D = ARCSin(C) \quad (2)$$

$$E = C + 40 \quad (3)$$

Where:

Z = ZRT for MT/MTG overreaching zone 3 functions
= ZR2 for M2/MG2 overreaching zone 2 functions
= ZR1 for M1/MG1 zone 1 functions

E = MT, M2 or M1 characteristic timer angle setting

All other terms are defined in Figure CS-1.

4. If OFFSET = 0 and E is less than 90 degrees, use a setting of 90 degrees. Never use a setting less than 90 degrees if OFFSET = 0.

5. If E is greater than 127 degrees, increase the OFFSET factor and repeat the calculations under 3 above until a satisfactory setting is obtained.

6. Set the MTG, MG2 and MG1 characteristic timer angle setting 20 degrees less than the respective MT and M1 characteristic timer angle setting. Never use a setting less than 90 degrees if OFFSET = 0.

Consider the following examples:

Case 1:

Z = 10 ohms at 85° ZL = 15 ohms at 10°

Z - ZL = 0.87 + j9.96 - 14.8 -j2.6 = 15.7 at 152°

| Z - ZL | = 15.7

| Z | = 10

A = 85

B = 10

From equation (1), with OFFSET = 0,

$$C = \frac{10*\mathrm{Sin}|85 - 10|}{15.7} = 0.615$$

From equation (2)

D = ASin(C) = ASin(0.615) = 38°

From equation (3)

E = D + 40 = 78 degrees

Since E is less than 90°, use a characteristic timer setting of 90 degrees.

Case 2:

Z = 25 ohms at 85° ZL = 11 ohms at 16°

With this reach and load impedance, the following settings can be used:

OFFSET = 0, E = 125°

OFFSET = 0.1, E = 104°

OFFSET = 0.2, E = 92°

OFFSET = 0.3, E = 82°

OFFSET = 0.4, E = 77°

If maximum steady-state coverage is the prime consideration, use the lowest available offset and the corresponding characteristic timer setting. Larger offset settings will reduce steady-state coverage but could result in better operating times.

MB (64° to 127°) in 1° steps

The characteristic timer of the MB function is dependent on the characteristic timer setting used on the MT function at the remote end of the line. Use the following setting:

MB = (MT - 10°)

NEVER SET MB GREATER THAN 105°.

MG1 Supervision (MHO or REACT)

If the zone 1 ground distance functions are operated in the variable mode,

MG1 Supervision = MHO

If the zone 1 ground distance functions are operated in the reactance mode,

MG1 Supervision = REACT

There are three switches related to the MG1 Supervision setting. All three must be set to the left (MHO) for variable mho operation, or all three must be set to the right (REACT) for reactance operation.

M1 SPVN (NO or M1 by MG1)

Set M1 SPVN = NO (Three-pole tripping)

Set M1 SPVN = M1 by MG1 (Single-pole tripping)

ETM101 (Zone 1)

I0 SENS (0.05 to 0.65)*In in 0.2 per unit steps

Set I0 SENS = 0.05 (Three-pole tripping)

Set I0 SENS = 2/3 of the minimum 3IO for a single-line-to-ground fault at the remote end of the line (Single-pole tripping)

VP SENS φ-G (0, 0.05, 0.30 or 0.35 per unit volts)

Set VP SENS φ-G = 0.05

VP SENS φ-φ (0, 0.05, 0.30 or 0.35 per unit volts)

If the minimum voltage at the relay for three-phase fault at the remote terminal of the line is less than ten percent,

Set VP SENS φ-φ = 0, otherwise

Set VP SENS φ-φ = 0.05

Iφ-φ (0.1 to 1.0)*In in 0.05 per unit steps

In Hybrid and Blocking type schemes,

Set Iφ-φ = 0.15

In all other schemes,

Set Iφ-φ = 0.1

VP, I2 and I0 (IN or OUT)

To use the zone 1 ground distance functions in the variable mho mode,

Set VP = IN

To use the zone 1 ground distance functions in the reactance mode,

Set VP = OUT

In either case,

Set I2 = IN

Set I0 = IN

ETM101 (Zone 2)

I0 SENS (0.05 to 0.65)*In in 0.2 per unit steps

Set I0 SENS = 0.05 (Three-pole tripping)

Set I0 SENS = 2/3 of the minimum 3IO for a single-line-to-ground fault at the remote end of the line (Single-pole tripping)

VP SENS ϕ-G (0, 0.05, 0.30 or 0.35 per unit volts)

Set VP SENS ϕ-G = 0.05

VP SENS ϕ-ϕ (0, 0.05, 0.30 or 0.35 per unit volts)

If the minimum voltage at the relay for three-phase fault at the remote terminal of the line is less than ten percent,

Set VP SENS ϕ-ϕ = 0, otherwise

Set VP SENS ϕ-ϕ = 0.05

$I\phi$-ϕ (0.1 to 1.0)*In in 0.05 per unit steps

In Hybrid and Blocking type schemes,

Set $I\phi$-ϕ = 0.15

In all other schemes,

Set $I\phi$-ϕ = 0.1

VP, I2 and I0 (IN or OUT)

To use the zone 1 ground distance functions in the variable mho mode,

Set VP = IN

Set I2 = IN

Set I0 = IN

ETM102 (Zone 3)

VP SENS φ-G (0, 0.05, 0.3 0r 0.35 per unit volts)

Set VP SENS φ-G = 0.05

VP SENS φ-φ (0, 0.05, 0.30 or 0.35 per unit volts)

If the minimum voltage at the relay for three-phase fault at the remote terminal of the line is less than ten percent,

Set VP SENS φ-φ = 0, otherwise

Set VP SENS φ-φ = 0.05

Iφ-φ (0.1 to 1.0)*In in 0.05 per unit steps

In Hybrid and Blocking type schemes,

Set Iφ-φ = 0.15

In all other schemes,

Set Iφ-φ = 0.1

ABM101/102

r (2 to 50)*5/In ohms in 0.2*5/In ohms steps
KV1 (0, 0.15, 0.3 or 0.45)

The reach to be set on the MB functions is dependent on the reach of the phase distance functions at the remote terminal of the line. Either the Zone 2, M2, or Zone 3, MT, functions may be used in the pilot tripping scheme depending upon the setting of switch 141-E1. Use the following procedure to determine the MB reach setting:

1. Start with KV1 = 0.45
2. If the MT or M2 reach is less than twice the positive sequence line impedance, Z1L,

   r = (MT or M2 reach)*(1 - KV1)
3. If the reach of the MT or M2 function is greater than twice the positive sequence line impedance, Z1L,

   r = (2)*(MT or M2 reach - Z1l)*(1 - KV1)
4. Check if the following is true:

   $$KV1 \leq \frac{r}{ZSmax}$$

   Where: r = the reach calculated above

   ZSmax = the maximum impedance of the source behind the terminal where the MB function is located.
5. If the condition in 4 above is not satisfied, return to step 1 above and try the next lower KV1 setting.

K (1 to 7) in 0.1 steps

The K factor establishes the zero sequence current compensation for the MB functions. Use the following setting:

$$K = \frac{(Z0L - Z1L)}{Z1L}$$

Where: Z0L = the zero sequence impedance of the transmission line

Z1L = the positive sequence impedance of the transmission line

OFFSET (IN or OUT)

The OFFSET setting establishes the reverse offset of the MB function. Use the following setting:

OFFSET = IN

POL (0° or 20°)

The POL setting establishes a phase shift in the polarizing signal. Use the following setting:

POL = 0°

<u>I1</u> (0.2 to 3.2)*5/In amperes in 0.2 steps

The I1 function establishes the pickup setting for the line pickup (close into fault) circuitry. Use the lesser of the following:

$$I1 = \frac{2*I1F}{3}$$

$$I1 = (1.25)*I1L$$

Where: I1F = minimum current for a three-phase fault just in front of the line terminal where the I1 function is located, or at a point on the line equal to the forward offset reach.

I1L = maximum load current seen at the terminal

<u>I2 SHIFT</u> (0°, -5°, -10° or -15°)
<u>I0 SHIFT</u> (0°, -5°, -10° or -15°)

The I2 shift and I0 SHIFT settings establish a phase shift in the Vpy and Vpz polarizing signals in the ground distance functions. Appropriate settings can be determined as follows.

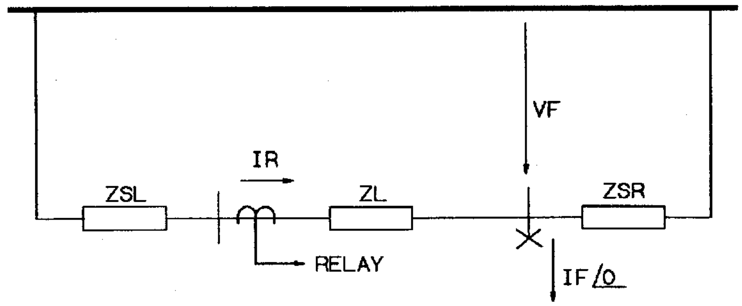
The term, homogeneous, is used to describe a system in which the angle of all of the system impedances are equal. A non-homogenous system is therefore one in which the impedances have different angles. Non-homogeneity in a system can cause a negative sequence or zero sequence reactance function to overreach or underreach. The tendency for the function to overreach will depend on whether the relay current leads or lags the total fault current (refer to Figure CS-2).

Overreaching can occur for leading currents, whereas underreaching can occur for lagging currents. The amount of lag/lead will depend on the system impedance angles. The phase shift circuits in the negative and zero sequence polarizing signals are provided to overcome the effects of non-homogeneity. The amount of phase shift required can be determined as shown in Figure CS-2.

The relay current (IR) will lead the fault current (IF) when the angle θf is greater than the angle θt. To prevent overreaching for this condition, use the following settings:

$$\text{I2 SHIFT} \geq (\theta f - \theta t)$$

$$\text{I0 SHIFT} \geq (\theta f - \theta t)$$



$$ZT = (ZSL + ZL) = ZT\angle\theta t$$

$$ZSR = ZSR\angle\theta r$$

$$ZF = ZT \text{ IN PARALLEL WITH } ZSR = ZF\angle\theta f$$

$$VF = (ZF\angle\theta f)(IF\angle 0)$$

$$IR = \frac{VF}{ZT} = \frac{(ZF\angle\theta f)(IF\angle 0)}{ZT\angle\theta t} = \frac{ZF*IF}{ZT}\angle\theta f - \theta t$$

Figure CS-2 Negative or Zero Sequence Network

VMM101/102

<u>II</u> (1 to 10) in 0.05 steps

The TLS1B system is provided with three dedicated zones of protection (zone 1, overreaching and blocking) with provisions for extending the zone 1 reach by up to a factor of 10 via the II setting. Switching of the reach will occur when timer TL2 times out provided switch 141C-2 on the ULM141 module is in the OPEN position.

If three forward zones of protection are to be used, set the overreaching functions with the required third zone reach and select a II setting that will give the required zone 2 reach:

Zone 2 = ZR1*II

Set switch 141C-2 to the OPEN position to implement zone 1 switching. Set timers TL2 and TL3 to give the required zone 2 and zone 3 times respectively. Close switches 141A-4 and 141A-1 to energize timers TL2 and TL3 respectively.

If only two forward zones of protection are required, either of the following methods can be used.

Method 1

Set switch 141C-2 to the closed position to defeat zone 1 switching. Set the overreaching functions to give the required zone 2 reach and set timer TL2 to give the required zone 2 time. Set switch 141A-4 to the CLOSED position to energize timer TL2 and OPEN switch 141A-1 to remove timer TL3 from service. With these settings, the overreaching functions may not provide the best operating times because the reach setting may be limited to provide the required zone 2 setting (see discussion of operating time under the APPLICATION section).

Method 2

Set switch 141C-2 to the OPEN position to enable zone 1 switching. Set the zone 1 extension factor II to give the required zone 2 reach. Set timer TL2 with the required zone 2 time and close switch 141A-4 to energize timer TL2. OPEN switch 141A-1 to de-energize timer TL3. Set the overreaching functions with a long enough reach to provide good operating times and if possible not so long as to require a lenticular characteristic (describe earlier in determining the characteristic timer setting). With these settings, the required zone 2 reach will be obtained via the extended zone 1 function and operating times will be optimized because of the longer reach settings made on the overreaching functions.

<u>OFFSET MT/MTG</u> (0 to 0.4)*ZR1 in 0.1 steps

The OFFSET MT/MTG setting establishes the forward offset in the phase and ground distance overreaching functions for both zone 2 and zone 3 (M2, MG2, MT, and MTG). The method for determining the amount of offset to be used was described earlier under the section used to calculate the characteristic angle timer settings for the distance functions. Use the offset setting determined there. In single-pole tripping schemes, use an offset setting of 0.3.

<u>OFFSET M1/MG1</u> (0 to 0.4)*ZR1 in 0.1 steps

The OFFSET M1/MG1 setting establishes the forward offset in the zone 1 phase and ground distance functions. Use the following settings:

1. If OFFSET MT/MTG = 0 then set

   OFFSET M1/MG1 = 0

2. If OFFSET MT/MTG > 0 and out-of-step blocking is not used, then set

   OFFSET M1/MG1 = 0, unless determined otherwise when M1/MG1 characteristic timer angle setting is calculated.

3. If OFFSET MT/MTG > 0 and out-of-step blocking is used, or if single-pole tripping is used, set

   OFFSET M1/MG1 = (OFFSET MT/MTG + 0.1)

<u>VP ANG</u> (0°, 10°, 15°, 20°, 25°, 30°, 35° or 45°)

The VP ANG setting establishes a phase shift in the Vpx polarizing signal of the ground zone 1 functions. Use the following setting:

VP ANG = 0°

<u>M1 VP</u> (IN or NOT IN)

The M1 VP setting allows the Vpx polarizing signal in the phase zone 1 functions to be shifted by the same amount as in the ground zone 1 functions. Use the following setting:

M1 VP = NOT IN

MULT (0.1, 0.25 or 0.1)

The MULT setting establishes the zero sequence supervision level in the MG1 and MTG functions, and the amount of zero sequence restraint in the M1 and MT functions. Set it to the same position as the MULT setting on the AFM101 or AFM104 module.

NB (5 to 80 ohms) in 5 ohm steps

Set NB = 20 ohms

KI2Z (0.6 to 1.0) in 0.05 steps

Set KI2Z = 1.0

I0Z REST (IN or OUT)

Set I0Z REST = OUT (Three-pole tripping)

Set I0Z REST = IN (Single-pole tripping)

I2LD (0.05 to 0.05)*In in 0.05 steps

Set I2LD = 0.05

ULM131

NB (64° to 90°) in 2° steps

Set NB = 90°

TL4 (0.4 to 6.3) seconds in 0.1 second steps

The TL4 setting establishes the zone 4 trip time which is controlled by the MB blocking functions. Switch 131A-3 must be CLOSED to energize this timer to implement zone 4 time-delayed backup protection. If used,

Set TL4 = required fourth zone time

TL24 (0.5 to 7.5) cycles in 0.5 cycle steps

The TL24 setting establishes the dropout time of the NB blocking functions.

Set TL24 = 0.5 cycles

TL25 (0.5 to 7.5) cycles in 0.5 cycle steps

The TL25 setting establishes the dropout time of the MB blocking functions.

Set TL25 = 3.0 cycles

ULM121/122

MOB ϕ (32° to 126°) in 2° steps

The MOB ϕ setting establishes the out-of-step blocking characteristic for the phase distance functions. Use the following setting:

MOB ϕ = (MT - 20°)

Where: MT = the characteristic timer setting for the phase overreaching functions.

Smaller timer settings can be used provided that the MOB ϕ setting (angle A in Figure CS-3) is greater than the angle B by at least 20°.

MOB G (64° to 126°) in 2° steps

The MOB G setting establishes the out-of-step blocking characteristic for the ground distance functions.

Set MOB G = MTG

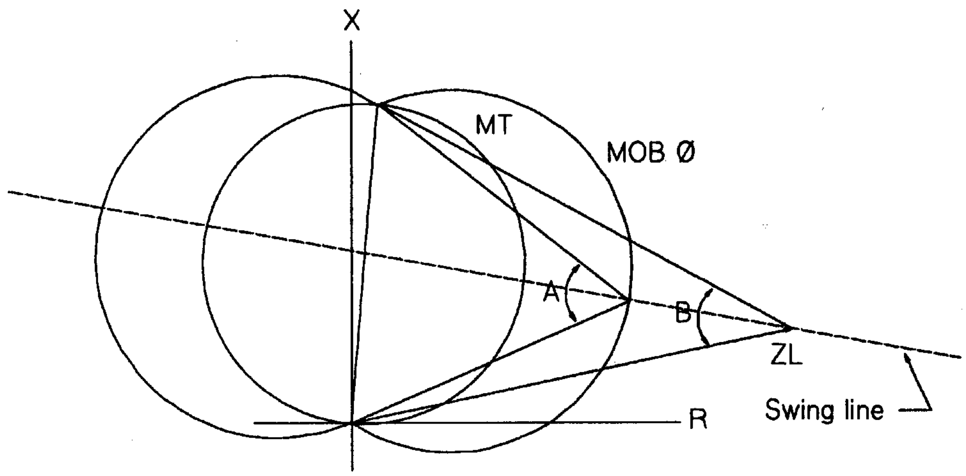
Where: MTG is the overreaching ground distance function characteristic timer angle (set on the UTM101 module)

TL6 (1 cycle to 7.75 cycles) in 0.25 cycle steps (Revision A relays only)

Timer TL6 establishes the time that the swing impedance (Figure CS-3) must stay between the MOB and MT characteristics for out-of-step blocking to be set up. The minimum time for the swing to traverse this distance can be established from system swing studies. Timer TL6 should be set with a pickup of 0.5 cycles less than this minimum traverse time. The pickup time should never be set less than 2 cycles. If necessary, increase the MT characteristic timer pickup setting to produce a more lenticular characteristic on MT to allow timer TL6 to be set to meet the two cycle minimum.

TL6 (Adaptive) (Revision B relays only)

Timer TL6 is an adaptive pickup fixed dropout timer and is factory preset.



A = MOB Ø characteristic timer angle setting

ZL = Minimum load impedance

Figure CS-3 Out-of-step Blocking

ULM141

TL1 (1 to 15 milliseconds) in 1 millisecond steps

In Blocking schemes:

Set TL1 = (2 + channel time + propagation time) milliseconds

Where: channel time = operating time of blocking channel

propagation time = time for signal to propagate from one end of the transmission line to the other end.

In all other schemes:

Set TL1 = 4 milliseconds

TL2 (0.2 to 3.15) seconds in 0.05 second steps

Set TL2 = required zone 2 time (if used)

TL3 (0.4 to 6.3) seconds in 0.1 second steps

Set TL3 = required zone 3 time (if used)

TL4 (0.4 to 6.3) seconds in 0.1 second steps

Set TL4 = required zone 3 time (if used)

TL14 (2 to 15) milliseconds in 1 millisecond steps

Set TL14 = 0; Coordination timer

TL15 (2 to 15) milliseconds in 1 millisecond steps

In hybrid scheme:

Set TL15 = 2

In all other schemes:

This timer is not used in these schemes, so setting is irrelevant.

TL16 (0.5 to 7.5) cycles in 0.5 cycle steps

In hybrid scheme:

Set TL16 = 0.5 cycles

This timer is used to provide security during weak infeed tripping conditions. Longer times may be used if additional security is required. Tripping will be delayed by any additional time if additional time is used.

In all other schemes:

This timer is not used in these schemes, so setting is irrelevant.

TL22 (0.4 to 6.3) seconds in 0.1 second steps

In blocking scheme:

This timer is not used in this scheme, so setting is irrelevant.

In all other schemes (with direct transferred tripping implemented through relay logic):

This timer is used in the reclosing control circuitry in the TLS1B system. It is used in conjunction with a direct transferred trip input and is used to distinguish between a line transferred trip as opposed to an equipment failure transferred trip. For a line transferred trip, reclosing would be inhibited as long as the signal was received but would then be permitted after the received signal went away. Timer TL22 should be set longer than the expected time that the line transferred trip signal would be received. On the other hand, for an equipment transferred trip, the trip signal will be transmitted for an extremely long time, or continuously by a lockout relay, thus timer TL22 will time out at which time reclosing will be locked out. Timer TL22 should be set with a long enough pickup time to meet this criteria.

If direct transferred tripping is not implemented through the relay logic, the timer setting is irrelevant.

ULM112

TL13 (2 to 30) milliseconds in 2 millisecond steps

In blocking schemes:

TL13 is not used in this scheme so the setting is irrelevant.

In all other schemes (with direct transferred tripping implemented through relay logic):

The TL13 timer is used to establish security when two channels are used and direct transferred tripping is implemented through the TLS1B system. Use a setting that is long enough to override any spurious channel outputs yet not so long as to cause undue delay when a transferred trip signal is received.

If direct transferred tripping is not used, the timer setting is irrelevant.

HIGH SPEED TRIPPING

If the positive sequence source to line impedance ratio is less than 0.5 (ZS1/Z1L < 0.5), and if high speed tripping is desired, the zone 1 distance functions can be set to the combination overcurrent/distance mode of operation to provide this requirement. In this mode of operation, the functions are required to operate dynamically and provide little steady-state coverage. To obtain high speed tripping, use the following settings:

r **AFM101/104**
MULT **AFM101/104** (front panel)
MULT **AFM101/104** (on board)
0 SUP **AFM101/104**

Set MULT = 1.0 (front panel)

Set MULT = 1.0 (on board)

Set r = Z1L

Where: Z1L = positive sequence impedance of transmission line

Set 0 SUP = 0.39

MULT **VMM101/102**

Set MULT = 1.0

VP Sen φ-φ **ETM101**
VP Sen φ-G **ETM101**

Set VP Sens φ-φ = 0.35
Set VP Sens φ-G = 0.35

M1 UTM101
MG1 UTM101

Set M1 = 64° (three-pole tripping)
Set M1 = 90° (single-pole tripping)

Set MG1 = 64° (three-pole tripping)
Set MG1 = 90° (single-pole tripping)

A FIL AFM101/104

Set A FIL = OUT

A1 FIL AFM211/212

Set A1 FIL = OUT

B FIL AFM101/104

Set B FIL = IN

B FIL AFM211/212

Set B FIL = IN

OFFSET M1/MG1 VMM101/102

If out-of step blocking is not used,

Set OFFSET M1/MG1 = 0

If out-of-step blocking is used and if OFFSET MT/MTG = 0 then,

Set OFFSET M1/MG1 = 0, otherwise,

Set OFFSET M1/MG1 = (OFFSET MT/MTG + 0.1)

THREE-POLE vs SINGLE-POLE TRIP SELECTION

Contact Converter CC5 (rear terminal blocks)
Switch 101B-2 **ULM101**

Two different methods are provided wherein the scheme can be switched from three-pole to single-pole tripping and vice versa. They are:

1. Contact converter CC5, which is accessed at the rear terminals of the TLS1 system. Three-pole tripping will be initiated for any type of fault when this contact converter is energized. This method should be considered when it is necessary to switch from single-pole to three-pole tripping periodically. An externally mounted switch can be used to implement the switching.

2. Switch 101B-2, located on the ULM101 board. Three-pole tripping will be initiated for any type of fault when this switch is set to the CLOSED position. This method should be considered when either single-pole or three-pole tripping is to be used on a permanent basis.

   Note that if method 1 described above (CC5) is used, then switch 101B-2 must be left in the OPEN position.

SETTINGS FOR SERIES COMPENSATED LINES

When the lines to be protected have compensation, or when adjacent lines are compensated. The following settings are affected.

MT/MTG Reach **AFM102/105**

The MT/MTG reach should be determined per the instructions given earlier. However, the reach (r≡x≡MULT) should never be set less than 150 percent (1.5≡times) the positive sequence impedance of the protected line.

MT/MTG Characteristic Timer Setting **UTM101**

The MT characteristic timer settings should be determined per the instructions given earlier and it should then be increased by 20 degrees. If this results in a timer setting greater than 127 degrees, increase the offset until a setting of 127 degrees or slightly less can be obtained. The MTG characteristic timer should be set 20 degrees less than the MT characteristic timer, but never less than 90 degrees.

M2/MG2 Reach **AFM103/106**

The M2/MG2 reach should be determined per the instructions given earlier. However, the reach (r≡x≡MULT) should never be set less than 150 percent (1.5≡times) the positive sequence impedance of the protected line if the M2 and MG2 are used as the primary pilot tripping zone.

M2/MG2 Characteristic Timer Setting **UTM102**

The M2 characteristic timer settings should be determined per the instructions given earlier and it should then be increased by 20 degrees. If this results in a timer setting greater than 127 degrees, increase the offset until a setting of 127 degrees or slightly less can be obtained. The MG2 characteristic timer should be set 20 degrees less than the M2 characteristic timer, but never less than 90 degrees.

M1/MG1 Reach Setting **AFM101/104**

Set the reach, r*MULT, to 100% of the positive sequence line impedance; i.e.

$$r * MULT = Z1L$$

where,

r = front panel reach setting

MULT = front panel multiplier setting (use MULT = 1.0 if possible)

M1/MG1 Characteristic Timer Setting UTM101

M1 = 64° (three-pole tripping)

= 90° (single-pole tripping)

MG1 = 64° (three-pole tripping)

= 90° (single-pole tripping)

Positive Sequence Replica Impedance Angle ISM101/102

This adjustment is normally set as close as possible to the positive sequence line impedance angle. However, if series capacitors are located between the source of potential to the relays and the remote terminal of the transmission line, and if MOV protection is used around the capacitors, reduce the ϕZ1 setting by 5 degrees; i.e., 80 degrees instead of 85, for example.

MG1 Zero Suppression AFM101/104
M1 Zero Suppression AFM211/212

The zone 1 functions are used as straight distance functions on uncompensated lines, and must be used as a combined overcurrent/distance function when applied on series compensated lines, or on lines adjacent to compensated lines.

When applied as a straight distance function, the measurement is made by comparing the phase relationship of the operate signal (IZ-V) to a polarizing signal Vp; where Z is the reach of the function, and, V and I are the voltage and current at the function. In the combined mode of operation, the operate signal must also be larger than a user set magnitude (level detector) in addition to having the correct relationship to the polarizing quantity.

For example consider the fault at F in the system shown in Figure CS-4. On the surface, it appears feasible to set a straight distance function to reach 80-90 percent of the compensated impedance of the line (Xl-Xc) to provide direct tripping. However, the function may overreach on the low frequency transients that could occur for faults beyond the capacitor if the fault level is insufficient to cause gap flashing or significant conduction in the MOV's. Studies have shown that it may not be possible to set a straight distance function with a short enough reach to prevent

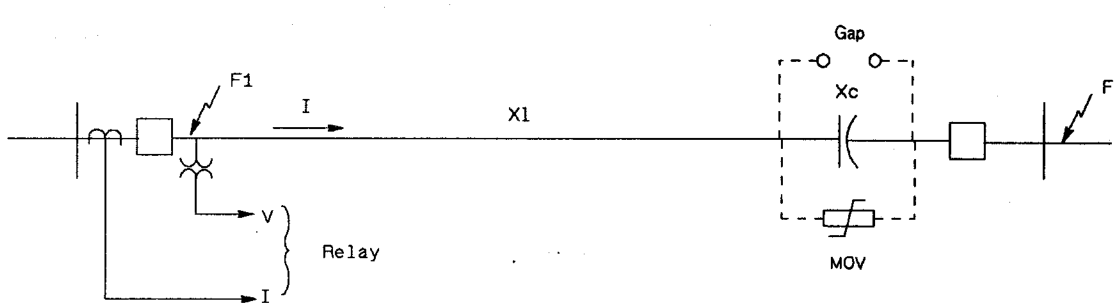


Figure CS-4 Series Compensated Line

overreaching. It is for this reason that the combined overcurrent/distance function was developed. The level detector setting is related to the amount of compensation and type of protection used around the compensation. For the fault at F, the voltage at the relay (R) is:

$$V = I^{*}(Xl - Xt)$$

Where:

Xt = Xc when gaps are used

Xt = parallel combination of Xc and MOV when MOV's are used

If the zone 1 functions are set with a reach, Z, equal to Xl, then the operate signal (IZ-V) for the fault at F is:

$$IZ - V = I^{*}(Xl) - I^{*}(Xl-Xt) = I^{*}Xl - I^{*}Xl + I^{*}Xt = I^{*}Xt$$

If gap flashing does not occur, of if there is not significant conduction in the MOV, then the operate signal, IZ-V, is equal to the voltage across the capacitor, or the capacitor/MOV combination. The level detector in the zone 1 function is set larger than this value so that it will not operate for faults external to the zone of protection, even in the presence of low frequency transients.

If, for the fault at F, significant MOV conduction occurs or the gaps flash, then $I^{*}Xt$ is equal to the MOV protective level, or zero respectively. Because IZ-V will be less than the level detector setting for this condition, the function will not operate and is very secure.

Now consider a fault at F1 directly in front of the function. For this fault (V = 0), and the operate signal $IZ-V = I^{*}Z = I^{*}Xl$. If the source behind the function is very strong and the line is very long, the operate signal will be very large and fast operation will result.

In determining the level detector settings, it is necessary to consider external faults beyond any capacitor located at the remote bus in adjacent line sections. All of the capacitors that appear between the source of the relay potential and those external faults must then be taken into consideration. Consider the forward fault at location F2 in Figure CS-5:

1. Capacitors C1 and C2 need only be considered if line side potential is used.
2. If bus side potential is used then capacitor C, C1 and C2 must be taken into consideration.

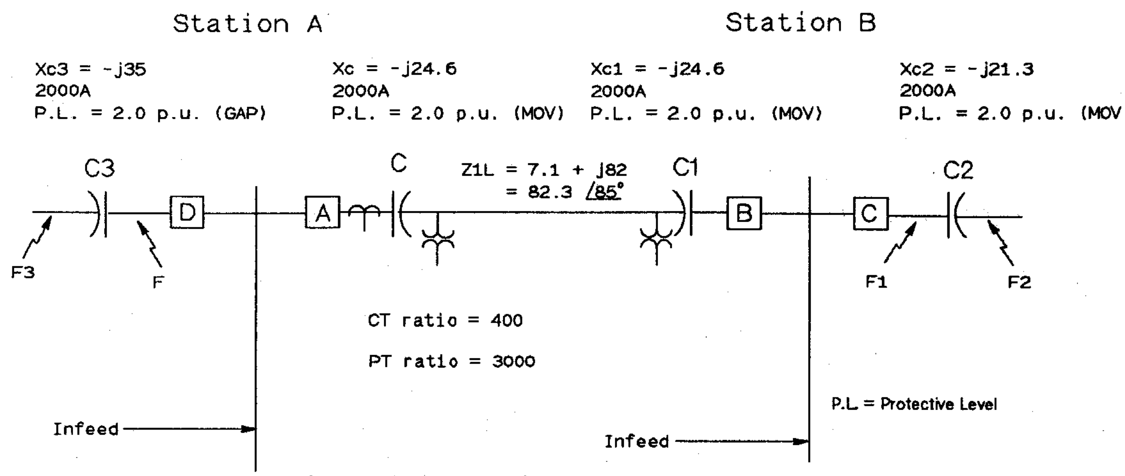


Figure CS-5 Typical Compensated System

Capacitor C2 should be treated as follows when determining the level detector settings:

1. With gaps:

   If the **minimum** fault current (I) for a fault at F1 (including infeed) is above the gap flashing level, then exclude C2 from the calculation.

2. With MOV's:

   If the MOV's are protected with gaps, and if the minimum fault current (including infeed) for a fault at F1 is above the gap flashing level, then exclude C2 from the calculation.

   If the minimum fault current for a fault at F1 is below the gap flashing level, or, if gaps are not used around the MOV's, calculate an effective protective level as follows:

$$EPL = \frac{(PL)*(IPL)}{(I)} \qquad (1)$$

Where,

EPL = effective protective level

PL = actual protective level in peak volts (secondary)

IPL = rms current required to start conduction in the MOV

I = **minimum** fault current for fault at F1

Note: Use the actual protective level (PL) if I is less than IPL

After it has been decided which capacitors should be considered, sum the protective levels of those capacitors as follows:

$$PLT = \Sigma \frac{(PLn)}{(67)\sqrt{2}}$$

Where:

PLn = the gap flashing level in peak volts if gaps are used to protect the capacitors, or,

PLn = the actual protective level, or the effective protective level described above, if MOV's are used to protect the capacitors.

Once PLT has been determined, the level detector setting (0 SUP) for the M1 and MG1 functions can be determined as follows:

MG1 Zero Suppression **AFM101/104**

$$0\ SUP = \frac{\sqrt{(0.15 + PLT^2)}}{MULT} \qquad (I\text{-}1)$$

M1 Zero Suppression **AFM211/212**

$$0\ SUP = \frac{\sqrt{(0.15 + 1.3\ PLT^2)}}{MULT} \qquad (I\text{-}2)$$

M1/MG1 Offset **VMM101/102**

If out-of-step blocking is used,

M1/MG1 OFFSET = MT/MTG OFFSET + 0.1

M1 A Filter **AFM211/212**

Set A FIL switch to out.

MG1 A Filter **AFM101/104**

Set A FIL switch to out.

VP Sens ϕ-ϕ ETM101
VP Sens ϕ-G ETM101

Set VP Sens ϕ-ϕ = 0.35
Set VP Sens ϕ-G = 0.35

MB Blocking Functions Phase Shift **ABM101/102**

POL = 20°

MB Characteristic Timer Dropout **ULM131**

TL25 = 7.5 cycles.

NB Negative Sequence Current Compensation **VMM101/102**

If there are no capacitors at the line terminal where the relays are located, or if bus side potential is used.

KI2Z = 1.0

If line side potential is used, and there are capacitors at the line terminal, calculate KI2Z as follows:

$$KI2Z = \frac{0.9*[NB - (XC-XS)]}{NB}$$

Where:

NB = offset reach for NB function.

XC = the total capacitive reactance (in secondary ohms) between the potential source to the relays and the source (XS) behind the capacitors; for example, XC = the capacitive reactance of capacitor C as shown in Figure CS-5.

XS = minimum negative sequence impedance (in secondary ohms) of the source directly behind the capacitors.

Start with NB = 20. If KI2Z turns out to be less than 0.6, then increase NB until KI2Z > 0.6.

NOTE: If XS > XC then set KI2Z = 1

NB Characteristic Timer Dropout **ULM131**

TL24 = 7.5 cycles

TABLE CS-4
TLS1B SETTINGS

Station:__________ Line:__________

Module	Adjustment	Type	Location	Setting
ISM101/102	IT	IΦ trip	On board	_____
ISM101/102	IB	IΦ block	On board	_____
ISM101/102	φZ1	Replica impedance	Front panel ...	_____
ISM101/102	φZ0	Replica impedance	Front panel ...	_____
AFM101/104	r	M1/MG1 Reach	Front panel ...	_____
AFM101/104	MULT	M1/MG1 Reach mult	Front panel ...	_____
AFM101/104	A FIL	MG1 A filter	On board	_____
AFM101/104	B FIL	MG1 B filter	On board	_____
AFM101/104	0 SUP	MG1 0 sup	On board	_____
AFM101/104	S	MG1 S signal	On board	_____
AFM101/104	MULT	I0ZR1 clip level	On board	_____
AFM101/104	K0	MG1 I0 curr. comp.	On board	_____
AFM101/104	∠ZR0	MG1 ∠ZR0	On board	_____
AFM102/105	r	M2/MG2 reach	Front panel ...	_____
AFM102/105	MULT	M2/MG2 reach mult	Front panel ...	_____
AFM102/105	A FIL	MG2 A filter	On board	_____
AFM102/105	B FIL	MG2 B filter	On board	_____
AFM102/105	0 SUP	MG2 0 sup	On board	_____
AFM102/105	S	MG2 S signal	On board	_____
AFM102/105	MULT	I0ZR1 clip level	On board	_____
AFM102/105	K0	MG2 I0 curr. comp.	On board	_____
AFM102/105	∠ZR0	MG2 ∠ZR0	On board	_____
AFM103/106	r	MT/MTG reach	Front panel ...	_____
AFM103/106	MULT	MT/MTG reach mult	Front panel ...	_____
AFM103/106	A FIL	MTG A filter	On board	_____
AFM103/106	B FIL	MTG B filter	On board	_____
AFM103/106	0 SUP	MTG 0 sup	On board	_____
AFM103/106	S	MTG S signal	On board	_____
AFM103/106	MULT	I0ZR1 clip level	On board	_____
AFM103/106	K0	MTG I0 curr. comp.	On board	_____
AFM103/106	∠ZR0	MTG ∠ZR0	On board	_____
AFM211/212	A1 FIL	M1 A filter	On board	_____
AFM211/212	B1 FIL	M1 B filter	On board	_____
AFM211/212	0(1) SUP	M1 0 sup	On board	_____
AFM211/212	S1	M1 S signal	On board	_____
AFM211/212	AT FIL	MT A filter	On board	_____
AFM211/212	BT FIL	MT B filter	On board	_____
AFM211/212	0(T) SUP	MT 0 sup	On board	_____
AFM211/212	ST	MT S signal	On board	_____

TLS1B SETTINGS (cont'd)

Station:__________ Line:________________

Module	Adjustment	Type	Location	Setting
AFM201/202	A2 FIL	M2 A filter	On board	_____
AFM201/202	B2 FIL	M2 B filter	On board	_____
AFM201/202	0(2) SUP	M2 0 sup	On board	_____
AFM201/202	S2	M2 S signal	On board	_____
UTM101	M1	M1 char. timer	On board	_____
UTM101	MG1	MG1 char. timer	On board	_____
UTM101	MT	MT char. timer	On board	_____
UTM101	MTG	MTG char. timer	On board	_____
UTM101	MB	MB char. timer	On board	_____
UTM101	MG1 Superv'n	MG1 supervision	On board	_____
UTM101	M1 Superv'n	M1 supervision	On board	_____
UTM102	MG2	MG2 char. timer	On board	_____
UTM102	M2	M2 char. timer	On board	_____
ETM101	I0 SENS	3I0 sens (Zone 1)	On board	_____
ETM101	VP SENS	MG1 VP sens	On board	_____
ETM101	VP SENS	M1 VP sens	On board	_____
ETM101	IΦ - Φ	IΦΦ (M1 sup)	Front panel ...	_____
ETM101	VP	MG1 VP	On board	_____
ETM101	I2	MG1 I2	On board	_____
ETM101	I0	MG1 I0	On board	_____
ETM101	I0 SENS	3I0 sens(Zone 2)	On board	_____
ETM101	VP SENS	MG2 VP sens	On board	_____
ETM101	VP SENS	M2 VP sens	On board	_____
ETM101	IΦ - Φ	IΦΦ (M2 sup)	Front panel ...	_____
ETM101	VP	MG2 VP	On board	_____
ETM101	I2	MG2 I2	On board	_____
ETM101	I0	MG2 I0	On board	_____
ETM102	VP SENS	MTG VP sens	On board	_____
ETM102	VP SENS	MT VP sens	On board	_____
ETM102	IΦ -Φ	IΦΦ (MT sup)	Front panel ...	_____
ABM101/102	r	MB reach	Front panel ...	_____
ABM101/102	K	MB I0 curr. comp.	On board	_____
ABM101/102	KV1	MB volt. comp.	On board	_____
ABM101/102	OFFSET	MB offset	On board	_____
ABM101/102	POL	MB pol phase sh.	On board	_____
ABM101/102	I1	I1	On board	_____
ABM101/102	I2 SHIFT	I2 shift	On board	_____
ABM101/102	I0 SHIFT	I0 shift	On board	_____

TLS1B SETTINGS (cont'd)

Station:_________ Line:_______________

Module	Adjustment	Type	Location	Setting
VMM101/102	II	Zone 1 reach ext.	Front panel ...	_____
VMM101/102	OFFSET MT/MTG	MT/MTG offset	On board	_____
VMM101/102	OFFSET M1/MG1	M1/MG1 offset	On board	_____
VMM101/102	VP ANG	MG1 phase shift	On board	_____
VMM101/102	M1 VP	M1 phase shift	On board	_____
VMM101/102	MULT	I0 zero supp	On board	_____
VMM101/102	NB	NB reach	On board	_____
VMM101/102	KI2Z	NB curr. comp.	On board	_____
VMM101/102	I0Z REST	I0Z restraint	On board	_____
VMM101/102	I2LD	I2	On board	_____
ULM131	NB	NB char. timer	On board	_____
ULM131	TL4	Timer TL4	On board	_____
ULM131	TL24	NB dropout	On board	_____
ULM131	TL25	MB dropout	On board	_____
ULM121/122	MOB ϕ	MOB timer	On board	_____
ULM121/122	MOB G	MOBG timer	On board	_____
ULM121	TL6 (Rev. A TLS1)	Timer TL6	On board	_____
ULM141	TL1	Timer TL1	On board	_____
ULM141	TL2	Timer TL2	On board	_____
ULM141	TL3	Timer TL3	On board	_____
ULM141	TL15	Timer TL15	On board	_____
ULM141	TL16	Timer TL16	On board	_____
ULM141	TL22	Timer TL22	On board	_____
ULM112	TL13	Timer TL13	On board	_____

Set by:_________

Date:_______

HARDWARE DESCRIPTION

ALUMINUM CASE ASSEMBLY

Construction

The TLS1B case is constructed from sheet aluminum. The front cover consists of an aluminum frame with a plate glass window. It is hung from the top of the case on a removable hinge. This allows easy access to all the modules.

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

The modules are mounted vertically in a double-shelf arrangement. The sockets within the case (towards the rear) serve as a mechanical support as well as the means of electrical connection. There are card guides on the top and bottom of each shelf to allow easy removal and insertion, as well as to provide an extra support for the modules.

Electrical Connections and Internal Wiring

External connections are made to each case through 16 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.

Connection to the printed-circuit-board modules is made by means of 60-pin edge connectors. Connection to the MGM module is made by means of two connector sockets: an 8-contact current block and a 104-pin signal block. The current-block contacts are rated to handle current-transformer (CT) secondary currents.

Identification

The TLS1B model number label is located on the front cover MOD 10 label.

A marking strip indicating the name and position of every module in a given case is included on the edge of the divider between the two shelves. It is placed to be read when the front cover is fully opened or closed.

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

PRINTED-CIRCUIT-BOARD MODULES

Basic Construction

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

Identification

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

XTM TEST PLUGS

Description

The XTM test plugs are designed specifically for post-installation testing of the TLS1B system. There are two plugs; XTM28L1 (left-hand plug) and XTM28R1 (right-hand plug), each providing access to fourteen relay and fourteen system points. The system points are located on the outer edge. The plugs are keyed by the contact- finger arrangement so that there may be no accidental interchange between the left- hand and right-hand plugs.

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

CAUTION

Not all external connections to the TLS1B are wired through the test receptacle.

Terminal Designation

The test receptacle and connection plugs are located to the left of the magnetics module (extreme lower left-hand position). Their terminals are labeled 1 through 28, with 1 through 14 corresponding to the left-hand side and 15 through 28 corresponding to the right-hand side. These points are designated on the elementary diagram (Figure SD-20) as TP1 through TP28.

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

XTM Test-Circuit Connections

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

Connections should be made to the test plugs prior to insertion into the TLS1B.

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 TLS1B for those signals that are wired through the test receptacle (refer to TP points on elementary diagrams, Figure SD-20). For the terminals connected to the current-transformer (CT) secondaries, shorting bars are included on the system side of the test receptacle. These are clearly visible through the transparent plastic face plate on the receptacle. The shorting bars make contact before the connection-plug contacts break during removal, so that the CT secondaries are never open-circuited.

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

When the test plugs are inserted into the receptacle, parts of the power system become isolated from the TLS1B. Refer to the TLS1B elementary diagrams (Figure SD-20) for the TP points associated with each of the test plugs.

WARNING

IT IS CRITICAL THAT JUMPERS BE INSERTED ON THE SYSTEM-SIDE TEST PLUG TERMINALS THAT ARE CONNECTED TO THE CT SECONDARIES AS SHOWN IN FIGURE SD-20. IF THESE JUMPERS ARE LEFT OUT, THE RESULTING HIGH VOLTAGES DEVELOPED PRESENT A SERIOUS HAZARD TO PERSONNEL AND MAY SEVERELY DAMAGE EQUIPMENT.

CARD EXTENDER

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

The extender has 60 test points, which are identified by numbers 1 through 60.
One method of removing power for certain cases is to turn off the power switch on the PSM power-supply module and then remove both of the connection plugs located in the TPM position on the left side of the case.

CAUTION

Remove power from the TLS1B before removing or inserting any of the printed-circuit board modules. Failure to observe this caution may result in damage to the relay.

To remove the power from the relay, turn OFF the power switch on the PSM power supply module and then remove both of the TPM test plugs located to the left of the on the lower left side of the case (see Figure MO-1).

WARNING

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

RECEIVING, HANDLING AND STORAGE

CAUTION

> This relay contains electronic components that could be damaged by electrostatic discharge currents if those currents flow through certain terminals of the components. The main source of electrostatic discharge currents is the human body, and the conditions of low humidity, carpeted floors, and isolating shoes are conducive to the generation of electrostatic discharge currents. Where these conditions exist, care should be exercised when removing and handling the modules. Persons handling the modules should make sure that their body charge has been discharged by wearing a anti-static wrist band or by touching some point at ground potential before handling any of the modules.

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

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

INSTALLATION

Environment

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

Mounting

The TLS1B cases have been designed for standard rack mounting. The case measures eight rack (8RU) units in height. The unit may also be flush-mounted on a panel. Refer to Figure HD-1.

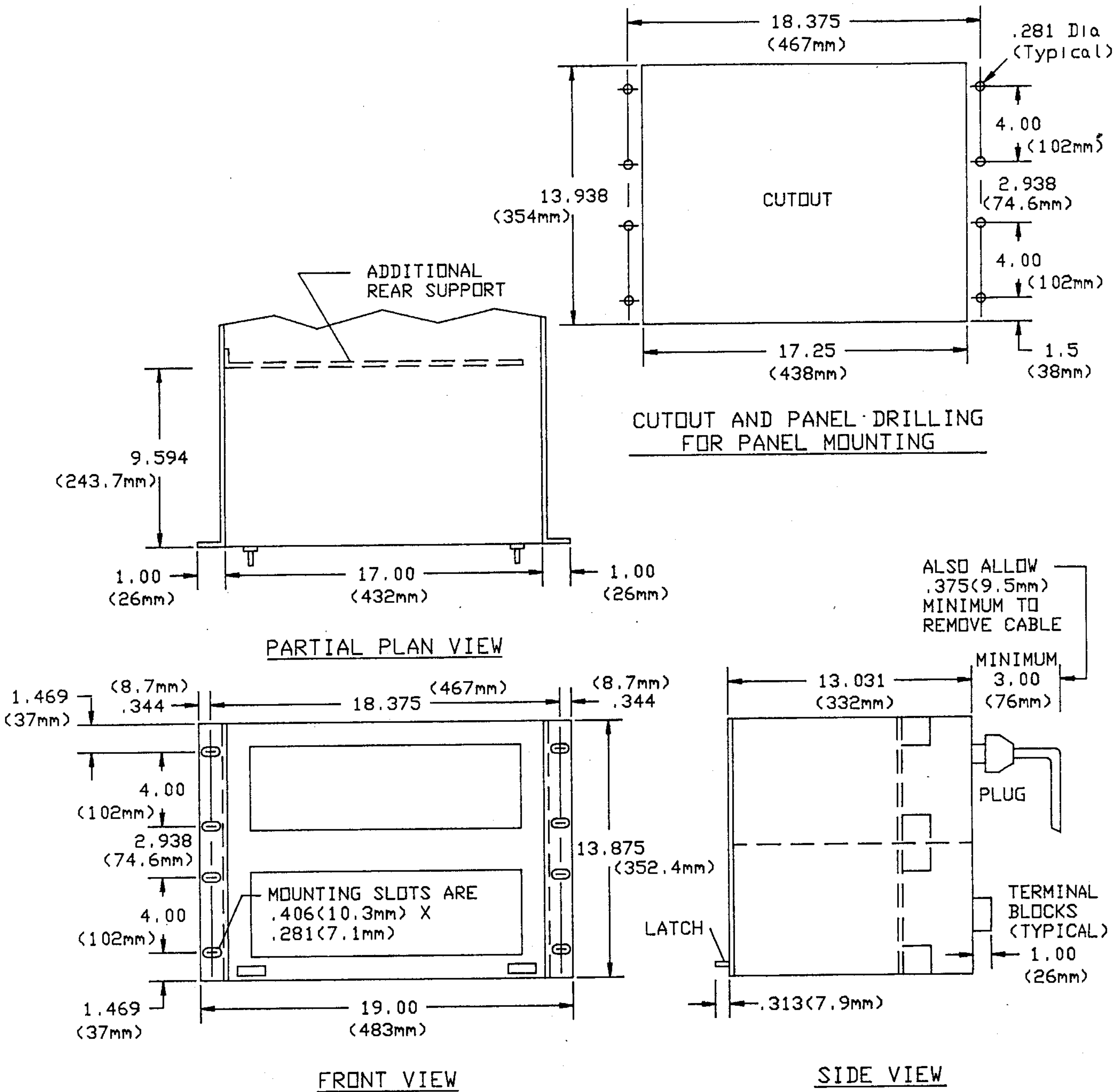


Figure HD-1 (0184B6393 [1]) Outline and Mounting Dimensions for MC-2 Case

MODULE DESCRIPTION

ABM101, ABM102 (See Figure MO-2)

These modules provide the following functions:

1. Reach adjustment for MB units
2. Zero-sequence current compensation adjustment for MB units
3. Polarizing voltage for MB units
4. Operating signal for MB units
5. Coincidence logic for MB units
6. Positive-sequence-current detector
7. Fault detector
8. Zero-sequence-current supervision for ground-tripping units
9. Negative-sequence-current supervision for ground-tripping units

The ABM101 is used in systems rated for 60 hertz, while the ABM102 is used for 50 hertz systems.

Front Panel Switches

These switches adjust the positive-sequence reach of the MB units. The reach of 5-ampere rated relays can be adjusted from 2 to 50 ohms in 0.2 ohm steps by selecting the appropriate switches. The reach is equal to 2 plus the sum of the numbers of the switches whose toggles are to the right (i.e. closed). For example, if the top four switches are positioned to the right, the reach will be 5 ohms:

$$(2 + 0.2 + 0.4 + 0.8 + 1.6) = 5.0$$

For relays rated 1 ampere, the reach will be five (5) times the value determined by the above method.

On-Board Switches

I1 These switches adjust the pickup level of the positive-sequence-current detector. Pickup current is in per unit of rated current (IN) and is adjustable from 0.2 to 3.2 per unit in 0.2 per-unit steps. The per-unit pickup current is equal to 0.2 plus the sum of the numbers of the switches whose toggles are to the right.

K These switches adjust the zero-sequence-current compensation factor [(Z0 - Z1)/Z1] for the MB units from 1 to 7 in 0.1 steps. K is equal to 1 plus the sum of the numbers of the switches whose toggles are to the right.

KV These switches adjust the voltage compensation factor for the MB units from 0 to 0.45 per unit in 0.15 per-unit steps. KV is equal to 0 plus the sum of the numbers of the switches whose toggles are to the right.

On-Board Links

I0 SHIFT This link selects the phase shift in the zero-sequence-current supervision signal for the ground-tripping units. The phase shift can be 0°, 5°, 10° or 15° lag.

I2 SHIFT This link selects the phase shift in the negative-sequence-current supervision signal for the ground-tripping units. The phase shift can be 0°, 5°, 10° or 15° lag.

OFFSET This link determines whether the MB unit characteristics are offset into the protected line ("IN" position) or not offset ("OUT" position).

POL This link selects the phase shift in the polarizing voltage for the MB units. The phase shift can be either 0° or 20° leading.

AFM101, AFM102, AFM103, AFM104, AFM105, AFM106 (See Figures MO-3, MO-4, MO-5)

These modules perform identical functions; however, they are found in different locations in the cases, depending upon how they are to be used. There are two basic qualities that separate these modules one from the other:

1. The system frequency for which the AFM module has been designed.
2. The minimum and maximum reaches, as well as the smallest increment of adjustment (step), is different on each of the AFM modules.

Table MO-1 tabulates these differences. Use it as a reference for the "Front Panel Switches" discussion that follows.

TABLE MO-1 MODULE BREAKDOWN

MODULE	SYSTEM FREQUENCY (hertz)	REACH (OHMS) MIN.	MAX.	STEP	WHERE USED 3-ZONE TLS1B
AFM101	60	1	25	0.1	M1/MG1
AFM102	60	2	50	0.2	M2/MG2
AFM103	60	3	75	0.3	MT/MTG
AFM104	50	1	25	0.1	M1/MG1
AFM105	50	2	50	0.2	M2/MG2
AFM106	50	3	75	0.3	MT/MTG

These modules provide the following functions:

1. Reach adjustment
2. Zero-sequence-current compensation adjustment
3. Zero-sequence supplementary-angle adjustment
4. Operate-circuit filter and signal processing
5. Operate-circuit "IZ-V" summation
6. Summation of zero-sequence-current and negative-sequence-current supervision signals

Front Panel Switches

These switches adjust the positive-sequence reach of the M1/MG1 units. The reach of 5-ampere rated relays can be adjusted from (MIN.) to (MAX.) ohms in (STEP) ohm steps. The reach is equal to (MIN.) plus the sum of the numbers of the switches whose toggles are to the right. See Table MO-1 to determine the values of MIN., MAX., and STEP.

For relays rated 1 ampere, the reach will be five (5) times the value determined by the above method.

MULT This switch multiplies the reach set on the r switch by 1, 0.25 or 0.1. For example, if the r switch is set for "10" ohms, and the MULT switch is set for 0.25", the actual reach will be 2.5 ohms.

On-Board Switches

KO These switches adjust the zero-sequence-current compensation (Z0/Z1) for the MG1 units from 1 to 7 in 0.1 steps. K0 is equal to 1 plus the sum of the numbers of the switches whose toggles are to the right.

Options - These switches provide flexibility for different applications by permitting signals to be added, as follows:

S This switch adds the high-level bypass signal into the polarizing signals when the toggle is to the right.

A FIL This switch adds the output of the A filter to the operate signal when the toggle is to the right.

0 SUP These switches select the amount of zero suppression in the output of the B filter. The zero suppression can be adjusted from 0.1 to 1.5 per unit in 0.03 per-unit steps, and is equal to 0.1 plus the sum of the numbers of the switches whose toggles are to the right.

On-Board Links

B FIL The output of the B filter is added into the operate signal when this link is in the "IN" position.

MULT This link determines the clipping level of the I0ZR1 signals that are used in the operate signals. THIS LINK SHOULD NORMALLY BE IN THE SAME POSITION AS THE FRONT PANEL MULT SWITCH.

/ZRO This link provides a supplementary phase shift for the zero-sequence-current signal so that MG1 and MTG can be set for different zero-sequence angles. This supplementary phase shift can be either 0°, 25°, 50° or 75° lagging.

AFM201, AFM202 (See Figure MO-6)

This module provides the following functions:

1. Operate-circuit filters and signal processing for the M2 unit.
2. High-level bypass signal for the M2 unit.

The AFM201 module is used for 60-hertz-rated system, while the AFM202 module is used for 50-hertz-rated systems.

<u>On-Board Switches</u>

Options - These switches provide flexibility for different applications by permitting signals to be added as follows:

S This switch adds the high-level bypass signal into polarizing signals when the toggle is to the right.

A FIL These switches add the output of the A filter to the operate signal for the M2 unit when the toggle is to the right.

O SUP This switch selects the amount of zero suppression in the output of the B filter for the M2 unit. The zero suppression can be adjusted from 0.1 to 1.5 per unit in 0.03 per unit steps, and is equal to 0.1 plus the sum of the numbers of the switches whose toggles are to the right.

<u>On-Board Link</u>

B FIL The output of the B filter is added into the operate signal for M2/MG2 only when this link is in the "IN" position.

AFM211, AFM212 (See Figure MO-7)

These modules provide the following functions:

1. Operate-circuit filters and signal processing for M1 or MT units
2. High-level bypass signal for M1 or MT units.

The AFM211 module is used for 60-hertz-rated systems, while the AFM212 module is used for 50-hertz-rated systems. One AFM211 (or AFM212) module will cover two zones of protection (M1/MG1 and MT/MTG units) in the TLS1B Modular Relay System.

On-Board Switches

Options - These switches provide flexibility for different applications by permitting signals to be added as follows:

S This switch adds the high-level bypass signal into polarizing signals when the toggle is to the right.

A1 FIL
AT FIL These switches add the output of the A filter to the operate signal when the toggle is to the right. A1 FIL is used in M1/MG1, and AT FIL is used in MT/MTG.

These switches select the amount of zero suppression in the output of the B filter for the M(1) or M(T) units. The zero suppression can be adjusted from 0.1 to 1.5 per unit in 0.03 per unit steps, and is equal to 0.1 plus the sum of the numbers of the switches whose toggles are to the right.

On-Board Links

B1 FIL
BT FIL The output of the B filter is added into the operate signal only when this link is in the "IN" position. B1 FIL is used in M1/MG1 and BT FIL is used in MT/MTG.

ETM101 (See Figure MO-8)

This module provides the following functions:

1. Coincidence-logic circuitry for the M1/MG1 and M2/MG2 units.
2. Polarity detectors for M1 polarizing voltage

Two modules are provided, the one for the M1/MG1 units is located in the upper card row and the other for the M2/MG2 units is located in the lower card row.

Front Panel Switches

Iφ-φ These switches set the phase-to-phase current sensitivity of the coincidence-logic circuits. Sensitivity can be set between 0.1 and 1.0 per unit of rated current (IN) in each phase, and is equal to 0.1 plus the sum of the numbers of the switches whose toggles are to the right.

On-Board Switches

I0 SENS These switches set the ground-current sensitivity (3I0) of the MG1, MG2 coincidence-logic circuits. Sensitivity can be set for 0.05, 0.25, 0.45 or 0.65 per unit of rated current (IN) and is equal to 0.05 plus the sum of the numbers of the switches whose toggles are to the right.

PHA, PHB, & PHC These switches determine which polarizing signals are used in the coincidence logic for the MG1, MG2 units. Zero-sequence-current polarizing I0 will be used for an input to the coincidence logic when the "I0" toggles are to the right. Similarly, negative-sequence polarizing will be used when the I2 "I2" toggles are set to the right, and voltage polarizing will be used when the Vp "Vp" toggles are set to the right. THE TOGGLES FOR PHA, PHB AND PHC SHOULD NORMALLY BE SET IN THE SAME PATTERN.

Vp SENS φ-φ φ-G These switches set the sensitivity of the voltage-polarizing signals in per unit. The sensitivities for each phase can be separately set for 0, 0.05, 0.3 or 0.35 per unit by placing the desired toggle or toggles to the right. The toggles labeled "φ-G" affect the MG1, MG2 units and the "φ-φ" toggles affect the M1, M2 unit. Use care when making these settings, since the toggles for "φ-G" and "φ-φ" are located on the same switch package.

ETM102 (See Figure MO-9)

This module provides coincidence logic for the MT/MTG units.

__Front Panel Switches__

Iφ-φ These switches are identical to the corresponding switches on the ETM101 module, except that they affect the MT unit instead of the M1 unit.

__On-Board Switches__

Vp SENS φ-φ φ-G These switches are identical to the corresponding switches on the ETM101 φ-φ module except that they affect the MT/MTG units instead of φ-G the M1/MG1 units.

IOM101 (See Figure MO-10)

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

IOM201, IOM202, IOM203

These modules provide the contacts for the auxiliary outputs, including alarms, DLA and channel-control contacts. See the SPECIFICATIONS section of this book for the different contact ratings.

ISM101, ISM102 (See Figure MO-11)

These modules provide the following functions:

1. IZ signal interfaces
2. Voltage signal interfaces
3. Positive-sequence and zero-sequence-characteristic-angle selection
4. Blocking-unit coordinating level detectors (IB)
5. Tripping-unit coordinating level detectors (IT)
6. Undervoltage-unit coordinating level detectors (U/V)

The ISM101 is used in 60-hertz-rated systems, while the ISM102 is used in 50-hertz- rated systems.

<u>Front Panel Switches</u>

φZ1 This switch selects the relay's positive- and negative-sequence-impedance-characteristic angle. Characteristic angles can be selected between 50° and 85° in 5° steps. This angle will be the same for all measuring units.

φZ0 This switch selects the relay's zero-sequence-impedance-characteristic angle for all measuring units; however, this angle can be shifted for the MG1, MG2, and the MTG by means of the supplementary ∠ZRO link on the AFM10(-) modules in 25° lag steps. The φZ0 switch selects characteristic angles between 50° and 85° in 5° steps.

<u>On-Board Switches</u>

IB These switches adjust the pickup level of the blocking-unit coordinating level detectors. Pickup current is in per unit of rated current (IN) and is adjustable from 0.1 to 1.0 per unit in 0.05 per-unit steps. The per unit pickup current is equal to 0.1 plus the sum of the numbers of the switches whose toggles are to the right.

IT These switches adjust the pickup level of the tripping-unit coordinating level detectors. Pickup-current adjustment is identical to that for the IB above.

MGM

The magnetics module contains the current and potential transformers to couple the TLS1B measuring elements to the system. The current circuits are rated at 1 or 5 amperes. The current transformer (CT) inputs are shorted automatically when the module is removed. This module is rated for either 50 or 60 hertz. Current and frequency ratings are specified on the module front panel.

The TRIP output relays are also mounted in this module, together with their drive interface. The output relays are telephone-type relays, which pass the ANSI trip-duty-contact test.

PSM211, PSM212, PSM213 (See Figure MO-12)

This module provides all power to operate the TLS1B system. The input voltage must match the rating of the power supply (i.e. PSM211 = 48 VDC, PSM212 = 110-125 V, PSM213 = 220-250 V). The power supply is self-protecting and will not be damaged by a continuous short circuit. The output voltage will recover when the fault is removed. An output alarm is provided to indicate voltage outside the desired limits. A green light-emitting diode (LED) on the front panel indicates normal output voltage. A switch mounted on the front panel turns off the 12 and 24 volt supplies. A 3-amp, 250 V fuse is provided on the board to protect the printed- circuit board.

TAM101 - Optional (See Figure MO-13)

See the CONTINUOUS MONITOR section of this manual.

ULM101 (See Figure MO-14)

The ULM101 module provides the logic and timing for single-pole tripping. Insertion of the ULM101 module automatically switches the scheme from three-pole tripping to single-pole tripping; conversely, removal returns the scheme to three-pole tripping.

The only settings required are the selection of three-pole-tripping options. These are set via switches 101A and 101B. The switches provide the following options (switch closed for condition described, unless otherwise noted):

<u>On-Board Switches</u>

Position

101A-1-2
O O MT does not select 3-pole trip
O C Trip 3 pole for CC3 and MT
C O Trip 3 pole for CC1 or CC3 and MT
C C Trip 3 pole for any MT

3 Key 3-pole trip for any MT
4 A phase open selection
5 B phase open selection
6 C phase open selection

7-8
O O Single-pole trip after zone 2 or zone 3 time
C O Trip 3 pole after zone 3 time
O C Trip 3 pole after zone 2 time
C C Trip 3 pole after zone 2 or zone 3 time

101B-1 Trip 3 pole for an input on CC3
2 Trip 3 pole for all faults
3 1 pole/3 pole channel-keying logic

An amber light-emitting diode on the front panel indicates three-pole tripping has been selected.

ULM112 (See Figure MO-15)

This module provides a target, contact converter buffers, channel-input logic and the transfer-trip security timer. There are two logic switches: 111A and 111B, and a timer, TL13, which must be set.

__Switches__

111A-1	Closed for direct-transfer trip
2	Open for bus-side potential Closed for external phase-selection input
3	Closed to invert CC1
4	Closed to invert CC3
111B-1	Open for directional-comparison block and hybrid schemes; Closed for switch-zone schemes
2	Open: switch zone for CC1 or CC3; Closed: switched-zone-1 reach to zone-2 reach for CC4
3	Closed for transfer trip
4	Open: transfer trip via CC1 and CC3; Closed: transfer trip via CC2.

__Timer__

TL13 Direct-transfer-trip security timer. Set by positioning switches to the right to obtain the desired time. The setting is additive, and has a minimum setting of 2 milliseconds.

__Front Panel Target Lamps__

All red targets will seal in and retain their status (latch), even if DC power is lost. These targets can only be set while the trip bus is active. The MOB target is non-latching.

RESET Resets the red sealed-in targets. Once RESET is pushed, all red lamps should blink on for 1 to 2 seconds. The RESET button only affects the red LED targets. No other relay functions are affected.

ULM121/122 (See Figures MO-16A and MO-16B)

The ULM121/122 module contains the system clock, clock-failure-detection logic, out-of-step-blocking timers, and the channel-keying logic.

Logic switches select the rated system-frequency-keying logic, protection scheme and fault-detector-override logic.

Switches

121A-1	Open: 60 Hz; Closed: 50 Hz
2	Open: permissive underreaching transfer trip; Closed: permissive overreaching-transfer trip
3	Block keying for out-of-step
4	Block RI via scheme logic
5	Invert Key 1
6	Invert Key 2
7	Key 1 and 2 for transfer trip
8	Not used (leave in OPEN position)
121B-1	Override fault detector for inputs on CC7 or CC8
2	Override fault detector for out-of-step
3	Override fault detector permanently
4	Closed: enable fault-detector-override logic
5	Closed: blocks MOBG if receiver is active (ULM122 only) (Revision B TLS1)
121C-1 & 2	Open: hybrid Closed: blocking position, i.e., both open or both closed. Both toggles are to be in the same position.

Timers (ULM121 only) (Revision A TLS1)

TL6 Out-of-step-operating-time pickup is the sum of the closed switches. Minimum, 1 cycle; maximum, 7.75 cycles; in 0.25-cycle steps

MOB/MOBG Characteristic timer setting. Minimum, 32°; maximum, 126°; in 2° steps.

Use the following equation to determine the characteristic timer setting:

TIMER SETTING = SUM OF SWITCHES + B * 32

B = 1 if SW32 and SW64 are open
B = 0 if SW32 or SW64 are closed

EXAMPLE: SW4 and SW16 closed.
Therefore B = 1
Timer Setting = 4 + 16 + (1 * 32) = 52

EXAMPLE SW4, SW16 and SW64 closed.
Therefore B = 0
Timer Setting = 4 + 16 + 64 + (0 * 32) = 84

ULM131 (See Figure MO-17)

The ULM131 module provides measuring-unit-supervision signals, zone-4 time, the blocking-unit dropout timer, and the negative-sequence blocking-unit characteristic timer.

Switches

131A-1		Open: supervise NB with the AND of the MT units; Closed: supervise NB with any MT
	2	Block reclose initiate for out-of-step
	3	Closed: put zone 4 in service
	4	Closed: put line-pickup tripping in service
	5	Open: line-side potential; Closed: bus-side potential
	6	Not used (Leave in OPEN position)

Timers

TL4 Zone 4 timer. Set for desired time. Minimum, 0.4 second; maximum, 6.3 seconds, in 0.1-second steps. The operating time is the sum of the closed switches.

TL24 NB dropout. Set desired time. Minimum, 0.5 cycle; maximum, 7.5 cycles, in 0.5-cycle steps. The setting is the sum of the closed switches.

TL25 MBG dropout. Set desired time. Minimum, 0.5 cycle; maximum, 7.5 cycles, in 0.5-cycle steps. The setting is the sum of the closed switches.

NB Characteristic timer. Minimum, 64°; maximum, 96°, in 2° steps. The characteristic angle is 64° plus the sum of the closed switches.

ULM141 (See Figure MO-18)

The ULM141 module provides most of the scheme logic, fuse-failure and sequential- reclosing settings for the trip integrator; zone-2, zone-3 coordination; block repeat; weak-infeed and transfer-trip timer. In addition, 24 logic switches for scheme selection are provided.

Switches

141A-1		Closed: TL3 in service
	2	Supervise TL3 with MOB
	3	Supervise zone 1 with MOB
	4	Closed: TL2 in service
	5	Supervise channel trip with MOB
	6	Supervise zone 1 with blocking unit
	7	Supervise weak infeed with MOB
	8	Supervise TL2 with MOB
141B-1		Open: repeat out; Closed: repeat in
	2	Open: add time delay to repeat
	3	Closed: weak-infeed tripping

141C-1	Sequential reclose logic
2	Open: switch zone via TL2; Closed: trip via TL2
3	Sequential-reclose input logic
141D-1	Closed: M2 Open: MT
2	Comparer input logic
141E-1	Comparer input logic
2	Sequential-reclose logic
3	Closed: TL16 in service
4	Not used (leave in OPEN position)
5	Not used (leave in OPEN position)
6	Block reclose for MT
141F-1	Block-reclose logic
2	Block-reclose logic
3	(TL15 input select) repeat logic

<u>Timers</u>

TL1 Trip integrator; set as required. Minimum, 1 millisecond; maximum, 15 milliseconds, in 1-millisecond steps. The time is the sum of the closed switches.

TL2 Zone 2 timer. Minimum, 0.2 second; maximum, 3.15 seconds, in 0.1-second steps. The time is the sum of the closed switches.

TL3 Zone 3 timer. Minimum, 0.4 second; maximum, 6.3 seconds, in 0.1-second steps. The time is the sum of the closed switches.

TL14 Coordination timer. Minimum, 2 milliseconds; maximum 15 milliseconds, in 1-millisecond steps. The time is the sum of the closed switches.

TL15 Block repeat timer. Minimum, 2 milliseconds; maximum 15 milliseconds, in 1-millisecond steps. The time is the sum of the closed switches.

TL16 Weak-infeed timer. Minimum 0.5 cycle; maximum, 7.5 cycles in 0.5-cycle steps. The time is the sum of the closed switches.

TL22 Transfer-trip timer. Minimum, 0.4 second; maximum, 6.3 seconds, in 0.1- second steps. The time is the sum of the closed switches.

UTM101 (See Figure MO-19)

The UTM101 module provides the characteristic timers for the M1, MG1, MT, MTG and MB units. Each unit can be set to pick up from 64° to 127°, in 1° steps. The setting is equal to 64 plus the sum of the closed switches.

Three switches are provided to select the MG1 Supervision for mho or reactance operation. When making this selection, all three toggles must be in the same position, that is, all open or all closed.

A switch is provided to supervise M1 by MG1 when it is in the closed position.

UTM102 (See Figure MO-20)

The UTM102 module provides the characteristic timers for the M2 and MG2 units. Each unit can be set to pick up from 64° to 127°, in 1° steps. The setting is equal to 64° plus the sum of the closed switches.

VMM101, VMM102 (See Figure MO-21)

These modules provide the following functions:

1. Polarizing signals for M1/MG1, M2/MG2, and MT/MTG units
2. NB function
3. Zone switching of M1/MG1 reach (not used)
4. I0 supervision for MG1, MG2, and MTG units
5. 3I0Z1 restraint signal for M1, M2, and MT units.

The VMM101 is used for 60-Hz-rated systems, and the VMM102 for 50-Hz-rated systems.

__Front-Panel Switches__

II These switches select the reach of switched zone 2 in multiples of the zone 1 reach, which is set on the AFM101 or AFM104 module. The reach multiplier is adjustable from 1 to 10, in steps of 0.05, and is equal to 1 plus the sum of the numbers of the switches whose toggles are to the right.

__On-Board Switches__

I2LD These switches select the pickup current of the negative-sequence- current-level detector of the NB function. Pickup is adjustable from 0.05 to 0.5 per unit, in 0.05-per-unit steps. Per-unit pickup current is equal to 0.05 plus the sum of the numbers of the switches whose toggles are to the right.

KI2Z These switches select the compensation factor for negative-sequence current in the NB function. This compensation factor can be adjusted from 0.6 to 1.0 in 0.05 steps, and is equal to 0.6 plus the sum of the numbers of the switches whose toggles are to the right.

NB These switches select the reach for the NB function. The reach for 5-ampere-rated relays is adjustable from 5 to 80 ohms in 5-ohm steps, and is equal to 5 plus the sum of the numbers of the switches whose toggles are to the right. For relays rated 1 ampere, the NB reach will be five (5) times the value determined by the above method.

OFFSET M1/MG1 These switches select the per-unit offset (into the protected line section) of the polarizing voltages for the M1/MG1 units. The offset is adjustable, from 0. to 0.4 per unit, in 0.1 per unit steps, and is equal to 0 plus the sum of the numbers of the switches whose toggles are to the right.

OFFSET MT/MTG These switches select the per-unit M2/MG2 offset (into the protected line section) of the polarizing voltages for the MT/MTG units. Offset adjustment is identical to that for OFFSET M1/MG1 above.

VP ANG These switches select the phase shift in the polarizing voltages for the MG1 units. The phase shift can be adjusted to 0°, 10°, 15°, 20°, 25°, 30°, 35° or 45° leading, and is equal to 0 plus the sum of the numbers of the switches whose toggles are to the right.

On-Board Links

I0Z REST This link provides zero-sequence-current restraint for the M1, M2, and MT units only when the link is in the "IN" position.

MULT This link determines the amount of zero suppression in the zero-sequence-current-supervision signal for the MG1, MG2, and MTG units, and in the zero-sequence-current-restraint signal for the M1 and MT units. THIS LINK SHOULD NORMALLY BE IN THE SAME POSITION AS THE FRONT PANEL MULT SWITCH ON THE AFM101 OR AFM104 MODULE.

M1 VP This link phase shifts the polarizing voltages for the M1 units by the same angle as that for the MG1 units if it is in the "SHIFT" position. If this link is in the "NOT SHIFT" position, the M1 polarizing voltages will not be shifted.

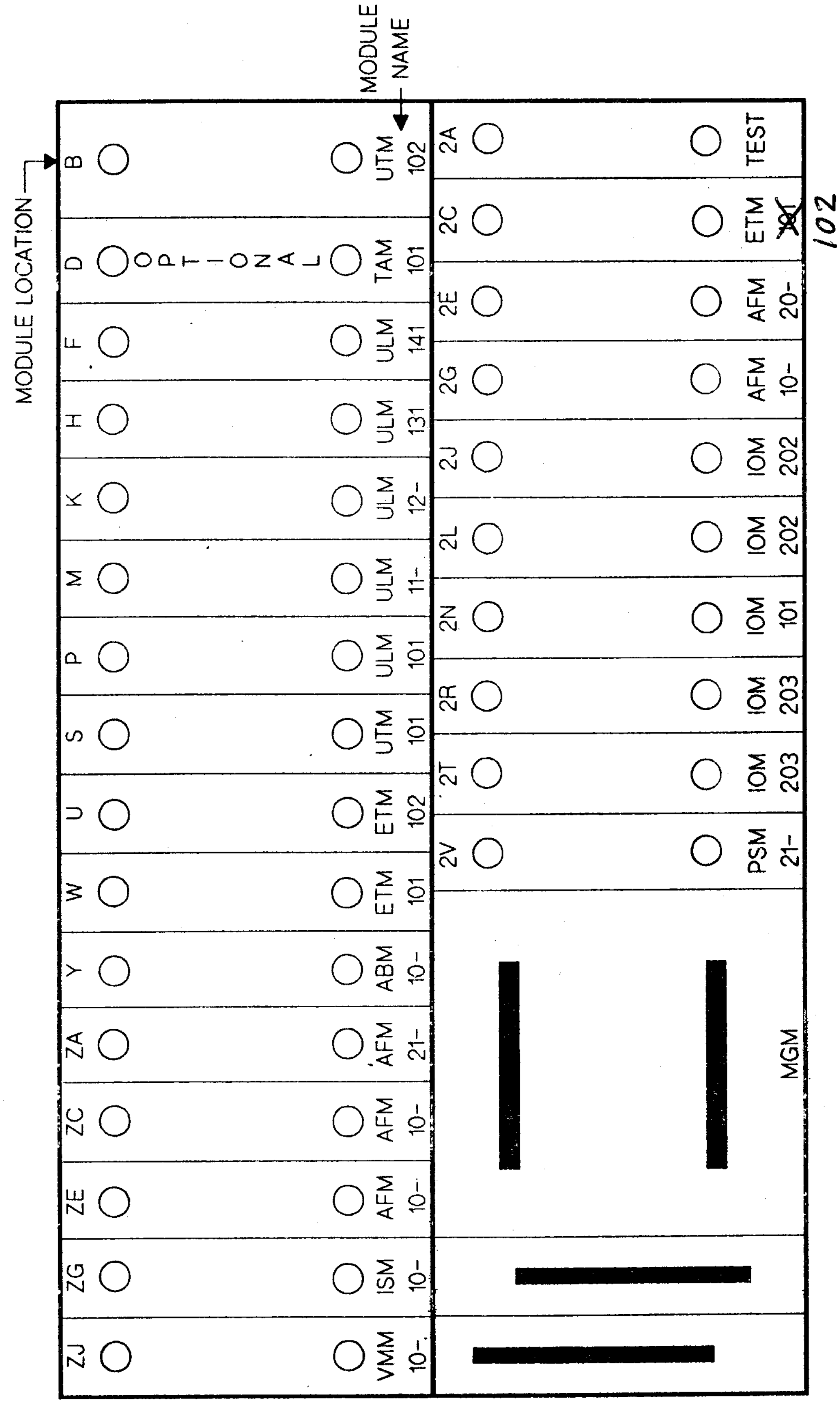


Figure MO-1 (0285A5352 [3]) Module Locations

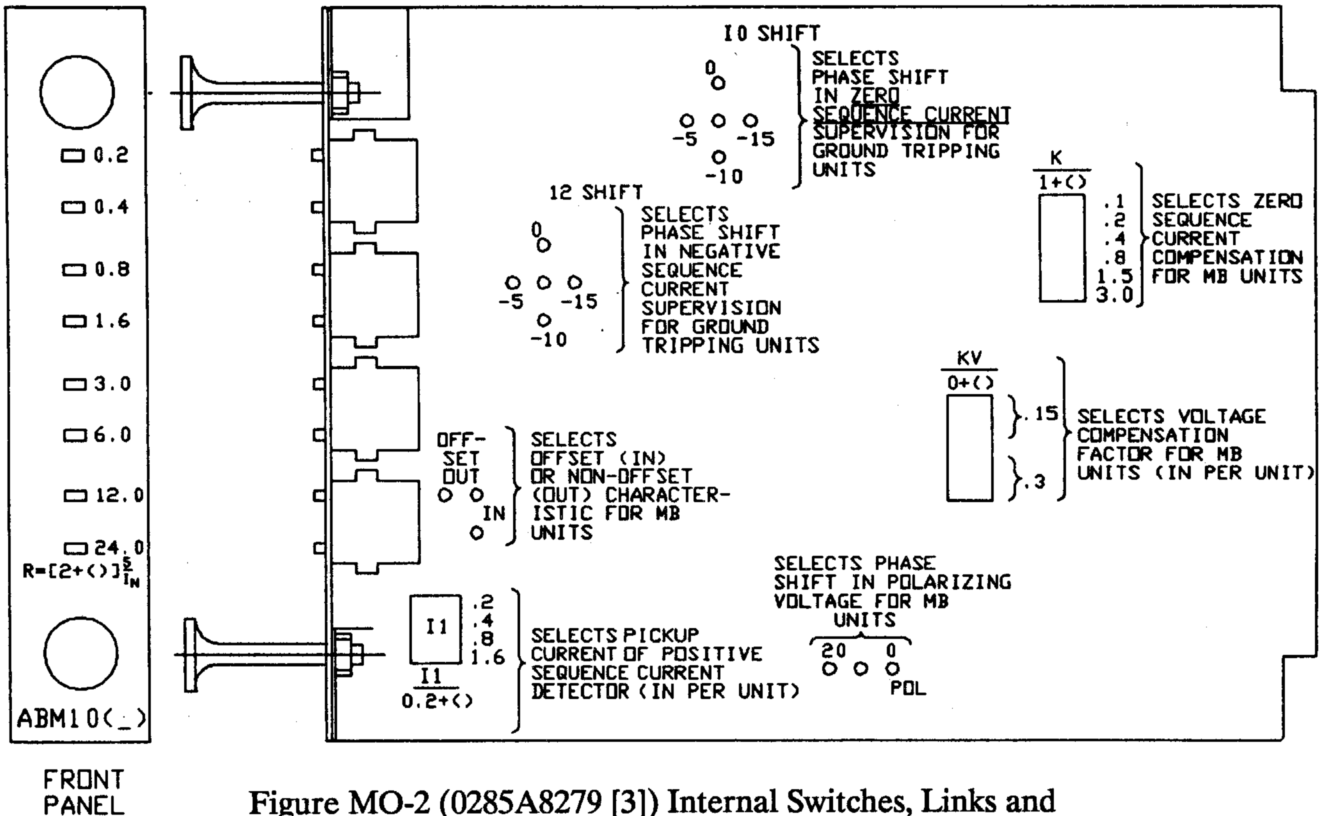


Figure MO-2 (0285A8279 [3]) Internal Switches, Links and Front Panel, ABM101 and ABM102 Modules

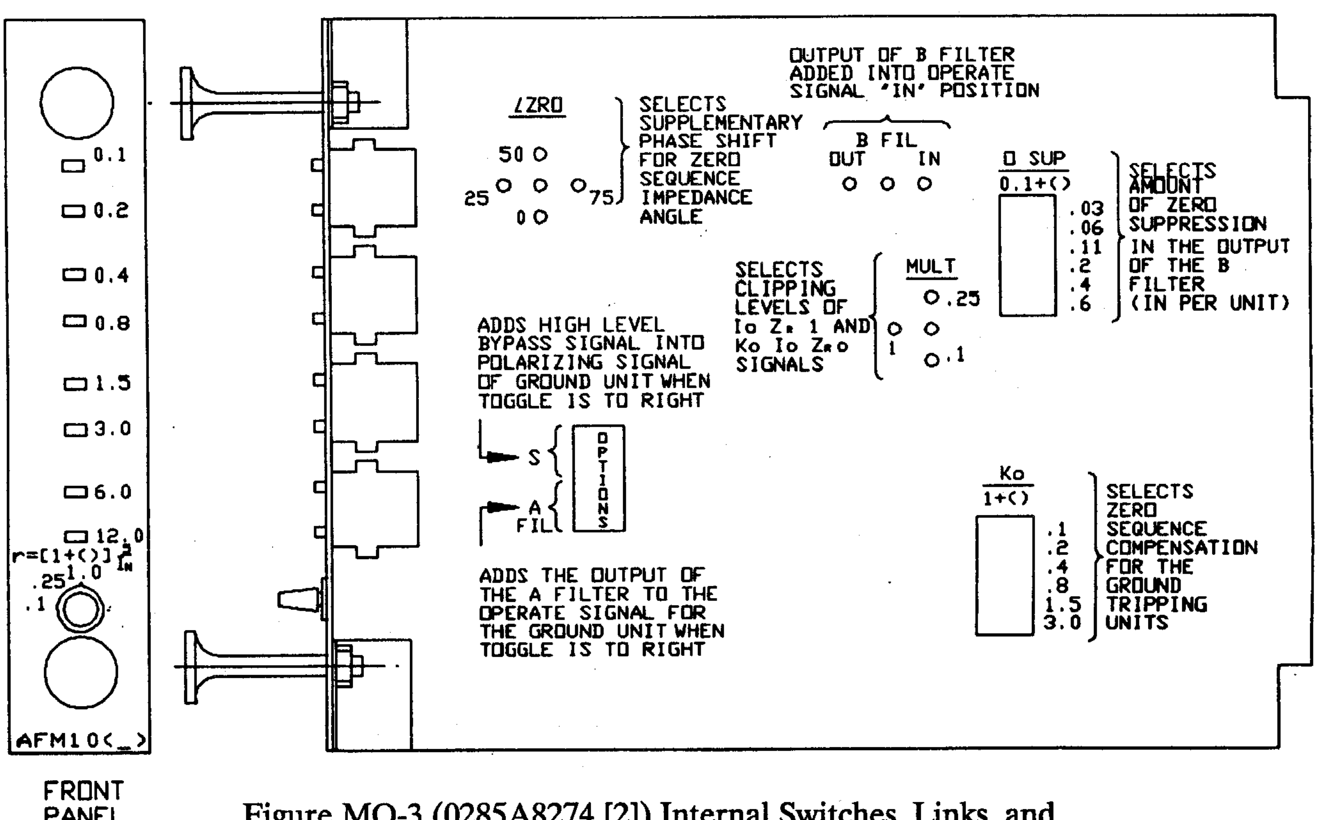


Figure MO-3 (0285A8274 [2]) Internal Switches, Links, and Front Panel, AFM10- Module

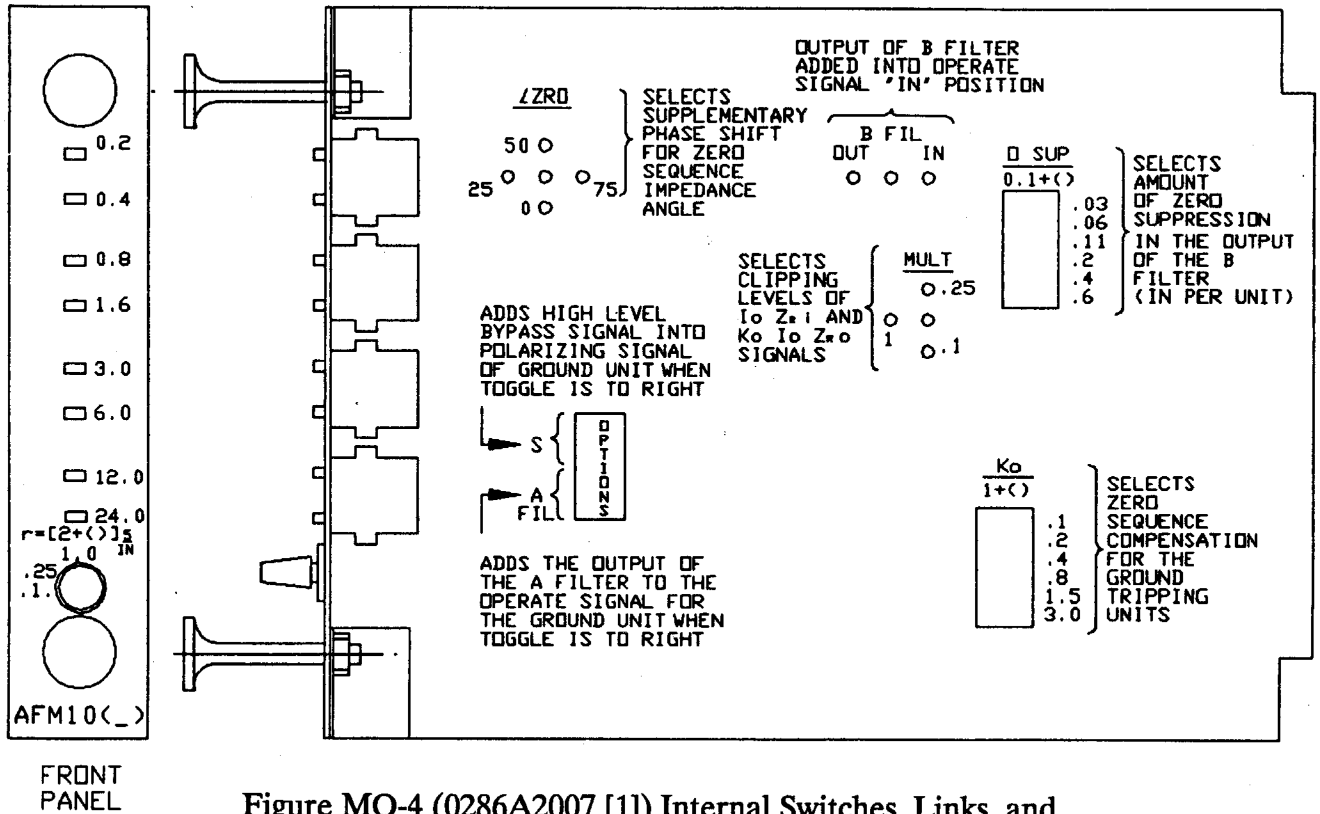


Figure MO-4 (0286A2007 [1]) Internal Switches, Links, and Front Panel AFM102 and AFM105 Modules

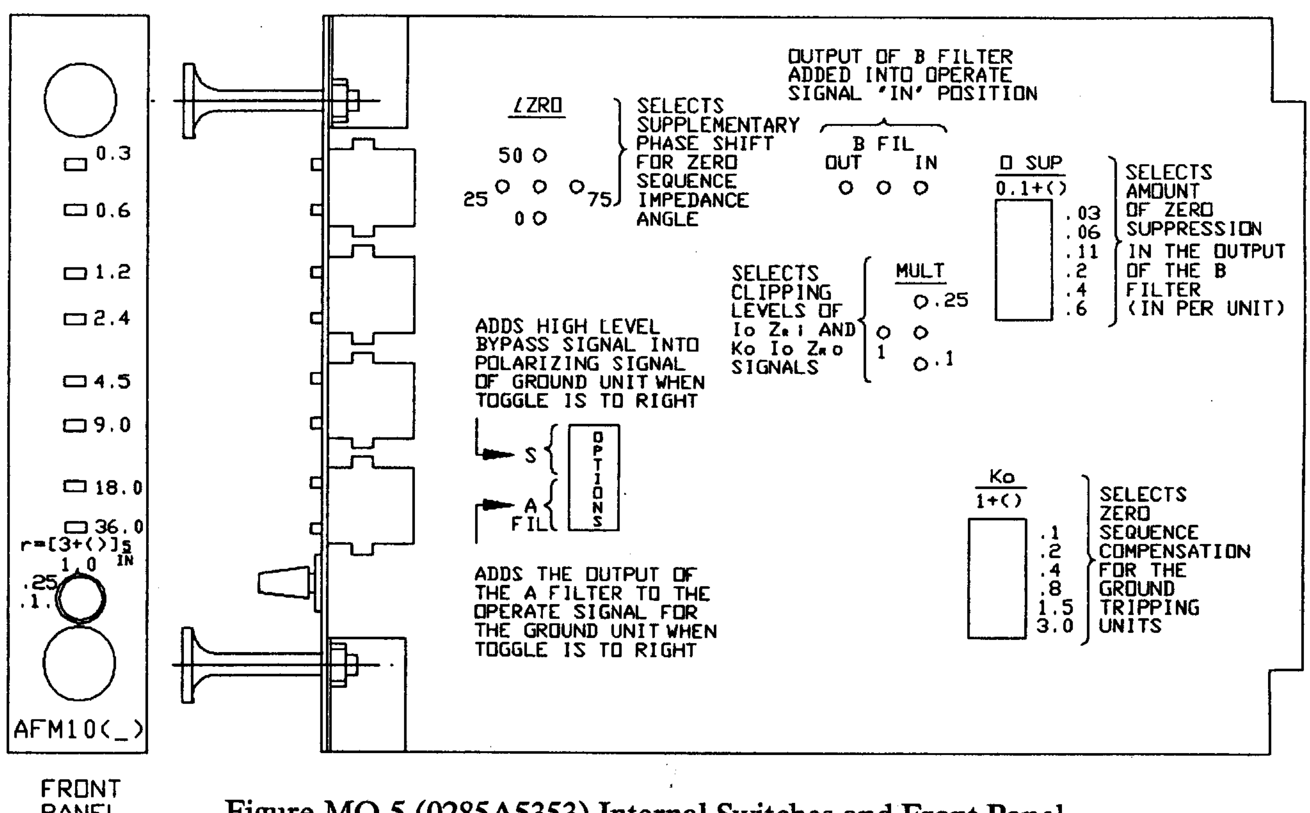


Figure MO-5 (0285A5353) Internal Switches and Front Panel, AFM103 and AFM106 Modules

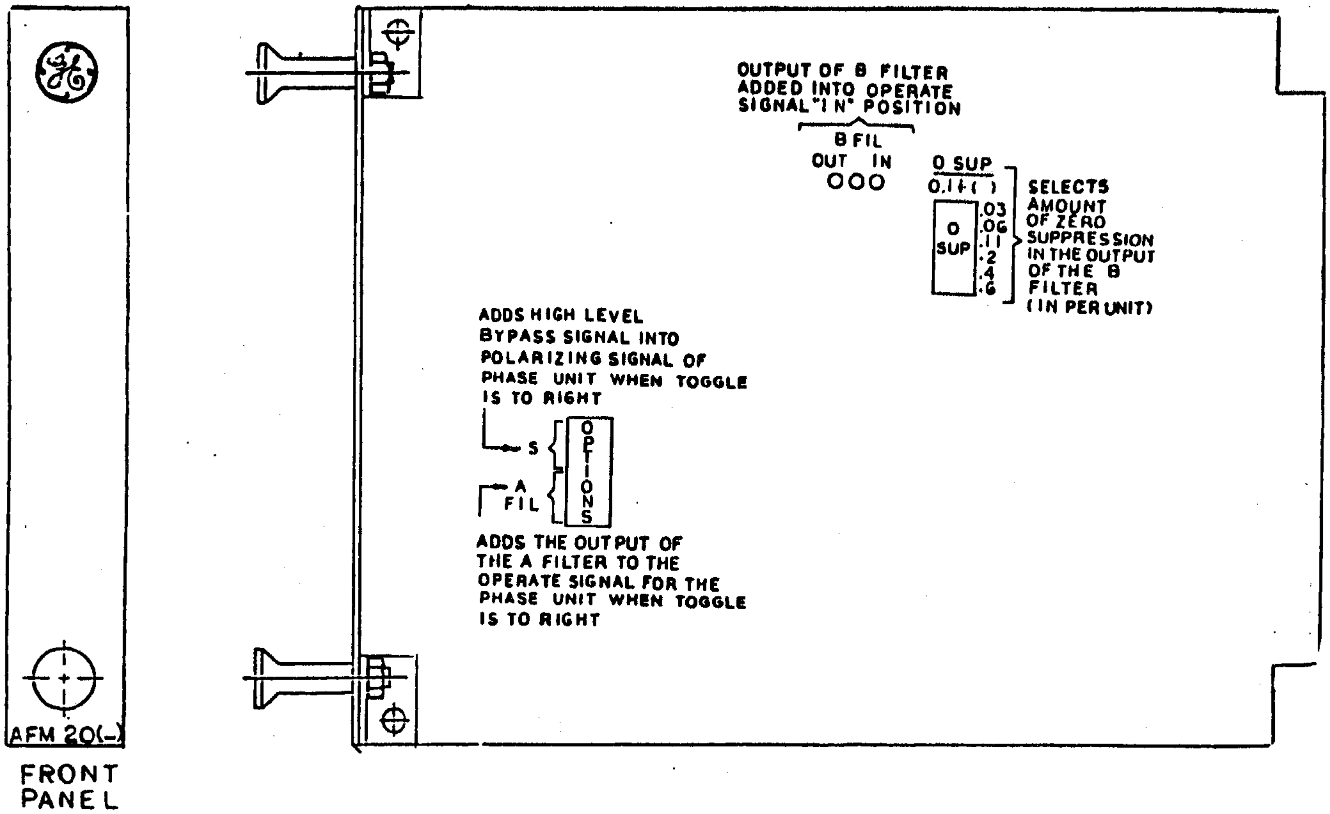


Figure MO-6 (0285A8270 [1]) Internal Switches and Front Panel, AFM201 and AFM202 Modules

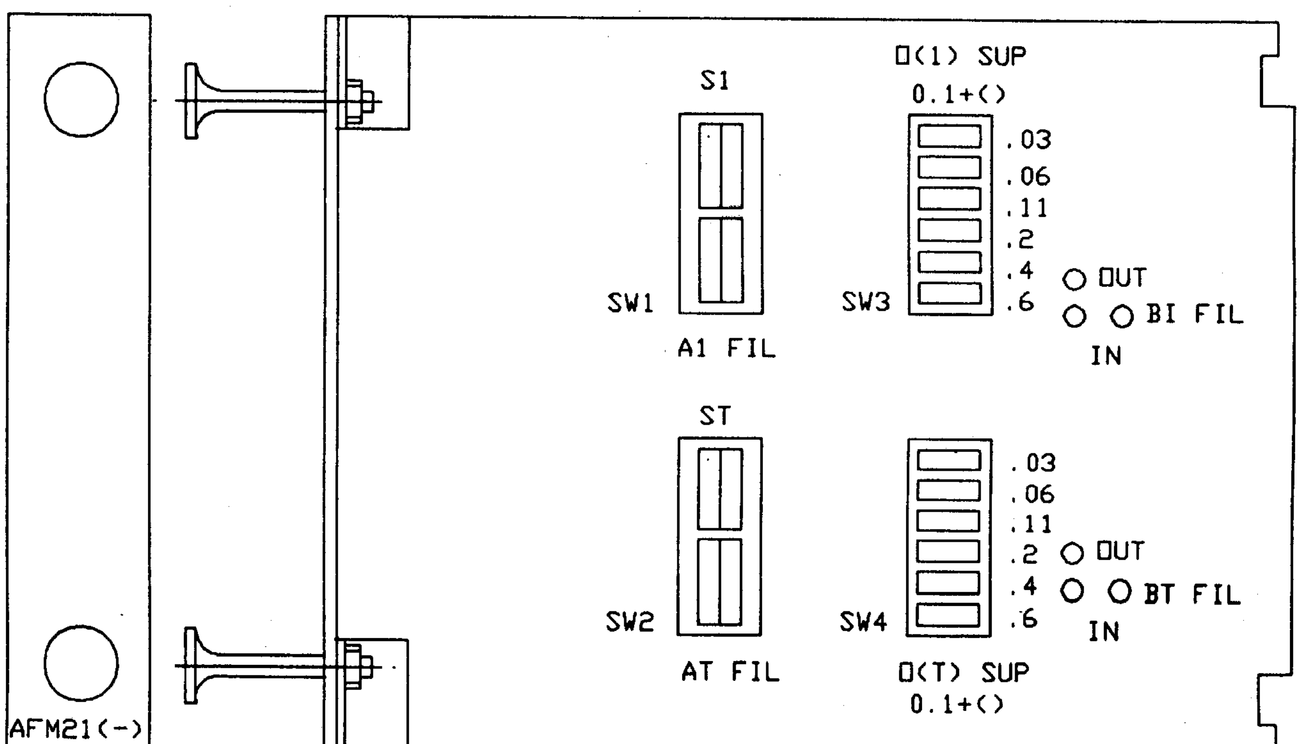


Figure MO-7 (0286A2752 [2]) Internal Switches and Front Panel, AFM211 and AFM212 Modules

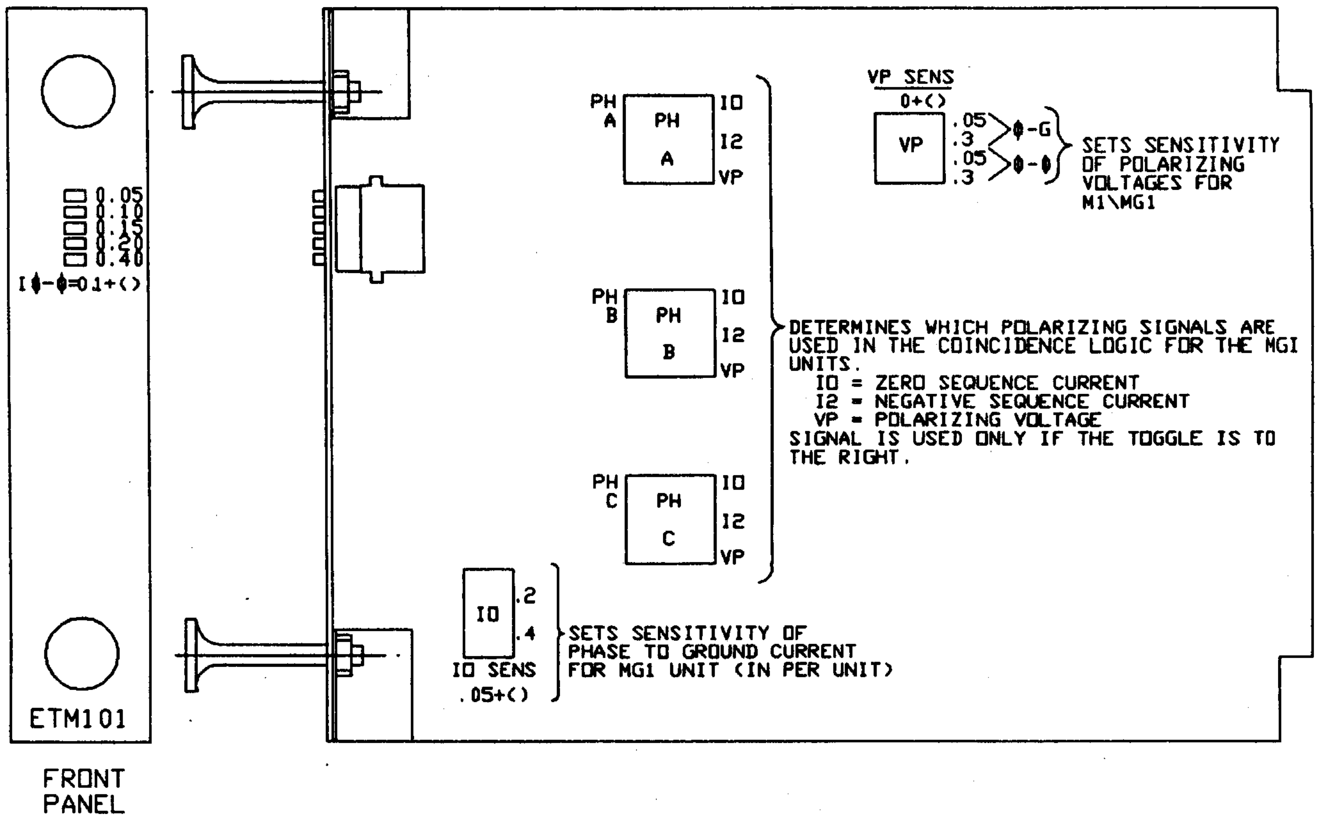


Figure MO-8 (0285A8280 [2]) Internal Switches and Front Panel, ETM101 Module

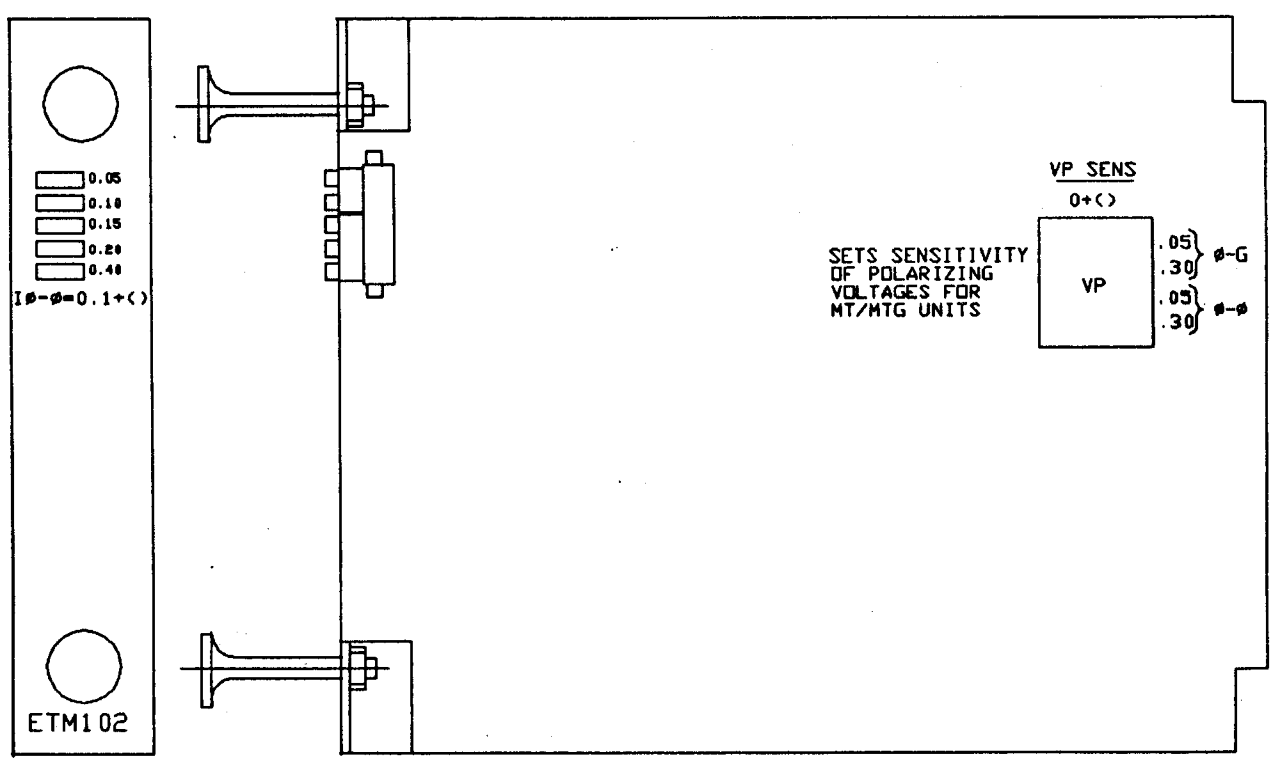


Figure MO-9 (0285A8275 [2]) Internal Switches and Front Panel, ETM102 Module

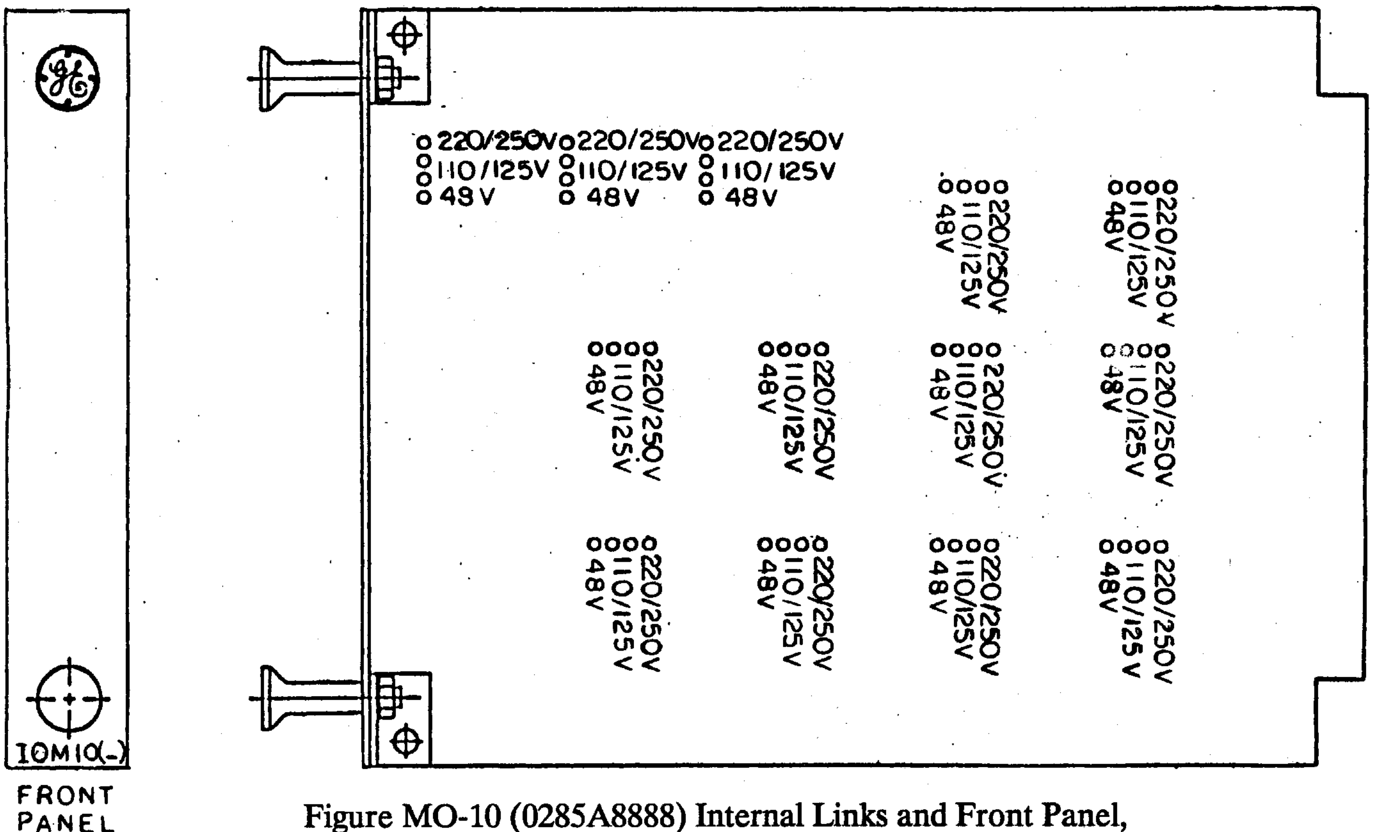


Figure MO-10 (0285A8888) Internal Links and Front Panel,
IOM101 and IOM102 Modules

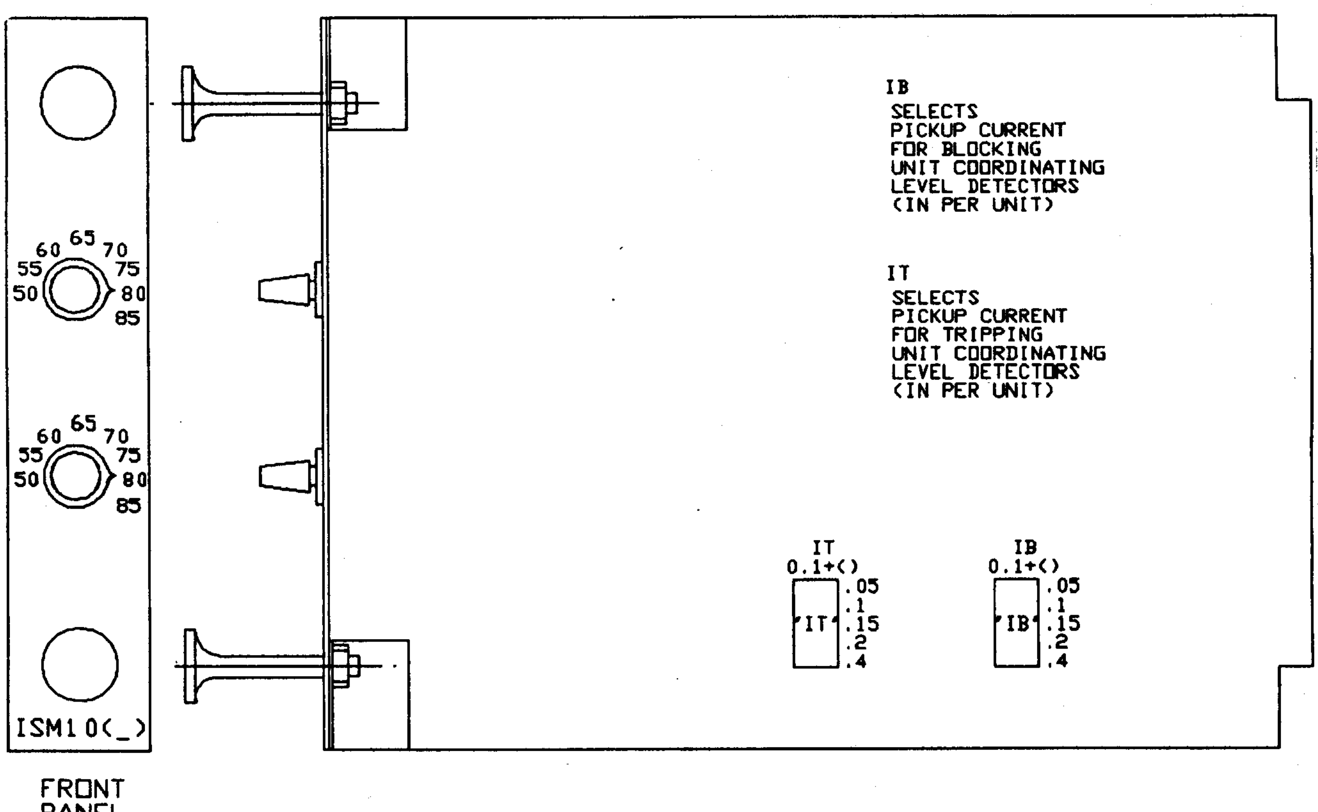


Figure MO-11 (0285A8273 [3]) Internal Switches and Front Panel,
ISM101 and ISM102 Modules

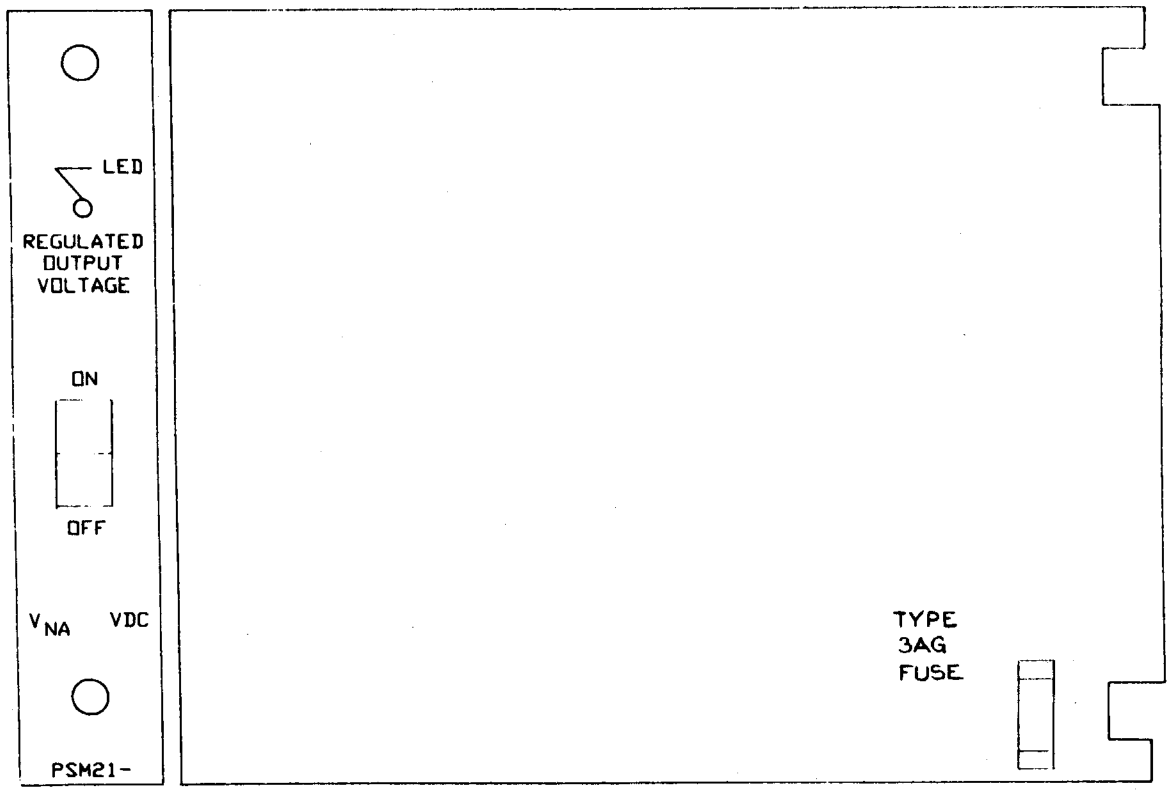


Figure MO-12 (0286A2547 [1]) Internal Fuse and Front Panel, PSM21- Module

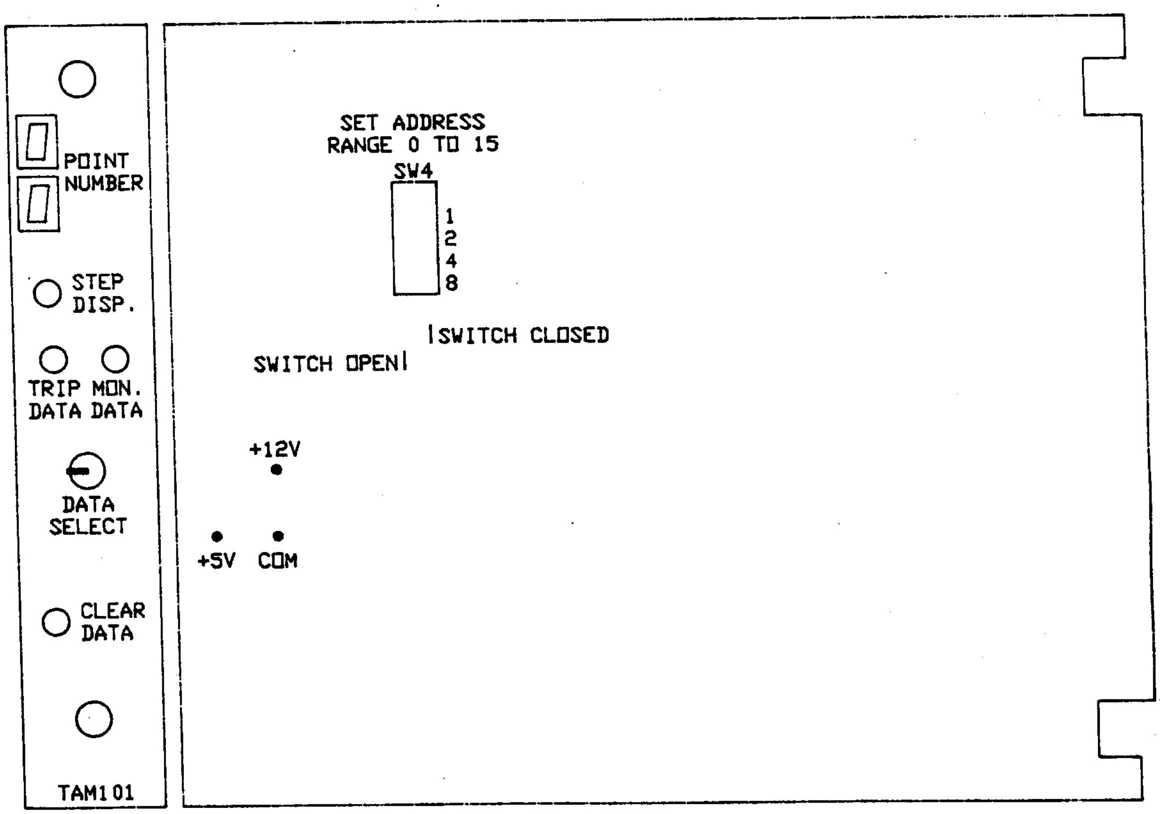


Figure MO-13 (0285A9831 [3]) Internal Switch and Front Panel, TAM101 Module

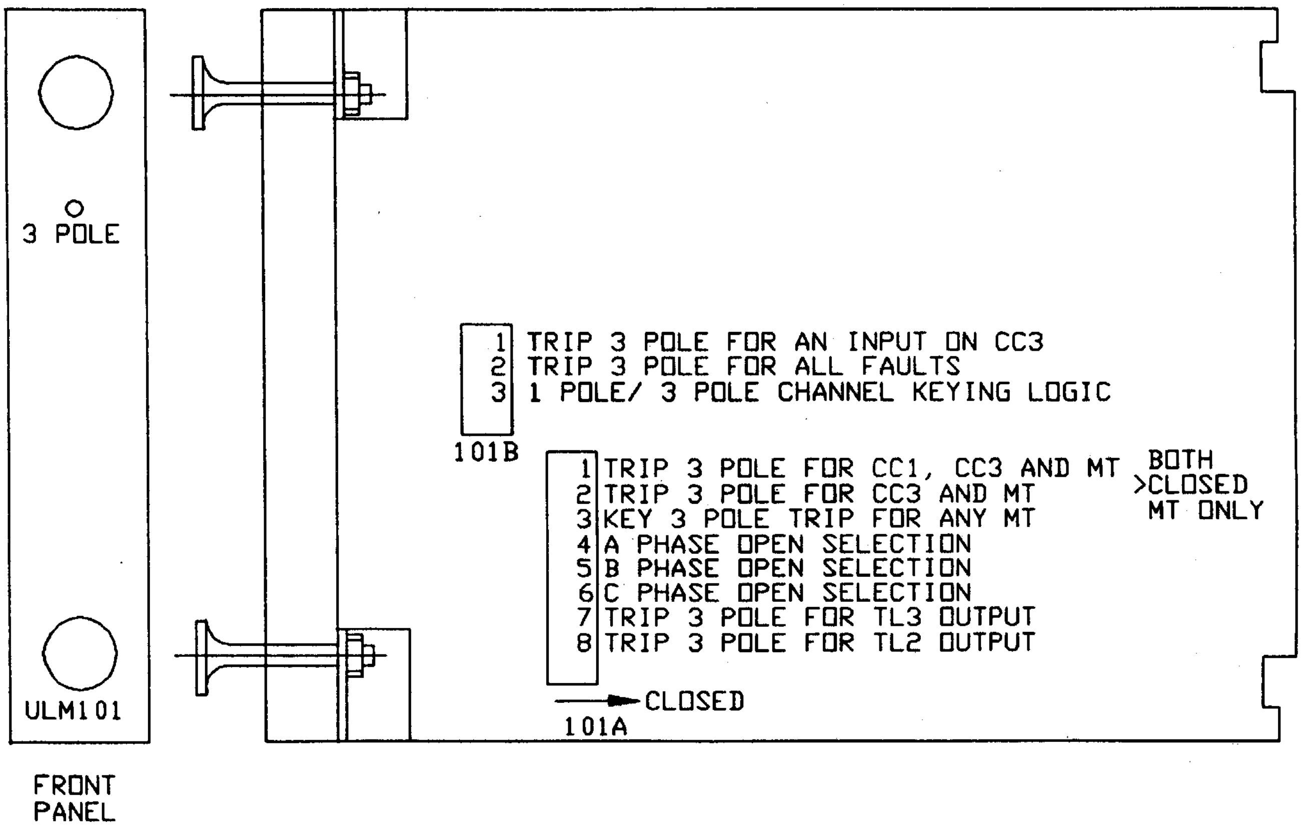


Figure MO-14 (0285A8271 [3]) Internal Switches and Front Panel, ULM101 Module

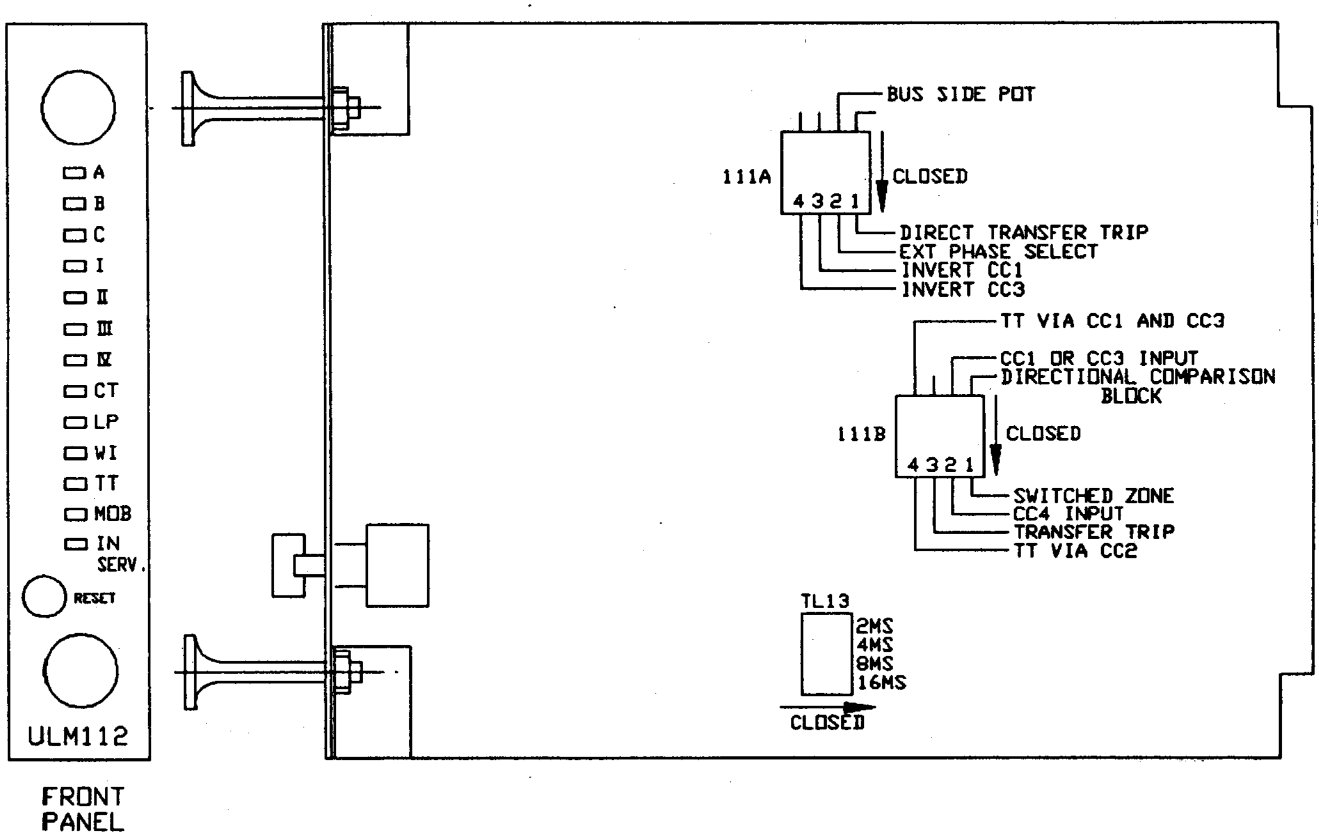


Figure MO-15 (0285A8272 [4]) Internal Switches and Front Panel, ULM112 Module

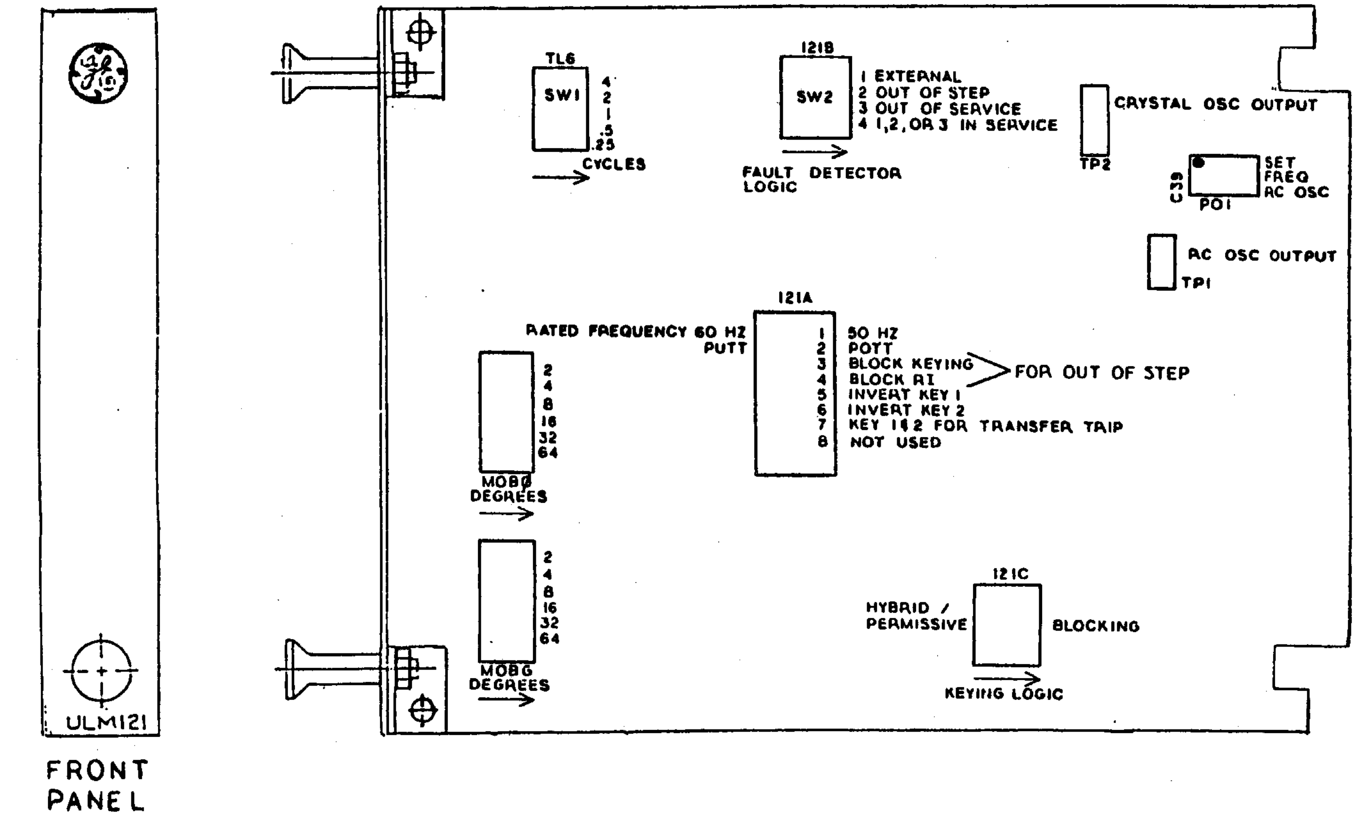


Figure MO-16A (0285A8281 [1]) Internal Switches and Front Panel, ULM121 Module

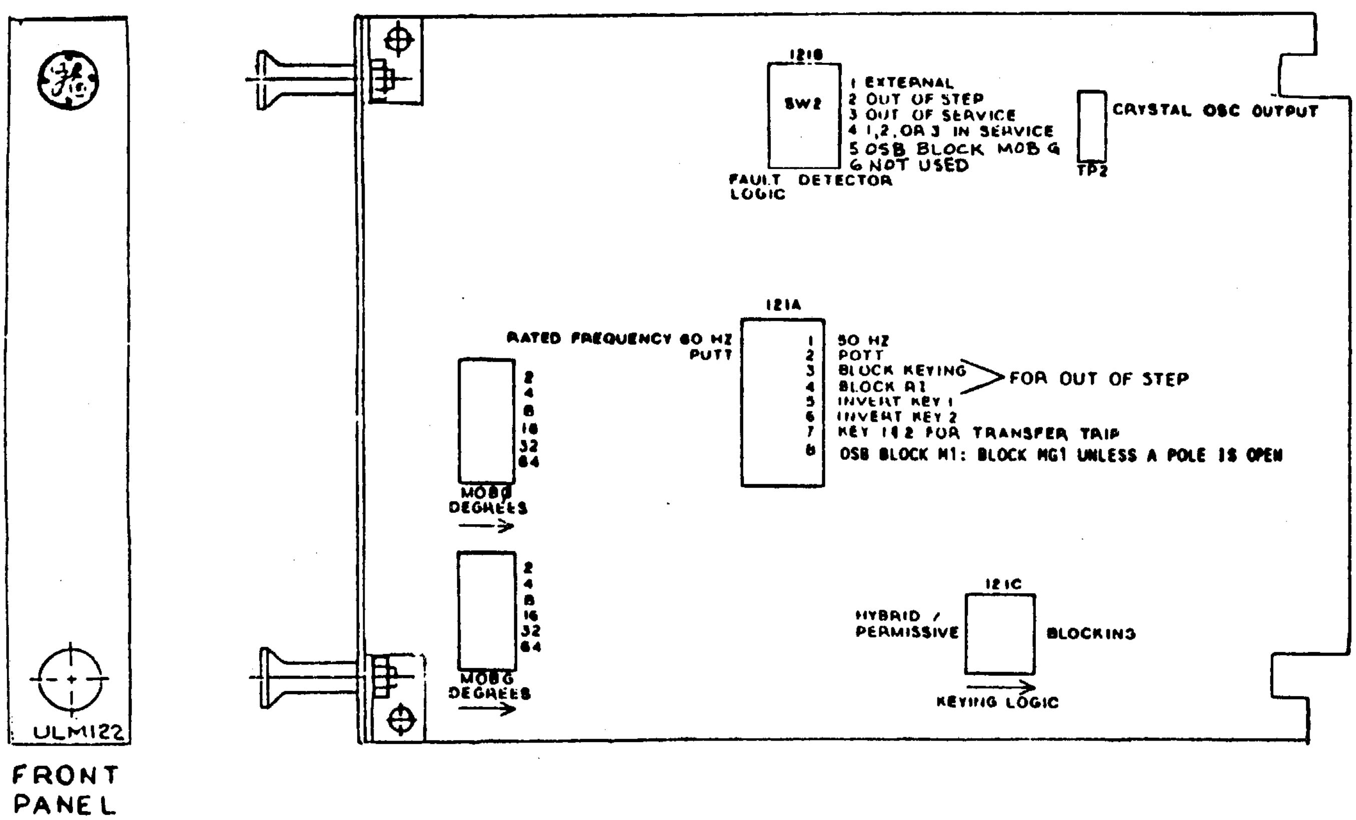


Figure MO-16B (0286A3595) Internal Switches and Front Panel, ULM122 Module

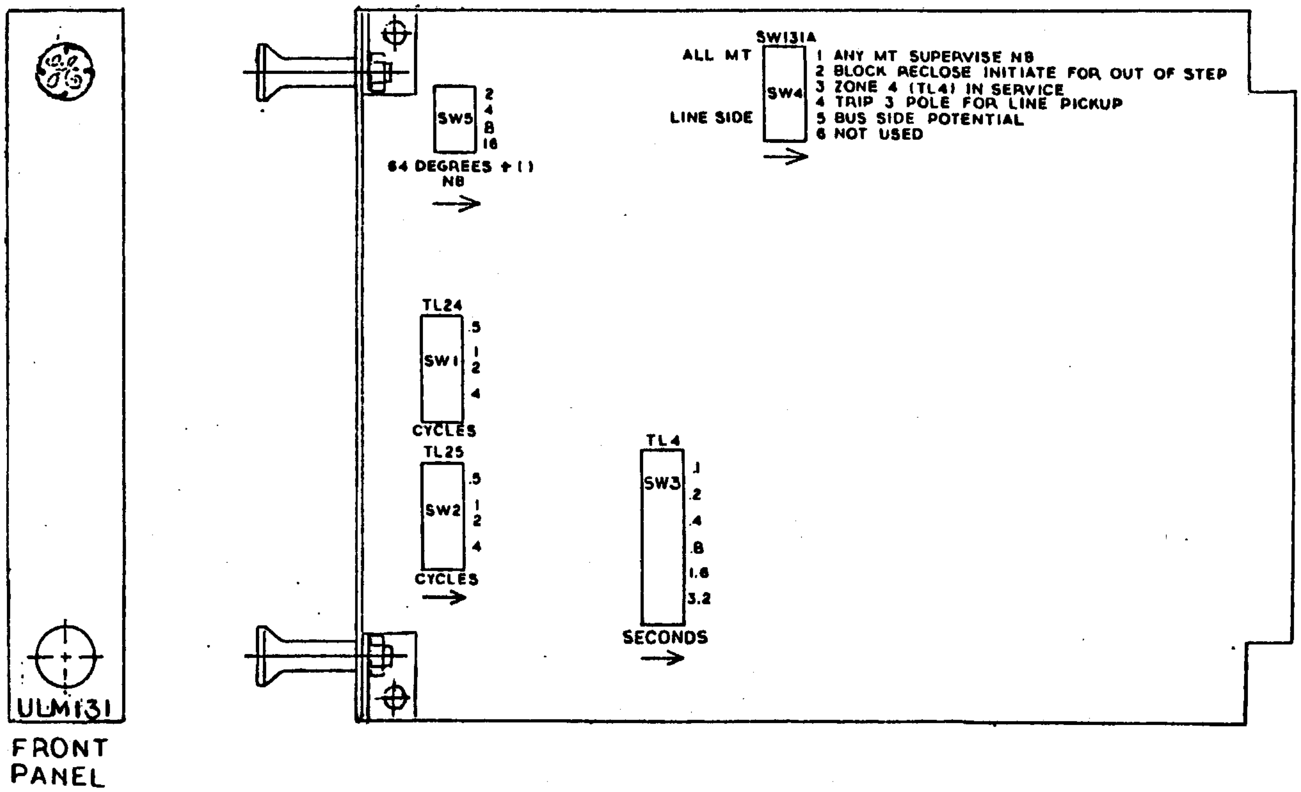


Figure MO-17 (0285A8276 [1]) Internal Switches and Front Panel, ULM131 Module

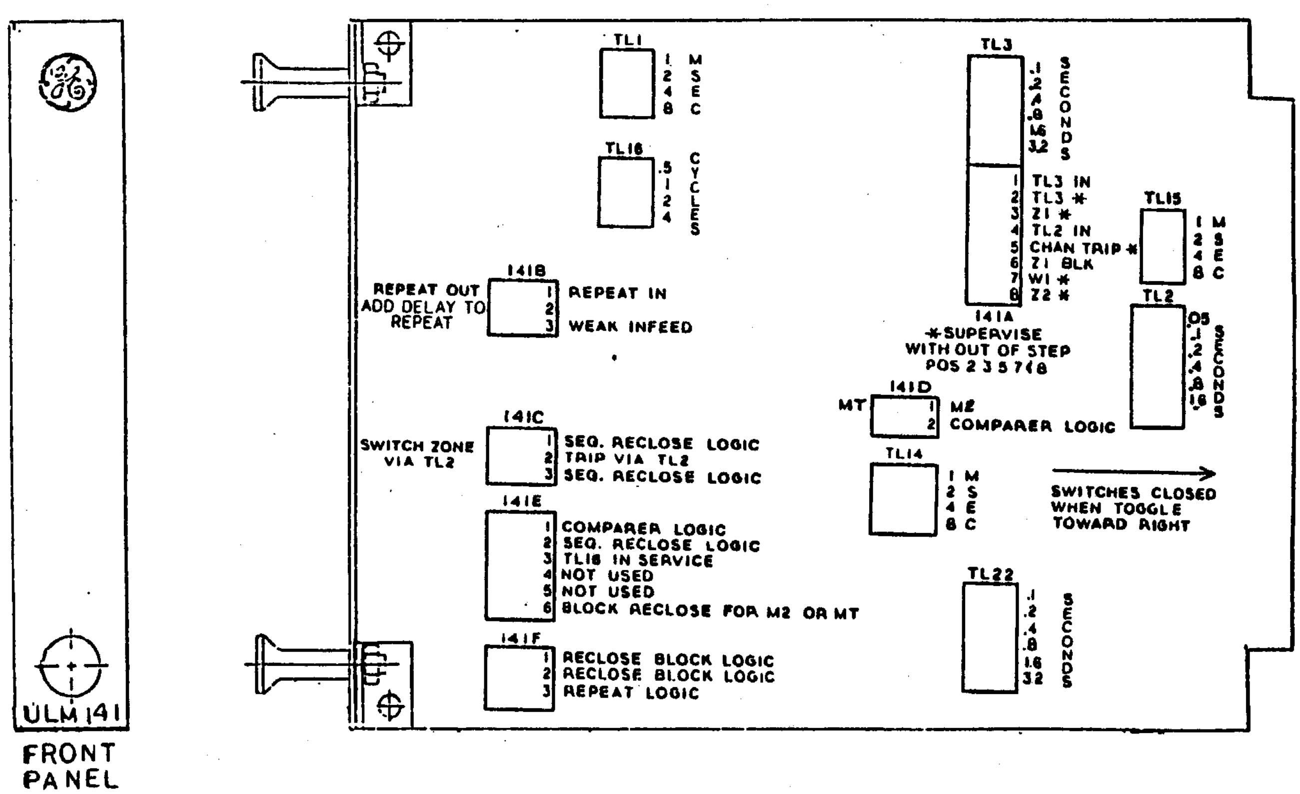


Figure MO-18 (0285A8277 [3]) Internal Switches and Front Panel, ULM141 Module

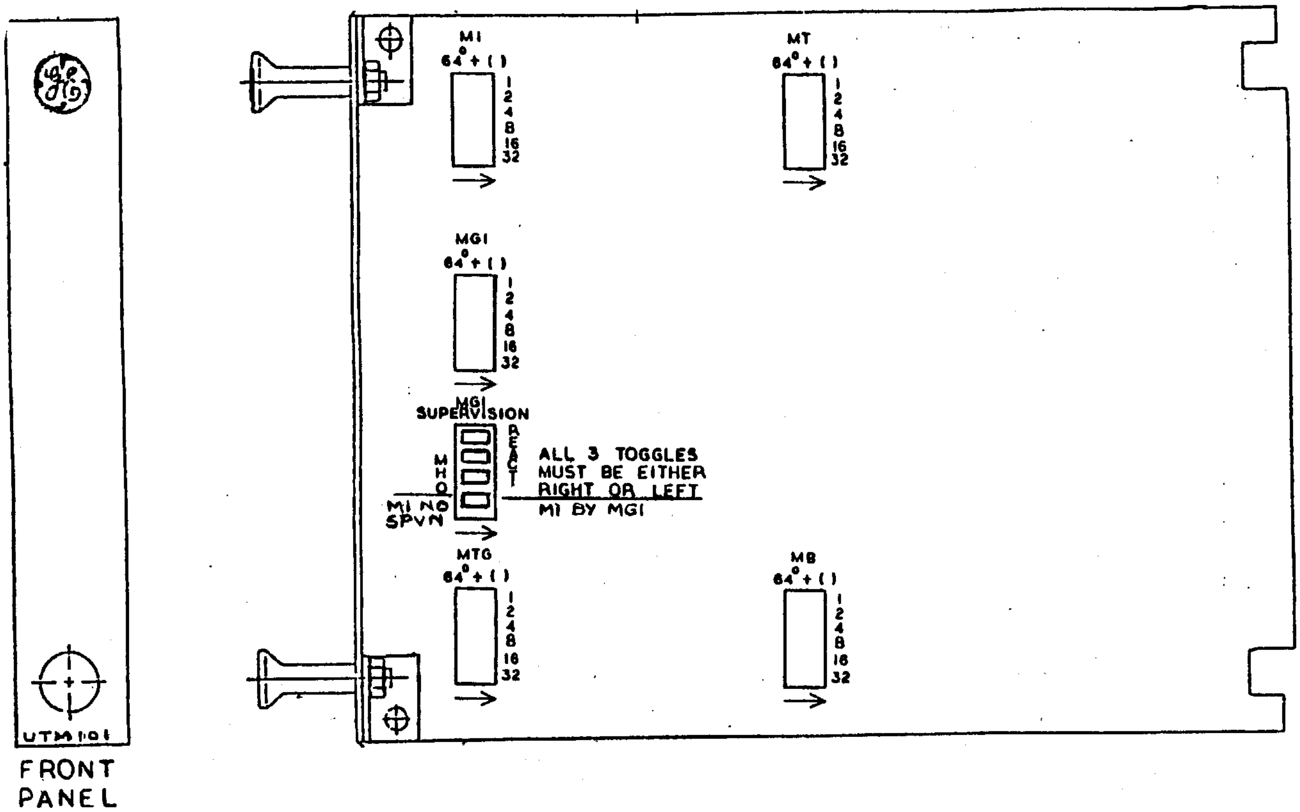


Figure MO-19 (0285A8278 [2]) Internal Switches and Front Panel, UTM101 Module

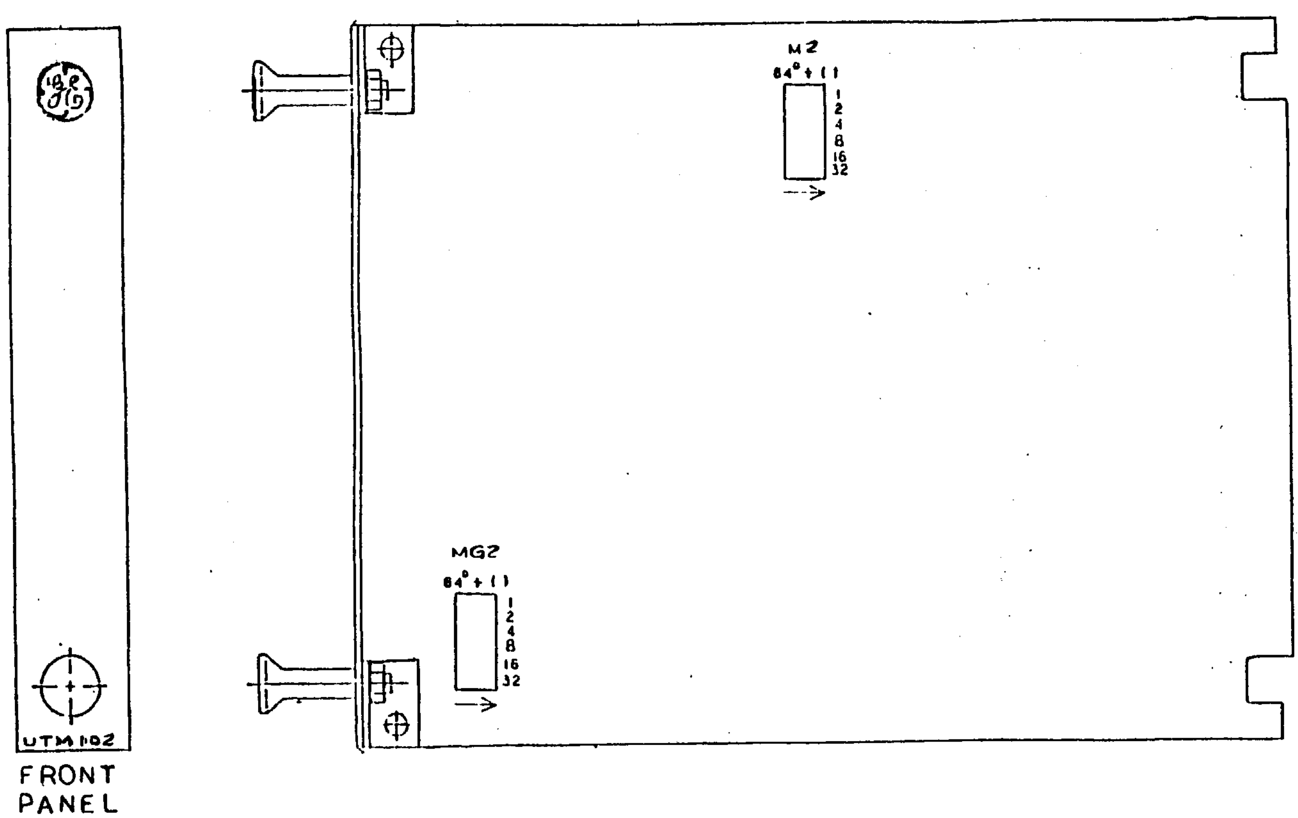


Figure MO-20 (0285A9114) Internal Switches and Front Panel, VTM102 Module

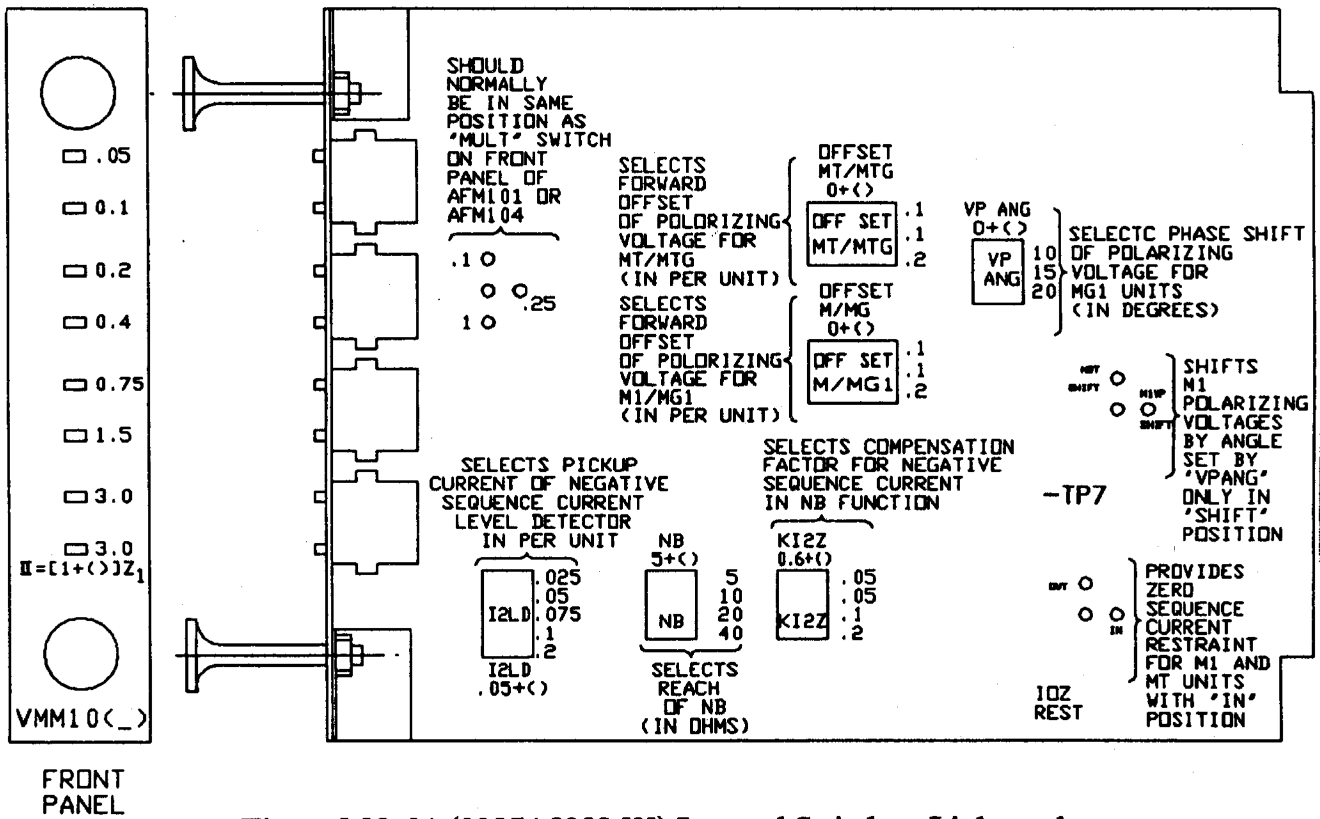


Figure MO-21 (0285A8282 [3]) Internal Switches, Links and Front Panel, VMM101 and VMM102 Modules

ACCEPTANCE TESTS

The operational tests described in this section should be conducted prior to the installation of the TLS1B system. These may be done on a "bench-top" basis. One method of removing power is to turn off the power switch on the PSM power-supply module and then remove both of the connection plugs located in the TPM position on the left side of the case. Inserting an extender into IOM or PSM positions still requires great care, as station battery potential will still be present at some points.

Test Data Sheets

Some helpful test data sheets are included in the back of this section. They will help in keeping track of the tests and the expected data.

Initial Test Settings

To begin the acceptance tests, the module settings should be as indicated in Tables AT-1 and AT-2. Remove power, then remove the modules to gain access to the links and switches referred to in Table AT-1. When an open switch is specified it will mean the switch is physically set left, closed is to the right. There are certain modules not listed in Tables AT-1 and AT-2. This simply means that there are no settings required for these modules. Module Locations are shown in Figure MO-1.

Test Equipment

The acceptance tests may be conducted in a conventional manner, using the following test equipment:

- Three-phase voltage, single-phase current, active test source
- DC-control-voltage source
- Three AC voltmeters
- One AC ammeter
- One oscilloscope
- One card extender (GE #0138B7406G1)
- One pair XTM test plugs (GE #XTM28R1 and XTM28L1)

The specific requirements for this equipment are given above and in the associated test-circuit diagrams (Figures AT1 and AT-2).

The three-phase AC sinusoidal voltage must be balanced and undistorted. Similarly, the DC power should come from a good DC source having less than 5% ripple.

Test Connections

The test-circuit diagrams indicate TLS1B terminal numbers (rear-cover terminals) and the corresponding XTM-test-plug terminal numbers. For the acceptance tests, the test connections should be made to the rear-cover terminals. The test plugs are intended for post-installation testing, and are described in a separate subsection under PERIODIC TESTS.

TABLE AT-1 INTERNAL MODULE SETTINGS

MODULE NAME	FIGURE NUMBER	MODULE LOCATION	TYPE	SWITCH OR LINK NAME	SETTING
ABM10(-)	M0-2	Y	SWITCH	I1	0.2
"	"	"	"	K	1
"	"	"	"	KV	0.3
"	"	"	LINK	IO SHIFT	0°
"	"	"	"	I2 SHIFT	0°
"	"	"	"	OFFSET	IN
"	"	"	"	POL	0°
AFM10(-)	MO-3,4,5	ZE,ZC,2G	SWITCH	KO	4.0
"	"	"	"	S	OPEN
"	"	"	"	AFIL	CLOSED
"	"	"	"	0 SUP	0.1
"	"	"	LINK	BFIL	IN
"	"	"	"	MULT	1
"	"	"	"	∠ZR0	0°
AFM20(-)	MO-6	2E	SWITCH	0 SUP	0.1
"	"	"	"	S	OPEN
"	"	"	"	AFIL	CLOSED
"	"	"	LINK	BFIL	IN
AFM21(-)	MO-7	ZA	SWITCH	S1	OPEN
"	"	"	"	ST	OPEN
"	"	"	"	A1 FIL	CLOSED
"	"	"	"	AT FIL	CLOSED
"	"	"	"	0(1) SUP	0.1
"	"	"	"	0(T) SUP	0.1
"	"	"	LINK	B1 FIL	IN
"	"	"	"	BT FIL	IN
ETM101	MO-8	W,2C	3 SWITCHES	I0	CLOSED
"	"	"	LABLED PHA	I2	CLOSED
"	"	"	PHB, PHC	VP	CLOSED
"	"	"	SWITCH	I0 SENS	0.05
"	"	"	"	VP SENS φ-φ	0
"	"	"	"	VP SENS φ-G	0
ETM102	MO-9	U	SWITCH	VP SENS φ-φ	0
"	"	"	"	VP SENS φ-G	0
IOM101	MO-10	2N	LINK	48-125-250	DC BATTERY
ISM10(-)	MO-11	ZG	SWITCH	IB	0.2
"	"	"	"	IT	0.2

TABLE AT-1 Internal Module Settings (Continued)

MODULE NAME	FIGURE NUMBER	MODULE LOCATION	TYPE	SWITCH OR LINK NAME	SETTING
TAM101 *	MO-13	D	LINK	+5/+12	+12
ULM12(-)	MO-16	K	SWITCH	121A-1	OPEN = 60HZ
"	"	"	"	"	CLOSED=50HZ
"	"	"	"	MOBϕ	126°
"	"	"	"	MOBG	126°
ULM131	MO-17	H	SWITCH	NB	90°
UTM101	MO-19	S	SWITCH	M1	90°
"	"	"	"	MT	90°
"	"	"	"	MB	90°
"	"	"	"	MG1	90°
"	"	"	"	MTG	90°
"	"	"	"	SPVN	M1 NO SPVN
"	"	"	"	3 SWITCHES	
"	"	"	"	MHO/REACT	MHO
UTM102	MO-20	B	SWITCH	MT	90°
"	"	"	"	MTG	90°
VMM10(-)	MO-21	ZJ	SWITCH	I2LD	0.05
"	"	"	"	KI2Z	1.0
"	"	"	"	NB	5
"	"	"	"	OFFSET M1/MG1	0.3
"	"	"	"	OFFSET MT/MTG	0.3
"	"	"	"	VP ANG	0°
"	"	"	LINK	I0Z REST	OUT
"	"	"	"	MULT	1
"	"	"	"	M1VP	NO SHFT

* Designates optional module

TABLE AT-2 FRONT PANEL SETTINGS

MODULE NAME	FIGURE NUMBER	MODULE LOCATION	NAME	SETTING
ABM10(-)	M0-2	Y	r	6.0 OHMS
AFM10(-)	MO-3, 4, 5	ZE, ZC, 2G	r	6.0 OHMS
"	"	"	MULT	1.0
ETM101/102	MO-8, 9	W, U	$I\phi$-ϕ	0.1
ISM10(-)	MO-11	ZG	ϕZ1	85°
"	"	"	ϕZ0	85°
VMM10(-)	MO-21	ZJ	II	1.0

* DESIGNATES OPTIONAL MODULES

OFFSET MHO CHARACTERISTIC TESTS

1. Insert the card extender into the system test slot "2A" (bottom right corner). Leave the extender in this position for all acceptance testing. All the signals connected at slot "2A" are listed in Table SE-2 in the "SERVICING" section of this manual.

2. **Connect the relay per Figure AT-1 for phase-to-ground (MG1, MG2, MTG, MB, NB) tests, and Figure AT-2 for phase-to-phase (M1, M2, MT) tests.** Connect the oscilloscope to the card extender pin # shown in Table AT-3 for the phase to be tested.

   NOTE: Where two values are shown: xx(yy) xx is for 5 ampere units and yy is for 1 ampere units.

3. Set VA, VB, and VC to 70 VRMS. Set current IOP at rated current (1 ampere rms or 5 amperes rms) and the phase angle to 85° lag. Reduce the voltage(s) of the phase(s) under test from approximately 70 volts rms until the measuring unit under test picks up, as indicated by the oscilloscope trace going from approximately 0 to approximately 10 volts. Pickup should occur for a voltage between 55 and 61 volts rms for the MG1/MG2/MTG units and between 31 and 35 volts rms for the M1/M2/MT units. This test checks the reach at the replica impedance angle, including the pull-back effect at this current level (approximately 3%).

4. Return VA, VB, and VC to 60 volts rms, and set the phase angle to 55° lag. Reduce the voltage(s) of the phase(s) under test until the measuring unit under test picks up, which should occur for a voltage between 43 and 54 volts rms for the MG1/MG2/MTG units and between 24 and 31 volts rms for the M1/M2/MT units. Change the phase angle to 115 lag and vary the voltage(s) of the phase(s) under test until the measuring unit under test again picks up, which should also be for a voltage between 43 and 54 volts rms for the MG1/MG2/MTG units and between 24 and 31 volts rms for the M1/M2/MT units. This test checks the shape of the mho circle.

TABLE AT-3 TEST CONNECTIONS

FUNCTION UNDER TEST	UNIT	PHASE UNDER TEST	CARD EXTENDER PIN NO.
Zone 1 Units	MG1	A-G	5
	"	B-G	6
	"	C-G	7
	M1	A-B	2
	"	B-C	3
	"	C-A	4
Over-reaching Units	MTG	A-G	11
	"	B-G	12
	"	C-G	13
	MT	A-B	8
	"	B-C	9
	"	C-A	10
	MG2	A-G	17
	"	B-G	18
	"	C-G	19
	M2	A-B	31
	"	B-C	32
	"	C-A	33
Blocking Unit	MB	A-G	14
	"	B-G	15
	"	C-G	16

NOTE: When doing these tests, the test voltage is to be measured phase-to-ground for both phase-to-ground and phase-to-phase tests. For phase-to-phase tests the current angles will be shifted -30°. This is because the current is referenced phase-to-phase and the voltage is referenced phase-to-ground. This will be the case whenever an active test source is used. The test extender reference is pin #1.

5. Repeat tests 3 and 4 for each phase of the M1, MG1, M2/MG2 and MT/MTG functions.

BLOCKING

1. Set VA, VB, and VC to 60 volts rms. Set current IOP at rated current (1 ampere rms or 5 amperes rms) and the phase angle at 265° lag. Reduce the voltage of the phase under test from approximately 70 volts rms until the MB phase under test picks up, as indicated by the oscilloscope trace going from approximately 0 to approximately 10 volts. Pickup should occur for a voltage between 52 and 58 volts rms. This test checks reach at the replica impedance angle, including the pull-back effect at this current level (approximately 3%).
2. After the MB phase under test picks up, continue reducing the voltage of the phase under test to 0 volts. The MB unit should remain picked up.

3. Return VA, VB and VC to 60 volts rms, and set the phase-angle to 235° lag. Reduce the voltage of the phase under test until the MB phase under test picks up, which should occur for a voltage between 46 and 54 volts rms. Change the phase-angle to 295° lag and vary the voltage of the phase under test until the MB unit again picks up, which should also be for a voltage between 46 and 54 volts rms. This test checks the shape of the mho circle.

4. Repeat tests 1 through 3 for each phase of the MB functions.

NB UNIT TESTS

1. Directional Check:

   a) Set VA to 30 volts rms, VB and VC to 67 volts rms, and IOP to rated current (IN). Set the phase angle to 265° lag. Check for +10 to +12 (high) volts DC at test card pin 29.

   b) Change the phase angle to 85° lag. Check for less than 1 volt DC (low) at test card pin 29.

LEVEL-DETECTOR TESTS (Current tests only)

1. Use figure AT-1 for the remainder of the tests.

2. Connect the oscilloscope probe to the test extender pin 34. Set current IOP to 0.45 (0.09) amperes rms. Apply the current IOP; the oscilloscope trace should go to approximately 10 volts, and remain there momentarily, after which it should return to approximately 0 volts. Remove current IOP.

3. Increase IOP to 2.25 (0.45) amperes rms and repeat test 2; the oscilloscope trace should remain at approximately 10 volts when IOP is applied. Tests 2 and 3 check the adaptive pick-up of the Fault Detector, FD.

4. Switch off phase A, B, and C voltage. Connect the scope to the test extender pin 30. Increase current IOP until the oscilloscope trace goes from approximately 0 to approximately 10 volts, at which point the current should be between 2.7 (0.54) and 3.3 (0.66) amperes rms. This test checks the I1 unit.

5. Change the oscilloscope connection to pin 26. Increase current IOP until the oscilloscope trace goes from approximately 0 to approximately 10 volts. The current should be between 0.9 (0.18) and 1.1 (0.22) amperes rms. Repeat this test for all three phases. Use test extender pin 27 for phase B and pin 28 for phase C. This test checks the IB unit.

6. Change the oscilloscope connection to pin 23. Increase current IOP until the oscilloscope trace goes from approximately 0 to approximately 10 volts. The current should be between 0.9 (0.18) and 1.1 (0.22) amperes rms. Repeat this test for all three phases. Use test extender pin 24 for phase B and pin 25 for phase C. This test checks the IT unit.

7. Connect the oscilloscope probe to the test extender pin 20. Current will not be needed for this test. Set VA, VB and VC to 60 volts rms. Reduce the voltage of VA until the oscilloscope trace pulses from approximately 0 to approximately 10 volts, at which point the voltage should be between 41 and 45 volts rms. The trace should seal-in at no less than 30 volts rms. Repeat this test for all three phases. Lower VB and use test extender pin 21 for phase B. Lower VC and use test extender pin 22 for phase C. These test check the under-voltage detectors.

TABLE AT-4 TLS1B TEST DATA

TESTER:________________ TLS1B #____________

DATE:__________________ SYSTEM #___________

OFFSET MHO CHARACTERISTICS

MHO UNIT	TEST PIN#	PHASE	CENTER φ-G ∠85° 55-61 φ-φ ∠55° 31-35	- 30° φ-G ∠55° 43-54 φ-φ ∠25° 24-31	+ 30° φ-G ∠115° 43-54 φ-φ ∠85° 24-31
MG1 φ-G	5	A-G			
	6	B-G			
	7	C-G			
M1 φ-φ	2	A-B			
	3	B-C			
	4	C-A			
MTG φ-G	11	A-G			
	12	B-G			
	13	C-G			
MT φ-φ	8	A-B			
	9	B-C			
	10	C-A			
MG2 φ-G	17	A-G			
	18	B-G			
	19	C-G			
M2 φ-φ	31	A-B			
	32	B-C			
	33	C-A			

MB TESTS

PHASE	TEST PIN#	CENTER ∠265° 52 - 58	0.0 VOLTS SEAL-IN	- 30° ∠235° 46-54	+ 30° ∠295° 46-54
A-G	14				
B-G	15				
C-G	16				

NB

I = 265° PICK UP AT TEST PIN 29 ______________ PASS

I = 85° NO PICKUP AT TEST PIN 29 ______________ PASS

FAULT DETECTOR

I = .45(0.09) AMPS. PULSE AT TEST PIN 34 ______________ PASS

I = 2.25(.45) AMPS. HIGH AT TEST PIN 34 ______________ PASS

LEVEL DETECTORS

TEST	TEST PIN#	PHASE	PICKUP LIMITS	DATA	
I1	30	A-G	2.7(0.54) - 3.3(0.66)		
IB	26	A-G	0.9(0.18) - 1.1(0.22) AMPERES		
	27	B-G			
	28	C-G			
IT	23	A-G			
	24	B-G			
	25	C-G			
				PULSE	>30V SEAL-IN
NV	20	A	PULSE AT 41 - 45 VOLTS SEAL-IN AT >30 VOLTS		
	21	B			
	22	C			

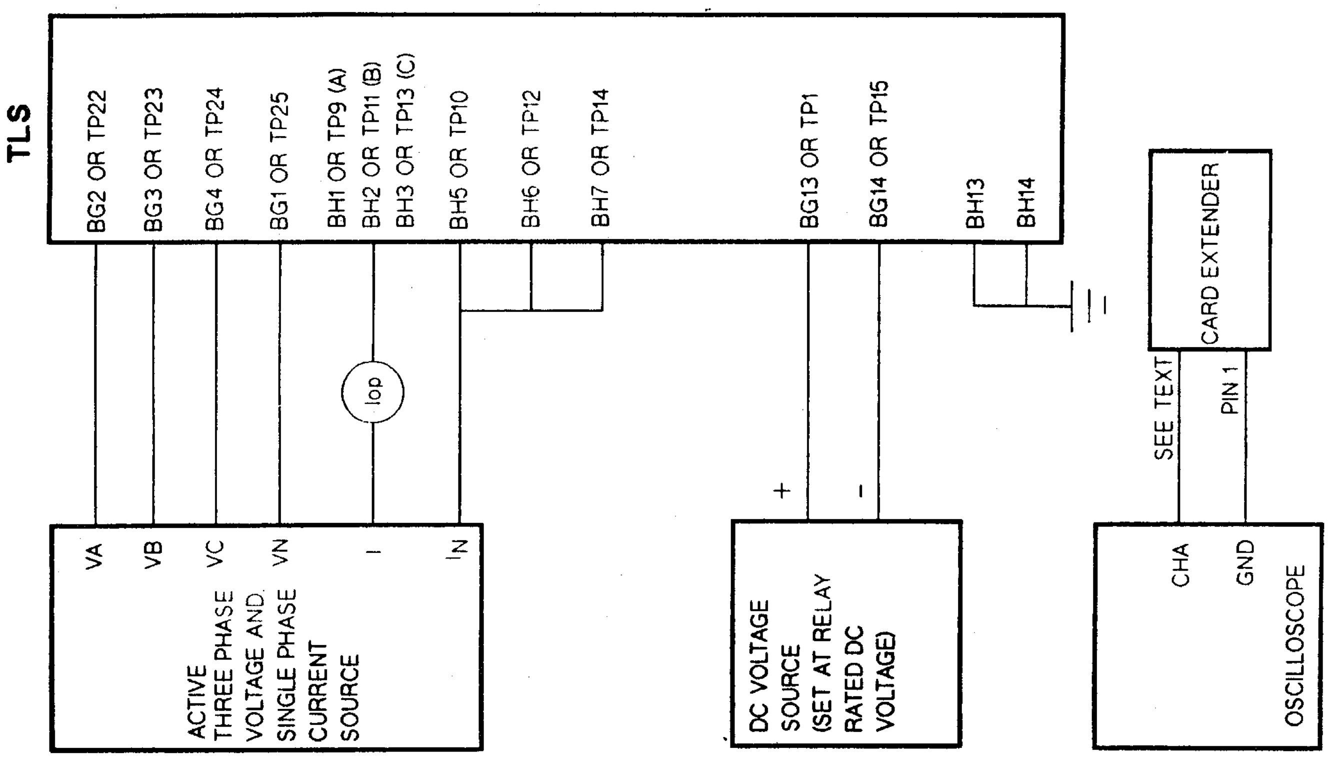


Figure AT-1 (0286A1883 [1]) Phase-to-Ground Circuit

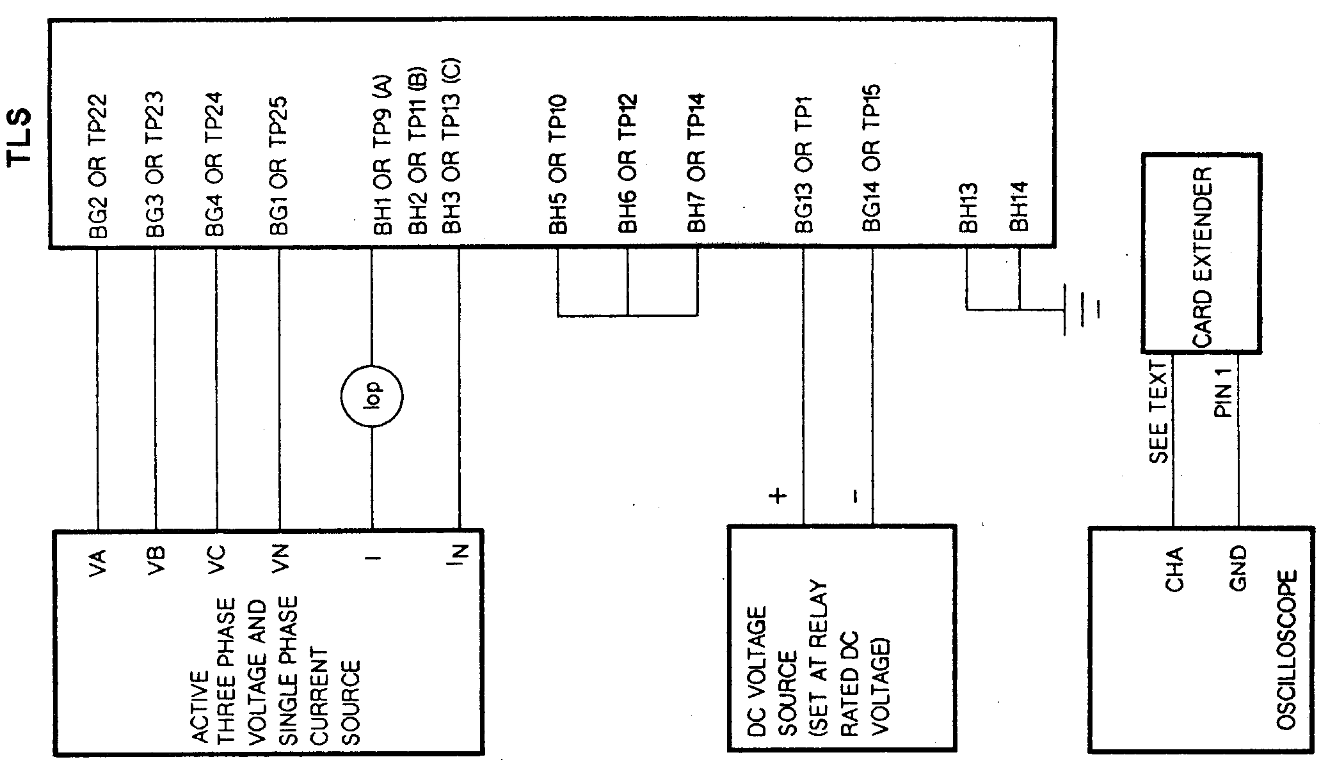


Figure AT-2 (0286A1884) Phase-to-Phase Circuit

PERIODIC TESTS

A periodic test program should be developed that checks all of the TLS1B functions employed in the scheme that is being used. It is left to the user's discretion to choose, from among the Acceptance Tests given in the previous section, those tests that may be applicable as Periodic Tests for a particular installation scheme.

EXTERNAL CONNECTIONS

External connections are made according to the elementary diagram, Figure SD-20. These are general diagrams incorporating all of the available options. Connection need not be made to those terminals associated with options that will not be used.

WARNING

TLS1B TERMINALS BH13 AND BH14 MUST BE TIED TOGETHER AND TO A GROUND BUS, AS SHOWN IN THE ELEMENTARY DIAGRAM, FIGURE SD-20. THE CONNECTION TO THE GROUND BUS MUST BE MADE USING NO. 12 WIRE OR LARGER. THE LEADS USED IN MAKING THESE CONNECTIONS SHOULD BE KEPT AS SHORT AS POSSIBLE.

External Connection Test

An overall check of current-transformer polarities, potential-transformer polarities, and connections to the TLS1B relay system can be made prior to placing the TLS1B in service, by using the system voltages and load current while monitoring the output of the NT directional unit. It should be noted that this test is a check of the external wiring and not a check of NT itself. It is assumed that the NT unit has been checked for correct directional action per the test method given in the ACCEPTANCE TESTS section. The load current should be greater than 0.5 ampere secondary for this test.

CAUTION

During this test the trip circuits of the TLS1B should be disconnected to prevent inadvertent tripping of the circuit breaker.

If the direction of power (KW) and reactive (KVAR) flow is away from the bus and into the protected line section, then use the XTM test-plug connections in Figure PT-1. These connections simulate an internal phase-A-to-ground fault by applying rated voltage to phase B and phase C and zero (0) voltage to phase A, while applying load current to phase A only. Check for an NT operation by observing a logic one (1) output at pin 18 of the test card extender inserted into the slot in location B at the top right of the unit. If the reactive flow is into the station bus, the resulting phase angle between load current and system voltage may be such that the NT unit will not operate.

If the direction of power and reactive flow is into the bus from the protected line section, then use the XTM test-plug connections in Figure PT-2. These connections reverse the phase A load current so that the NT unit will operate for this condition. If the reactive flow is away from the bus and into the protected line section, the resulting phase angle between load current and system voltage may be such that the NT unit will not operate.

TESTING THE TLS1B OPERATION WITH DIFFERENT SETTINGS

Because of the level of sophistication of the TLS1B modular relay system and the large number of selections that may be made, it is impossible to present one or two equations that will satisfy every condition. This section makes an attempt, however, to allow for the calculation of the pickup voltages for the MHO function when using the test circuits described in the various parts of the ACCEPTANCE TESTS section of this instruction book, but with different settings than those listed in Tables AT-1 and AT-2. This will permit some testing to be done using settings other than those specified as part of the acceptance tests.

To test with different settings, refer to the appropriate section of ACCEPTANCE TESTS. For instance, if the M1 function is being tested, use the same test setup and settings as described in the M1 portion, but use the equations and notes given below to modify the expected test results. Only those settings identified in the equations are allowed to be varied; otherwise, the expected results may be different than calculated.
M1/M2/MT (Phase-to-Phase Tests)

In order to calculate the nominal pickup voltage, the effective forward reach is needed. This may be calculated by the following equation:

$$ZF = 2 * ZNP * RM$$

Where: ZF = effective forward reach
ZNP = set nameplate reach
RM = reach multiplier .

Example:

If the current equals 5 amperes, the reach multiplier is 1, and the set nameplate reach is 6 ohms, the nominal phase-to-phase pickup voltage at the angle of maximum reach is:

$$\begin{aligned} VNOM &= I * ZF \\ &= 5 * 2 * 6 * 1 = 60\ V\phi\text{-}\phi \end{aligned}$$

Where: VNOM = nominal phase-to-phase pickup voltage
I = current

The offset reach in the TLS1B is based on positive-sequence voltage and current, and is not affected by the reach multiplier. The instruction-book test setup uses a balanced three-phase voltage and single phase-to-phase current. For this test, $V1 = V\phi N$ and $I1 = I\phi/\sqrt{3}$. Note that the voltmeter is connected phase-to-phase and $V1 = V\phi\text{-}\phi/\sqrt{3}$. Therefore, the effective forward offset is:

$$ZFO = ZNP * (\text{per-unit offset})$$

Where: ZFO = effective forward offset reach or, in terms of ZF,
Example:

$$ZFO = \frac{ZF * (\text{per unit offset})}{2 * RM}$$

If the current is 5 amperes, the set nameplate reach 6 ohms, and the per-unit offset is 0.3, the nominal phase-to-phase pickup voltage at the angle of maximum reach is:

$$5 * 6 * 0.3 = 9 \text{ volts}$$

MG1/MG2/MTG (Phase-to-Ground Tests)

The test circuit uses a balanced three-phase voltage and a single phase-to-ground current. Note that for the instruction-book tests it is assumed that $\phi Z1 = \phi Z0$. The effective forward reach is a function of K0 as well as the nameplate reach, and is equal to:

$$ZF = ZNP * \frac{2 + K0}{3} * RM$$

Where: K0 = zero-sequence compensation factor

Example:

If the current equals 5 amperes, RM equals 1, the set nameplate reach is 6 ohms and K0 equals 4, the nominal phase-to-ground pickup voltage at the angle of maximum reach (VNOM = IXZF)is:

$$VNOM = 5 * 6 * \frac{2 + 4}{3} = 60 \text{ volts}$$

Because the offset reach is positive-sequence ohms, it is not affected by the K0 setting. The test circuit produces $V1 = V\phi N$ and $I1 = I0/\sqrt{3}$; the effective forward offset reach is therefore:

$$ZFO = \frac{ZNP * (\text{per unit offset})}{3}$$

or, in terms of ZF,

$$ZFO = \frac{ZF * (\text{per unit offset})}{(2 + K0) * RM}$$

Example:

If the current equals 5 amperes, RM equals 1, the set nameplate reach is 6 ohms and K0 equals 4, and the per-unit offset is 0.3, the phase-to-ground pickup voltage at the angle of maximum reach is:

$$\frac{5 * 6 * 0.3}{3} = 3 \text{ volts}$$

MB

The test circuit uses a balanced three-phase voltage and a single phase-to-ground current. Note that in the instruction book tests it is assumed that $\phi Z1 = \phi Z0$. The effective blocking reach is a function of the set nameplate reach, K (current compensation) and KV (voltage constant). The reverse, or blocking-direction, reach is:

$$ZBLK = ZNP * \frac{3 + K}{3} * \frac{1}{1 - KV}$$

Where: K = current compensation
KV = voltage constant
ZBLK = blocking-direction reach

Example:

If the test current equals 5 amperes, the nameplate reach is 6 ohms, K equals 1 and KV equals 0.3, the phase-to-ground voltage at pickup at the angle of maximum reach will be:

$$\frac{5 * 6 * 3 + 1}{3} * \frac{1}{1 - 0.3} = 57.14 \text{ volts}$$

The forward (tripping direction) reach is not affected by K or KV. For the test circuit V1 = V -N and I1 = $I0/\sqrt{3}$, the effective offset reach will be:

$$ZBO = \frac{ZNP * (\text{per unit offset})}{3}$$

Where: ZBO = effective blocking offset reach or, in terms of the blocking-direction reach:

$$ZBO = ZBLK * \frac{1 - KV}{3 + K} * (\text{per unit offset})$$

Example:

If the current equals 5 amperes, the nameplate reach is 6 ohms and the per-unit offset is 0.1, the nominal phase-to-ground pickup voltage will be:

$$\frac{5 * 6 * 0.1}{3} = 1 \text{ volt}$$

OPTIONAL POSITIVE-SEQUENCE OVERVOLTAGE UNIT

The test conditions should equal that of the test found in the ACCEPTANCE TEST section of this manual. If the values for a particular installation are known, they can be used to test the relay for that installation. In testing the voltage functions, only one of the three phase voltages is varied. The positive-sequence voltage with unequal voltages can be calculated as:

$V1 = 1/3 (VA + VBa + VCa2)$

Assuming VA, VB and VC have the specified 120° phase relationship.

(LEFT)
XTM28L1

FROM	TO
1S	1R
9S	9R
10S	10R
11S	12S
13S	14S

(RIGHT)
XTM28R1

FROM	TO
15S	15R
23S	23R
24S	24R
25S	25R

S – SYSTEM SIDE OF XTM TEST PLUG
R – RELAY SIDE OF XTM TEST PLUG

CAUTION: CONNECTIONS BETWEEN POINTS 9 THROUGH 14 MUST BE MADE BEFORE INSERTING THE XTM TEST PLUG TO PREVENT OPEN CIRCUITING THE CT SECONDARIES.

Figure PT-1 (0286A1886) XTM Connections for External Connection Test for KW and KVAR Away From Bus

(LEFT)
XTM28L1

FROM	TO
1S	1R
9S	10R
10S	9R
11S	12S
13S	14S

(RIGHT)
XTM28R1

FROM	TO
15S	15R
23S	23R
24S	24R
25S	25R

S – SYSTEM SIDE OF XTM TEST PLUG
R – RELAY SIDE OF XTM TEST PLUG

CAUTION: CONNECTIONS BETWEEN POINTS 9 THROUGH 14 MUST BE MADE BEFORE INSERTING THE XTM TEST PLUG TO PREVENT OPEN CIRCUITING THE CT SECONDARIES.

Figure PT-2 (0286A1885) XTM Connections for External Connection Test for KW and KVAR Into Bus

SERVICING

SPARES

There are two basic approaches that may be followed in servicing the TLS1B. One approach is field service, where an attempt is made to replace defective components at the relay location. Generally, this will take the most time and require the highest degree of skill and understanding. It can also be expected to result in the longest system-outage time.

The preferred approach is module replacement, where a determination is made as to which function has failed and that function is replaced with a spare module. The system can then be quickly returned to service. Considerable time is saved, and there is much less pressure to make a decision about what to do with the defective part. This approach typically yields the shortest down time. It is recommended that a complete set of spare modules be kept at the main maintenance center.

For those who wish to repair at the component level, drawings are available from the factory. When requesting drawings, the following information must be supplied to the factory:

1. The model number of the module. (This is found on the lower part of the front nameplate of each module, e.g. ISM101);
2. The assembly number of the module. (This is found on the component side of the printed-circuit board. It is an eight-digit number with a letter inserted between the fourth and fifth digit and suffixed with a group identification, e.g. 0138B7420 G001 or G1);
3. The revision number (this is also found on the printed-circuit board, e.g. REV.1).

WITHOUT THE CONTINUOUS MONITOR MODULE

By inserting an extender card into the test slot, location "2A" (see Figure MO-1 in the MODULES section), one can gain access to various points throughout the TLS1B. This feature is extremely useful when testing and servicing the TLS1B.

If the Continuous Monitor, which is an option that is also a useful device for testing and servicing the TLS1B, is not provided, a second extender card can be inserted into the slot reserved for it, location "D" (Figure MO-1 in the MODULES section). This gives access to additional points throughout the TLS1B.

The pin number on the extender card versus signal for the test points (TP-) that are shown in the Logic Diagram, Figure SD-4 (in the SCHEME DESCRIPTION section), is given in Table SE-1. The pin number on the extender card versus the monitor points (CM-), also shown in the Logic Diagram, is given in Table SE-1.

WITH THE CONTINUOUS MONITOR MODULE

When the TLS1B is equipped with the optional Continuous Monitor, many problems can be quickly located. When a failure occurs that causes one or more internal logic levels to shift, this will normally cause one of the many points monitored by the Continuous Monitor to go to an abnormal state. If the monitored point stays in this state for more than 1 minute, the Continuous Monitor will give a Monitor Alarm contact closure. The front panel MON DATA indicator on the TAM101 module, Figure MO-13 in the MODULES section, will also light.

There are two different methods by which the operator can determine which point or points failed. He can place the front panel DATA SELECT switch in the MON DATA position and step through the display of abnormal points, using the STEP DISPLAY switch. When this method is used, the numbers of the abnormal points need to be recorded at this time.

The other alternative is to interrogate the Continuous Monitor through the serial data link. If monitor data is requested, the video terminal will display all the abnormal point numbers. The operator can leave these numbers on the screen to work from, or they can be copied from the screen and entered in the log.

These abnormal point numbers are the signal input numbers to the Continuous Monitor. Refer to Table SE-1 to find the mnemonic of the TLS1B signal connected to this input. Table SE-1 also gives the module where the signal originates. Refer to the system Logic Diagram, Figure SD-4 in the SCHEME DESCRIPTION section, and locate the abnormal signal levels on this diagram. Locate the earliest abnormal points, that is, the points closest to the AC inputs to the TLS1B. The problem is normally ahead of this point. Abnormal points that follow the first abnormal point in a signal path probably do not indicate a failure at these points. If there is an earlier, monitored, logic level in the same signal path that is normal, then the problem will usually be between the normal and the abnormal points.

The techniques just described locate failures that resulted in monitor alarms from the continuous monitor. If a failure is suspected of causing a false trip, then the trip data in the Continuous Monitor must be analyzed. Obtain the trip data point numbers using the front panel controls: DATA SELECT, TRIP DATA, STEP DISPLAY and LED display, or by using the serial data link. See if point 48 went to its abnormal state, HIGH. If not, the trip did not originate in the trip bus connected to the TLS1B. If point 48 went abnormal, see if point 47 went HIGH (abnormal state). If so, then there was a system disturbance and the trip probably was not a false trip. Check the event recorder, if used, and see if a trip condition did exist.

If there was no fault detector signal (point 47 did not go HIGH) then there was an error in the TLS1B. As in the case where a Monitor alarm light is lit, look for the earliest abnormal point in the signal path. Replace the module where this abnormal point is located. If the failure can not be localized as occurring between a normal and an abnormal monitored point, then it may be necessary to replace all modules between the abnormal point and the AC inputs that supply signals to the abnormal point.

POWER SUPPLY MODULE

Check the following items if the LED found on the front panel of the PSM21(-) module (Figure MO-12) fails to light when the Power Supply is turned on:

1. The correct DC supply is applied to the TLS1B.
2. The connection plugs, located on the left side of the MGM module (see Figure MO-1), are properly inserted into the test receptacle.
3. The condition of the fuse located on the PSM21(-) module, (Figure MO-12).
4. Check for the correct voltages from the Power Supply Module:

The voltages should be within ±5% of nominal. Check each of the following voltages with respect to pins 1, 30, 31 or 60:

Pins	4 or 34	+24 VDC
Pins	2 or 32	+12 VDC
Pins	29 or 59	-12 VDC

The following voltage is checked with respect to pins 25 or 55, and it should also be within ±5% of nominal:

Pins 21 or 51 +24 VDC.

TABLE SE-1 TEST POINTS FOR "Slot 2A"

TEST POINT	DESCRIPTION	TEST POINT	DESCRIPTION
1	Reference	31	M2AB
2	M1 φAB	32	M2BC
3	M1 φBC	33	M2CA
4	M1 φCA	34	FDP
5	MG1 φA	35	Loc. Trip Alt. (OR201)
6	MG1 φB	36	Local Block (OR302)
7	MG1 φC	37	Zone I Trip (OR204)
8	MT φAB	38	Channel Trip (AND407)
9	MT φBC	39	Trip Perm. (OR405)
10	MT φCA	40	3 Pole Select (OR20)
11	MTG φA	41	Zone II Trip (TL2)
12	MTG φB	42	Zone III Trip (TL3)
13	MTG φC	43	Zone 4 Trip (TL4)
14	MB φA	44	Line Pickup (OR304)
15	MB φB	45	DTT (TL13)
16	MB φC	46	Weak Infeed (TL16)
17	MG2A	47	Key XMTR #1
18	MG2B	48	Key XMTR #2
19	MG2C	49	MOB (TL6)
20	NVA	50	Fault Detect (OR210)
21	NVB	51	φA Sel (OR1)
22	NVC	52	φB Sel (OR2)
23	IT φA	53	φC Sel (OR3)
24	IT φB	54	ATRIP (OR406)
25	IT φC	55	BTRIP (OR5)
26	IB φA	56	CTRIP (OR6)
27	IB φB	57	PERM RCVR
28	IB φC	58	LTA (OR412)
29	NB	59	Local Block (OR302)
30	I1	60	+12 VDC

TABLE SE-2 CONTINUOUS MONITOR POINTS

DATA POINT	DESCRIPTION	DATA POINT	DESCRIPTION
1	Not Trip Int. (TU)	25	φB Trip (OR5)
2	Not Used	26	φC Trip (OR6)
3	Not Used	27	Trip Perm (OR405)
4	Not Used	28	Local Trip Att. (OR201)
5	M1 φAB	29	Zone I Trip (OR204)
6	M1 φBC	30	Zone II Trip (TL2)
7	M1 φCA	31	Zone III Trip (TL3)
8	MG1 φA	32	Zone IV Trip (TL4)
9	MG1 φB	33	Weak Infeed (TL16)
10	MG1 φC	34	Line Pickup (OR304)
11	MT φAB	35	DTT (TL13)
12	MT φBC	36	Ext. Trip (OR102)
13	MT φCA	37	Ch. Trip (AND407)
14	MTG φA	38	M2φ AB
15	Not Used	39	M2φ BC
16	Not Used	40	M2φ CA
17	MTG φB	41	Clock Failure
18	MTG φC	42	MOB (TL6)
19	Local Block (OR302)	43	MG2φ B
20	MB φA	44	MG2φ C
21	MB φB	45	3 Pole Set (OR20)
22	MB φC	46	Not Used
23	MG2φ A	47	Fault Det. (OR210)
24	φA Trip (OR406)	48	Any Trip Bus (OR208)

SERVICE LOGIC

The servicing logic diagram, Figure SE-2, will help in troubleshooting the TLS1B relay signals from module to module. Signal names and pinouts are provided to aid in this process. When tracing signals from module to module use Figure MO-1, located in the MODULES section, for module locations. Figure SE-2 is a reference diagram only. It is not necessarily representative of the actual hardware. If more detailed schematics are required, contact your local General Electric sales office as they are available.

Procedure

When troubleshooting the TLS1B, it is best to start directly at the trouble output or signal. Use the following figures to aid in the troubleshooting process:

- Elementary diagram Figure SD-20 located in the SCHEME DESCRIPTION section.
- Module Line-up Figure MO-1 located in the MODULES section.
- Service Logic located in this section.
- Module schematics if desired and/or necessary.

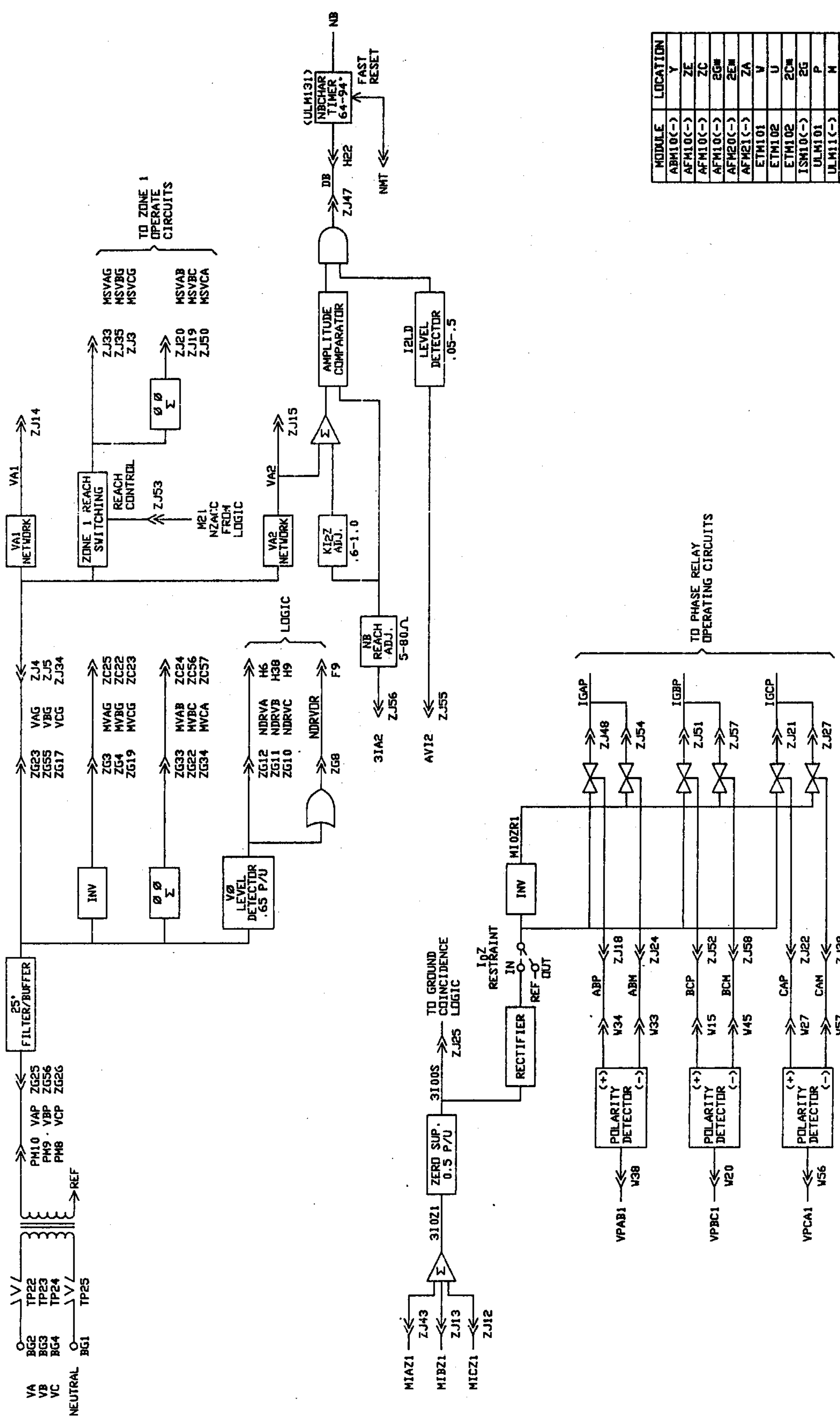
For example if the DLA contact "M1AB" does not close use the following procedure:

1. Check to see that the relay trips for a phase A-B zone 1 fault. If yes change the IOM202 module in slot 2E since this is where the actual contact is found as seen on the Elementary diagram.

2. If the relay does not trip try phase B-C. If this phase pair does trip than it can be assumed that the problem is in the relay logic.

3. Locate the M1AB signal on the Service Logic diagram, Figure SE-2 It is found on the UTM101 module. With an oscilloscope, measure this pin at the time a trip is expected. It should go high, +12 volts dc with respect to ground. If it does not, change the UTM101 module.

4. From here if it is desired to troubleshoot a particular component on the UTM101 module, a schematic diagram will be required.



MODULE	LOCATION
ABM10(-)	Y
AFM10(-)	ZE
AFM10(-)	ZC
AFM10(-)	ZG*
AFM20(-)	ZE*
AFM21(-)	ZA
ETM101	W
ETM102	U
ETM102	ZC*
ISM10(-)	ZG
ULM101	P
ULM11(-)	N
ULM12(-)	K
ULM131	H
ULM141	F
UTM101	S
UTM102	B*
VMM10(-)	ZJ

* - USED IN 3 ZONE TLS1 RELAYS ONLY

Figure SE-1 (0171C8787 Sh.1) Analog Block Diagram

MODULE	LOCATION
ABM10(-)	Y
AFM10(-)	ZE
AFM10(-)	ZC
AFM10(-)	2G*
AFM20(-)	2E*
AFM21(-)	ZA
ETM101	V
ETM102	U
ETM102	2C*
ISM10(-)	2G
ULM101	P
ULM11(-)	M
ULM12(-)	K
ULM131	H
ULM141	F
UTM101	S
UTM102	B*
VMM10(-)	ZJ

* - USED IN 3 ZONE TLS1 RELAYS ONLY

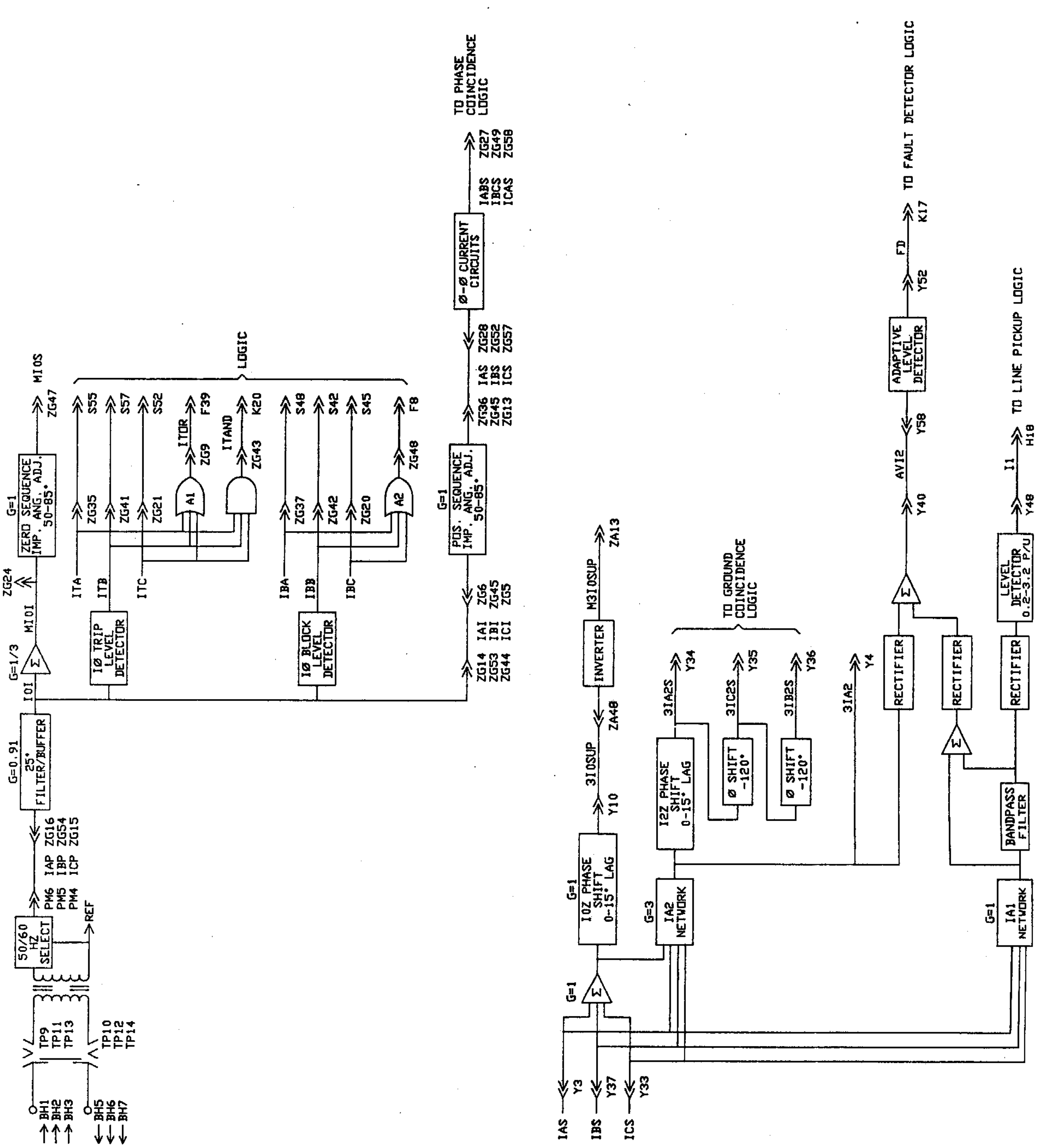


Figure SE-1 (0171C8787 Sh.2) Analog Block Diagram, continued

MODULE	LOCATION
ABM10(-)	Y
AFM10(-)	ZE
AFM10(-)	ZC
AFM10(-)	2G*
AFM20(-)	2E*
AFM21(-)	ZA
ETM101	V
ETM102	U
ETM102	2C*
ISM10(-)	2G
ULM101	P
ULM11(-)	M
ULM12(-)	K
ULM131	H
ULM141	F
UTM101	S
UTM102	B*
VMM10(-)	ZJ

* - USED IN 3 ZONE TLS1 RELAYS ONLY

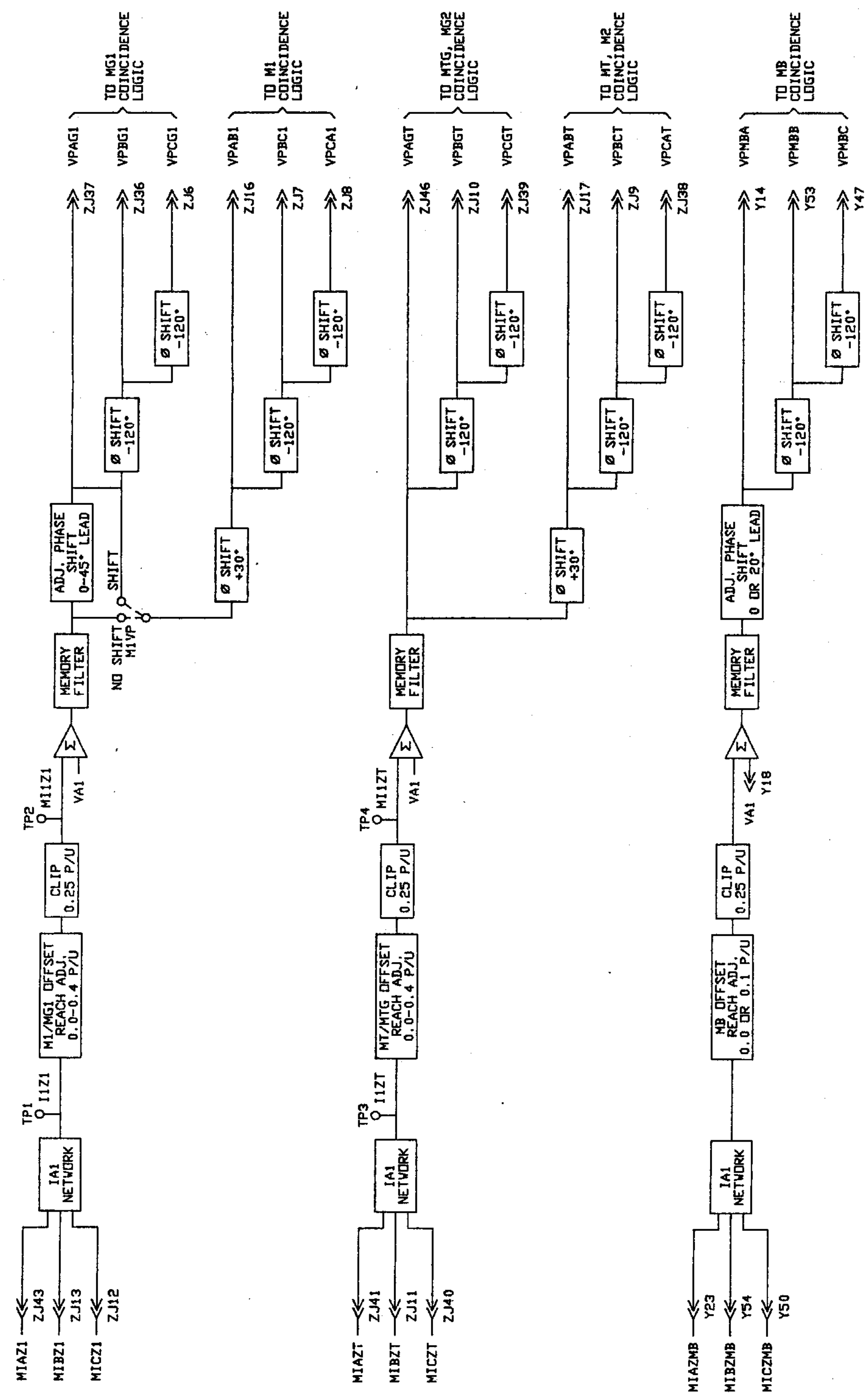


Figure SE-1 (0171C8787 Sh.3) Analog Block Diagram, continued

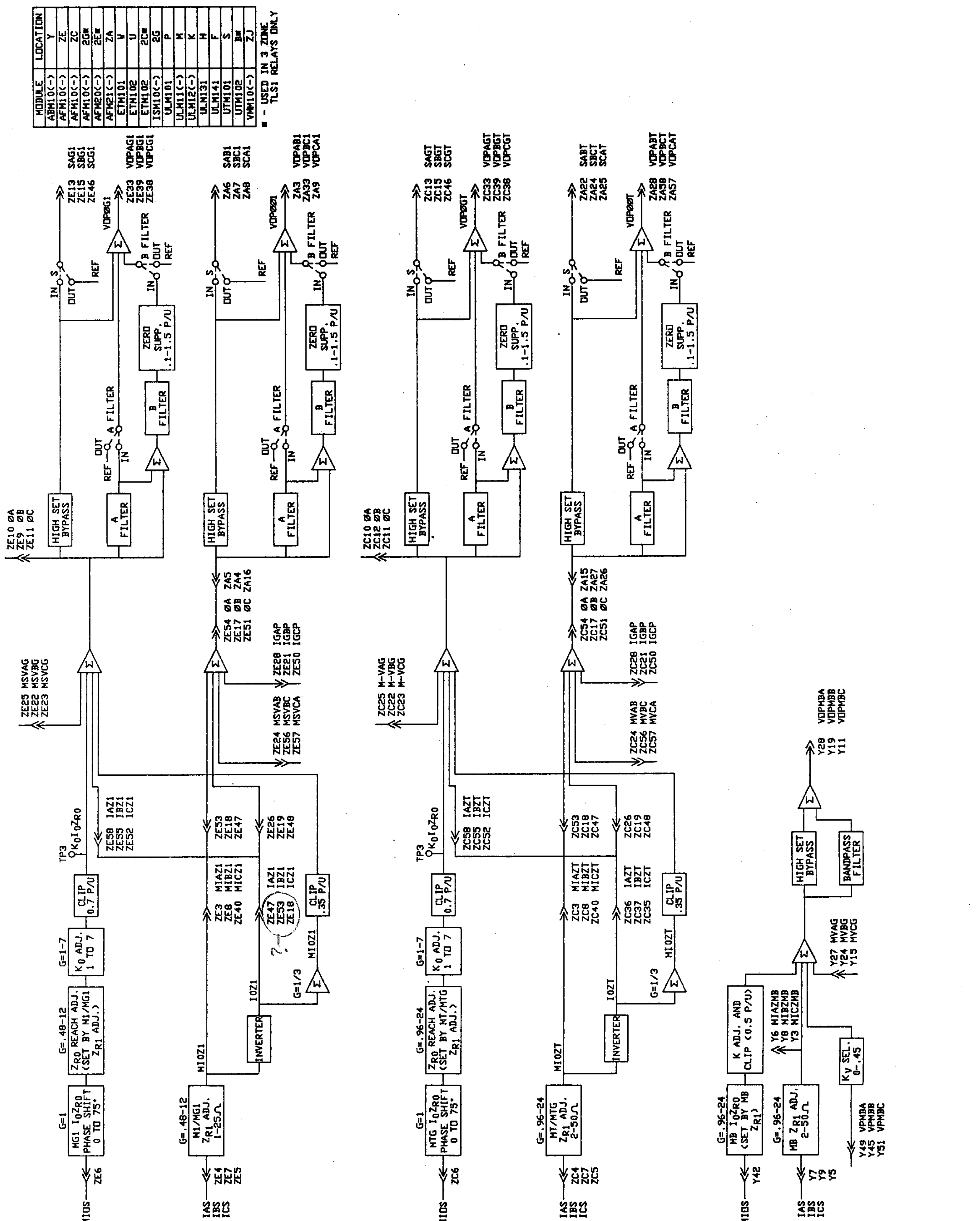


Figure SE-1 (0171C8787 Sh.4) Analog Block Diagram, continued

MODULE	LOCATION
ABM10(-)	Y
AFM10(-)	ZE
AFM10(-)	ZC
AFM10(-)	2G*
AFM20(-)	2E*
AFM21(-)	ZA
ETM101	V
ETM102	U
ETM102	2C*
ISM10(-)	2G
ULM101	P
ULM11(-)	M
ULM12(-)	K
ULM131	H
ULM141	F
UTM101	S
UTM102	B*
VMM10(-)	ZJ

* - USED IN 3 ZONE TLS1 RELAYS ONLY

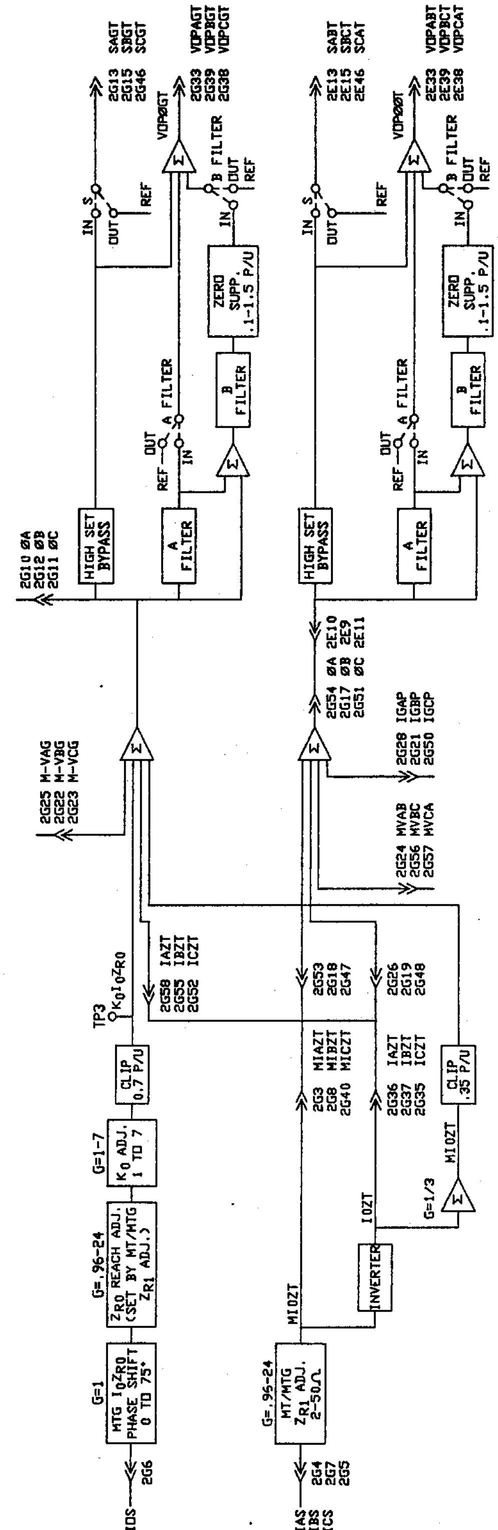


Figure SE-1 (0171C8787 Sh.5) Analog Block Diagram, continued

MODULE	LOCATION
ABM10(-)	Y
AFM10(-)	ZE
AFM10(-)	ZC
AFM10(-)	2G*
AFM20(-)	2E*
AFM21(-)	ZA
ETM101	W
ETM102	U
ETM102	2C*
ISM10(-)	2G
ULM101	P
ULM11(-)	M
ULM12(-)	K
ULM131	H
ULM141	F
UTM101	S
UTM102	B*
VMM10(-)	ZJ

* - USED IN 3 ZONE TLS1 RELAYS ONLY

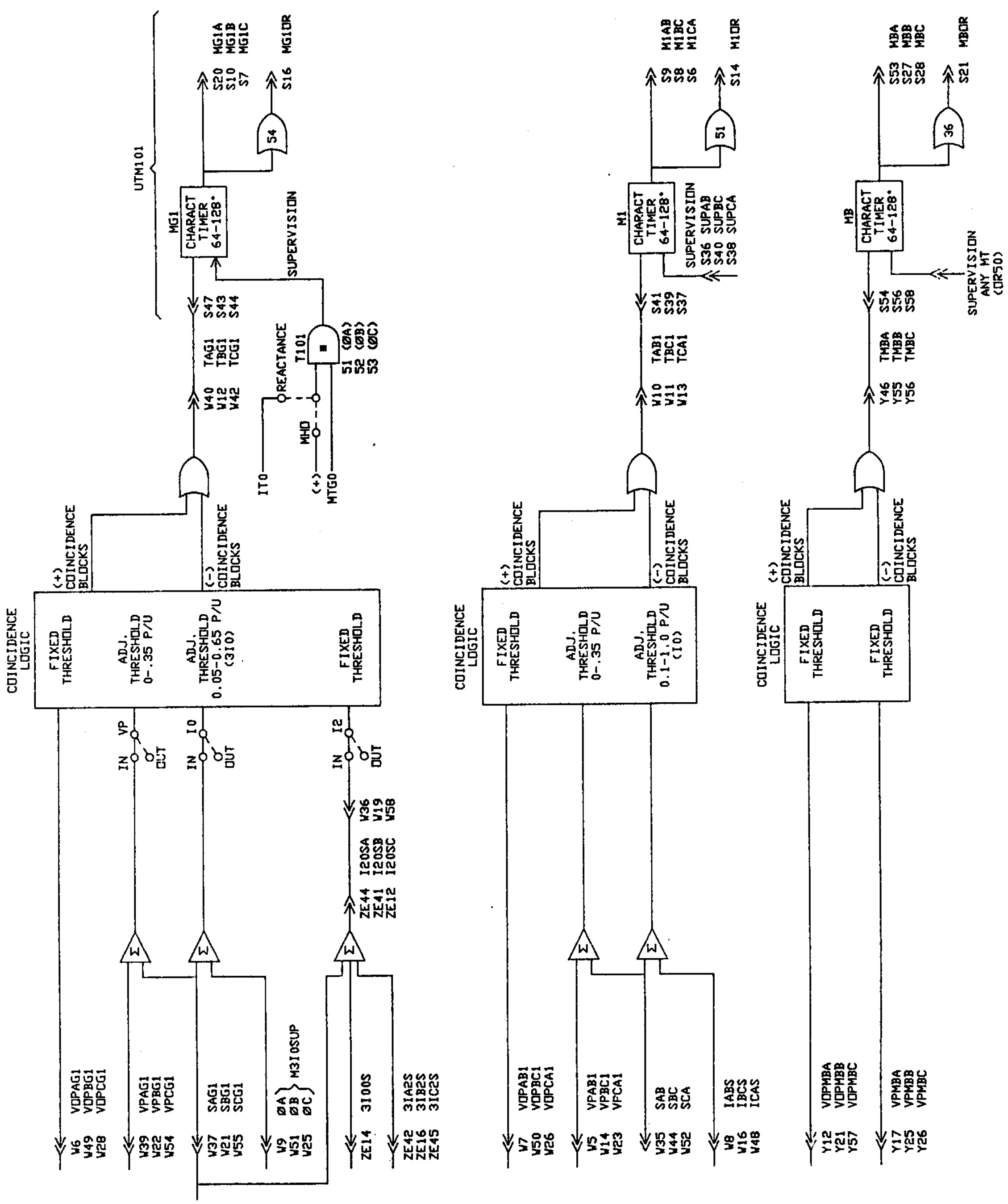


Figure SE-1 (0171C8787 Sh.6) Analog Block Diagram, continued

MODULE	LOCATION
ABM10(-)	Y
AFM10(-)	ZE
AFM10(-)	ZC
AFM10(-)	2G*
AFM20(-)	2E*
AFM21(-)	ZA
ETM101	W
ETM102	U
ETM102	2C*
ISM10(-)	2G
ULM101	P
ULM11(-)	M
ULM12(-)	K
ULM131	H
ULM141	F
UTM101	S
UTM102	B*
VMM10(-)	ZJ

* - USED IN 3 ZONE TLS1 RELAYS ONLY

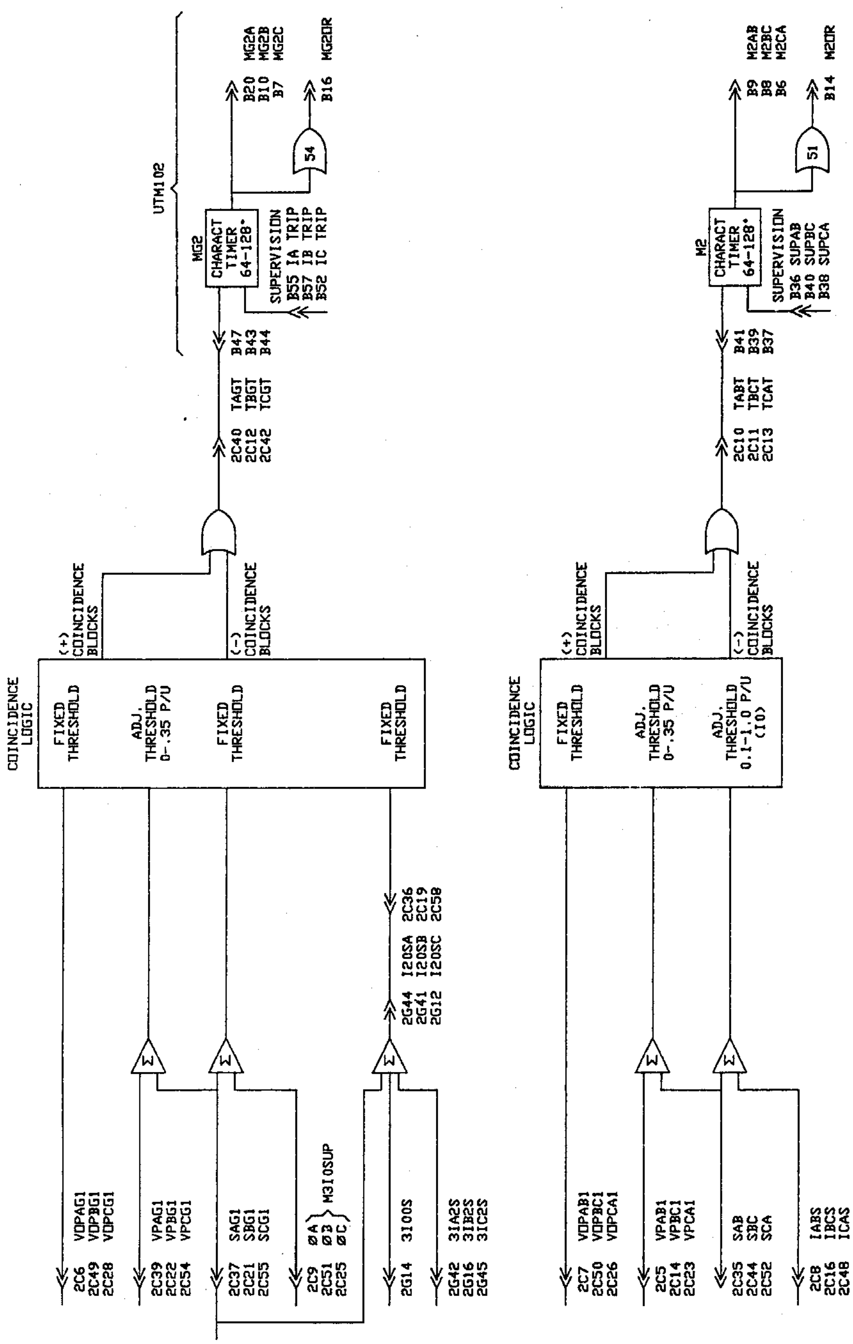


Figure SE-1 (0171C8787 Sh.7) Analog Block Diagram, continued

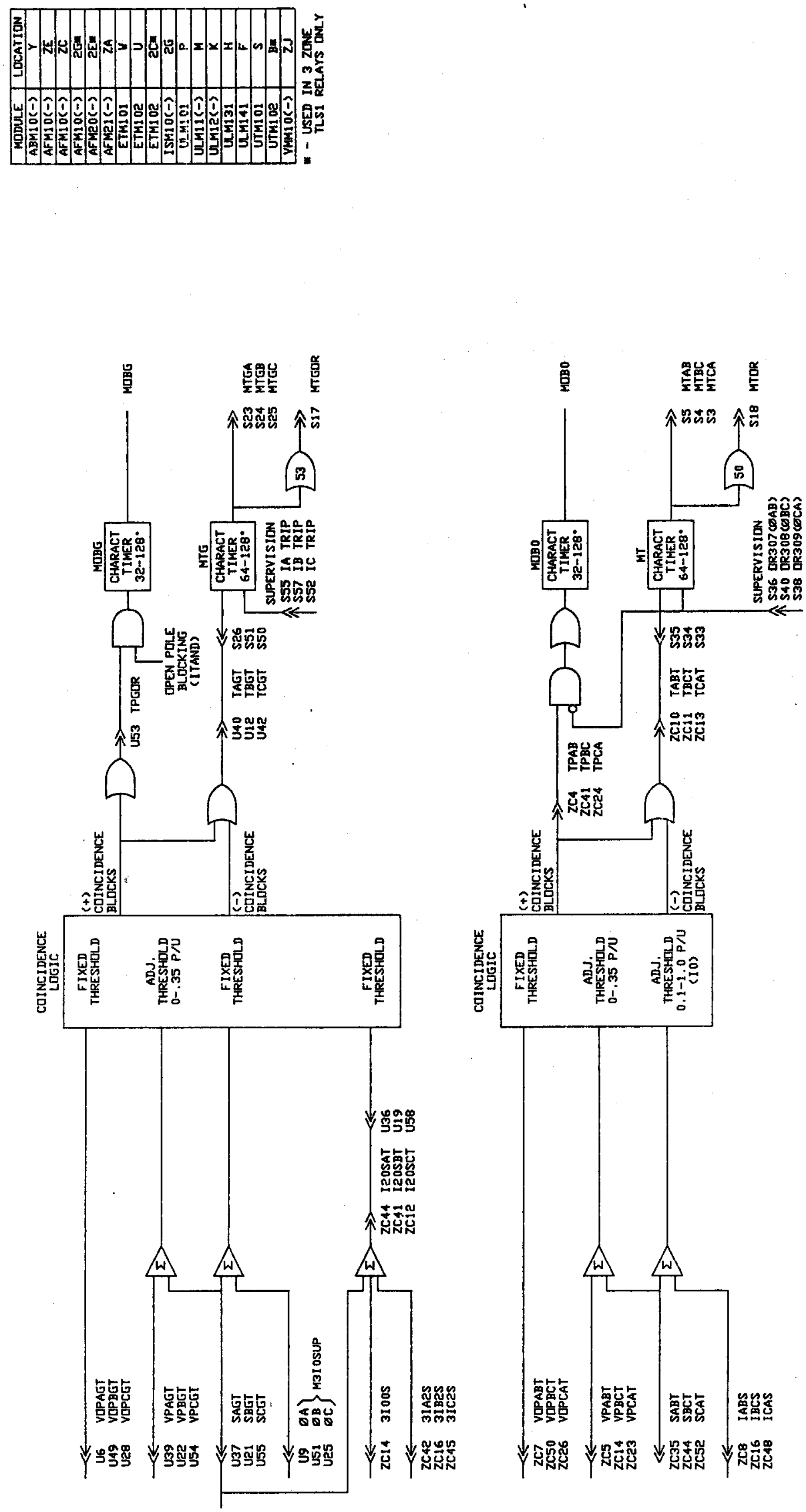


Figure SE-1 (0171C8787 Sh.8) Analog Block Diagram, continued

SPECIFICATIONS

RATINGS

Rated Frequency	50 or 60 hertz
Rated Voltage	100 to 120 volts AC
Rated Current	IN = 1 or 5 amperes
DC Control Voltage	48 VDC - Operating Range: 34-60 VDC 110/125 - Operating Range: 88-150 VDC 220/250 - Operating Range: 176-300 VDC
Maximum Permissible Currents	
Continuous	2 x IN
Three Seconds	50 x IN
One Second	100 x IN
Maximum Permissible AC Voltage	
Continuous	2.0 x rated
One Minute (one per hour)	3.5 x rated
Ambient Temperature Range	
For Storage	-40° to +65° Celsius
For Operation	The TLS1B has been designed for continuous operation between -20° C and +55° C per ANSI Standard C37.90. In addition, the TLS1B will not malfunction, nor be damaged by operation, at temperatures up to +65° C.
Insulation-Test Voltage	2 kV 50/60 hertz, one minute
Impulse-Voltage Withstand	5 kV peak, 1.2 to 50 milliseconds, 0.5 joule
Interference-Test Withstand	ANSI/IEEE C37.90 and IEC 255-5

BURDENS

Current Circuits	0.03 ohm ∠5°, IN = 5 amps 0.14 ohm ∠30°, IN = 1 amp	
Voltage Circuits	0.2 VA ∠49°, 60 hertz 0.24 VA ∠48°, 50 hertz	
DC Battery (contact converters)	1.4 milliamperes each	
DC Battery (for Power Supply and Telephone Relays)	<u>Normal</u>	<u>Tripped</u>
ALL VOLTAGE RATINGS	13 watts	40 watts

CONTACT DATA

Trip Outputs	Continuous rating = 3 amperes Make and carry for tripping duty (per ANSI C37.90) 30 amps Break 180 VA resistive at 125/250 VDC Break 60 VA inductive at 125/250 VDC
Auxiliary Outputs (including Alarms)	Continuous rating = 3 amperes Make and carry for 30 seconds 5 amperes Break 25 watts inductive at 125/250 VDC Make and carry continuously 50 watts Maximum of 250 volts or 0.5 ampere
DLA and Channel Control Contacts	10 watts 250 VDC maximum 0.5 amp maximum

Table SP-1 REACH SETTINGS IN OHMS

FUNCTION	MODULE	RANGE	RESOLUTION	MULTIPLIERS
M1/MG1	AFM101/104	(1 to 25)x 5/IN	0.1 x 5/IN	0.1, 0.25, 1.0
MT/MTG *	AFM102/105	(2 to 50)x 5/IN	0.2 x 5/IN	0.1, 0.25, 1.0
Switched **	VMM101/102	(1 to 10)x Z1	0.05	0.1, 0.25, 1.0
MB	ABM101/102	(2 to 50)x 5/IN	0.2 x 5/IN	
NB	VMM101/102	(5 to 80)x 5/IN	5 x 5/IN	

NOTES: * AFM102/105 may be used as MT/MTG in two-zone units
** Switched distance function based on M1/MG1

Table SP-2 REPLICA IMPEDANCE ANGLE SETTINGS

FUNCTION	MODULE	RANGE	RESOLUTION
∠ZR1 ***	ISM101	50° to 85°	5°
∠ZR0 ***	ISM101	50° to 85°	5°

NOTE: *** One replica impedance angle adjustment is used for all zones of protection

Table SP-3 CHARACTERISTIC TIMER SETTINGS

FUNCTION	MODULE	RANGE	RESOLUTION
M1/MG1	UTM101	64° to 127°	1°
MT/MTG	UTM101	64° to 127°	1°
NB	ULM131	64° to 96°	2°
MOB/MOBG	ULM121/122	32° to 126°	2°

Table SP-4 ADJUSTABLE LOGIC TIMERS

TIMER	MODULE	PU/DO	RANGE	RESOLUTION	DESCRIPTION
TL1	ULM141	PU	1 - 15 ms	1 ms	Trip Integrator
TL2	ULM141	PU	.2 - 3.15 sec	0.05 sec	Zone 2
TL3	ULM141	PU	.4 - 6.3 sec	0.1 sec	Zone 3
TL4	ULM131	PU	.4 - 6.3 sec	0.1 sec	Zone 4
TL6	ULM121*	PU	1 - 7.75 cyc	0.25 cyc	Out of Step
TL13	ULM111	PU	1 - 15 ms	1 ms	DTT
TL14	ULM141	PU	2 - 15 ms	1 ms	Coordination
TL15	ULM141	PU	2 - 15 ms	1 ms	Repeat Block
TL16	ULM141	PU	.5 - 7.5 cyc	0.5 cyc	Weak Infeed
TL22	ULM141	PU	.4 - 6.3 sec	0.1 sec	DTT Reclose Block
TL24	ULM131	DO	.5 - 7.5 cyc	0.5 cyc	NB Dropout
TL25	ULM131	DO	.5 - 7.5 cyc	0.5 cyc	MB Dropout

* Revision A TLS1

ACCURACY

Distance Measuring Units

Reach: $\pm 5\%$ of setting at angle of maximum reach

Angle of Maximum Reach: $\pm 3°$ of setting

Zone Timers $\pm 3\%$ of setting

Characteristic Timers

$\pm 1°$

DIMENSIONS

Standard rack-mounted unit

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

WEIGHT

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

OPTIONAL STATIC BREAKER FAILURE CHARACTERISTICS

Pickup Time:

From AC Input
Ten (10) milliseconds ± 5 milliseconds, plus the time set on the KIM102. This is measured from the time the AC input crosses the threshold.

Dropout Time:

6-12 milliseconds (2.9-3.4 milliseconds electronics only)

Reset Time:

10 milliseconds (electronics)

Dropout Ratio:

90% or more

Variation in Operate Level: With temperature - Less than ±3% typical

Variation in Operate Time: With temperature - Less than ±3% typical

Operate Time from BFI Input: 10-20 milliseconds

Dropout Time from BFI Input: 5-20 milliseconds

Pickup and Dropout Time of Contact Converters: Auxiliary Timers

Pickup Time - setting ±5% typical
Dropout Time - 8-16 milliseconds (5-10 milliseconds minimum)
Variation in operate time: With temperature - ±3% typical.

Contact-Converter Operation by Capacitive Discharge:

Maximum circuit capacitance to avoid operation (BFI input)

Control Voltage	Maximum Capacitance
48 VDC	3.5 microfarads
125 VDC	1.0 "
250 VDC	0.5 "

OPTIONAL POSITIVE SEQUENCE OVER-VOLTAGE CHARACTERISTICS

Overvoltage Time Delay:

Pickup time - 0.22-5.1 seconds, adjustable in 0.08 second steps

Dropout time - 64 milliseconds, nominal

Output-Relay Operate Times:

Pickup time - 5 milliseconds

Dropout time - 8 milliseconds

CONTINUOUS MONITOR

BASIC OPERATION

The continuous monitor function works on the principle of recognizing a change in state of one or more of up to 40 monitored points (reference Table SE-2 in the SERVICING section) as an abnormal relay system condition if this change in state occurs when the power system is in a quiescent state. This means that the process must know the state of the power system at all times (i.e., quiescent or fault). A fault detector (FD) is used to determine the state of the power system. This same fault detector may also be used to supervise a trip output from the relay system's scheme logic, even if the optional Continuous Monitor module is not included. The fault detector responds to negative-sequence current as well as the change in the positive-sequence current.

A microprocessor, software stored in an EPROM, and other required support chips are the hardware/software that comprise the Continuous Monitor module. The module operation can be described functionally with the aid of Figure CM-1. If one or more of the monitored points changes state (either logic level 0 to 1 or logic level 1 to 0), the fault detector has not operated, and this condition persists for a minimum of 5 seconds, then the Continuous Monitor module issues an alarm output to indicate that an abnormal condition - a relay system failure - has occurred. Based on the actual software and hardware implementation, the "A" time delay in Figure CM-1 is not a fixed value, but rather a statistically variable 5 seconds minimum and 10 seconds maximum. An alarm output is also produced if a fault detector output persists for 60 seconds. This would be an indication that the fault detector itself had failed.

No monitor data will be taken after a bad fault detector is sensed. To alert the user, the program displays "Fd" on the front panel LED numeric display after it senses a bad fault detector. It is still possible to use the STEP DISP. pushbutton to step through the trip and monitor data already stored. If this is done, the "Fd" does not reappear on the display. For this reason, the LED labeled MON. DATA on the front panel is made to blink continuously after a fault-detector failure. This alerts the operator to the fact the unit is not operating normally.

Once OR1 in Figure CM-1 produces an output, indicating a relay system failure, the microprocessor program stores bit patterns in non- volatile memory that identify which monitored point(s) changed state. These "faulty" monitored points are not stored in chronological order, nor time-tagged, but are simply accumulated in memory. Repeated operation and reset of a particular monitored point does not result in this point being stored more than once. This accumulation of "faulty" monitored points continues until the memory is cleared. Since non-volatile memory is used, the data is not lost if the DC power supply is turned off or the DC is removed externally. To clear the memory, a CLEAR command must be given by either (1) the operator pushing a button on the front panel of the module or (2) a remote terminal communicating with the module via a serial data link. When the first relay-system failure is detected, the Continuous Monitor module closes an alarm contact that remains closed until the memory is cleared.

ADDITIONAL FUNCTION

The primary function of the Continuous Monitor module is to detect and to alarm for a relay-system failure. The other function is to store in non-volatile memory those monitored points that have changed state during a relay-system trip output. Following a trip output, the Continuous Monitor module scans the monitored points for 10 milliseconds. Any points that change state within this 10 millisecond interval are accumulated in memory as trip data. This can be useful in analyzing relay-system response to particular faults. This function and its memory are separate and distinct from the primary function of detecting relay-system failures. The Continuous Monitor module can have both "trip data" and "monitor data" in memory at the same time.

Data for five (5) trip events will be stored sequentially. If a sixth trip event occurs prior to the memory being cleared, then the data for the first trip event will be overwritten by the data for the sixth trip event. Thus the data for the five most recent trip events will be retained.

The front panel LED numeric display shows "Fb" when the trip input to the Continuous Monitor is HIGH. This was done to make the unit easier to test. Without this feature, it is difficult to avoid the appearance of Continuous Monitor failure when the trip input is accidentally held HIGH. This makes it difficult to diagnose the real condition.

ACCESS OF STORED DATA

Figure CM-2 shows the front panel of the Continuous Monitor module with its LEDs, two-digit LED numeric display, toggle switch and pushbuttons. The stored data, either monitor or trip, can be accessed locally at the front panel of the module, or it can be accessed from a remote terminal via an optional serial data link.

Local Access

For local access, the two LEDs on the front panel of the module indicate that monitor data and/or trip data are stored in memory. A DATA SELECT toggle switch is used to select which data are to be accessed. The step display (STEP DISP.) pushbutton is then pushed repeatedly to cause the stored points to be displayed via the two- digit point number (POINT NO.) LED numeric display.

After the DATA SELECT switch is set to the monitor data (MON DATA) position, the LED numeric display should show 0/0 (i.e., the upper and lower display digits are both zero) to indicate the beginning of the monitor data. If 0/0 is not displayed, the STEP DISP. pushbutton should be pushed to bring the display to 0/0. The next push of the STEP DISP. pushbutton will cause the first stored monitor point to be displayed and this process is continued until 0/0 reappears on the LED numeric display to signal the end of the monitor data.

After the DATA SELECT switch is set to the TRIP DATA position, a 0/0 on the LED numeric display indicates the beginning of the trip data. Once again, successive operations of the STEP DISP. pushbutton cause all the trip data to be displayed between the initial 0/0 and the subsequent 0/0. However, additional codes, E/1, E/2 through E/5 are displayed to differentiate between the trip events. E/1 refers to the last trip event, E/2 to the next-to-last trip event, and E/5 to the earliest stored trip event, assuming five trip events are stored in memory. When starting from 0/0, the first push of the STEP DISP. pushbutton will cause E/1 to appear on the LED numeric display. Successive operations of the STEP DISP. pushbutton will cause all trip data points associated with the last trip event to be displayed, followed by E/2 to indicate the beginning of the trip data points associated with the next-to-last trip event. This continues until 0/0 is displayed to indicate the end of the trip data.

Remote Access

For remote access, a serial data link must be supplied. The Continuous Monitor module includes the necessary software to operate with a serial data link and the chassis backplane wiring connects the input/output ports to a 25-pin connector on the rear of the chassis. This connector resembles an RS-232 connector, but it does **not** provide an RS-232 interface. To provide serial data transmission, an optional, small, fiber-optic transmitter/receiver module (FOM101) can be supplied, which consists of standard Hewlett-Packard devices using SMA connectors and packaged by GE into a connector housing. This device is simply plugged into the 25-pin connector on the rear of the chassis. One means of completing the serial data link is to connect one end of a fiber-optic cable to the small fiber-optic transmitter/receiver module on the rear of the relay chassis and the other end to a commercially available fiber-optic-to-RS-232 converter. The RS-232 side of the converter can then be connected to a modem to provide remote access via telephone lines, as shown in Figure CM-3. Either a "dumb" or a "smart" terminal may be used at the remote site, since no terminal software is required.

The serial data link option provides the user with the capability of remotely interrogating the Continuous Monitor module to read the data in memory and to clear the memory. Clearing the memory also clears the alarm contact. In the examples below, the full-duplex system as shown in Figure CM-3 is assumed, and the entries by the operator at the terminal are shown in parentheses. Carriage returns are not indicated, but every entry **must** be followed by a carriage return. Entries must be exactly as shown; extra spaces or added punctuation may cause the message to be ignored.

The first step in obtaining data remotely is to address the particular Continuous Monitor module by its identifying number (up to 16 unit-identification numbers can be assigned via an on-board switch setting on the module). This module or unit-number designation allows several modules at one substation to be addressed via one serial data link. Assume that unit 2 is to be addressed. Enter the following at the keyboard:

(***2)

The Continuous Monitor module will respond with one of the following messages:

***2 N	No data in memory
***2 M	Monitor data only in memory
***2 T	Trip data only in memory
***2 M T	Monitor and trip data in memory

Assume that "***2 M T" is received, indicating the presence of both monitor and trip data.

To access the monitor data, enter the following at the keyboard:

(MON)

Assume the response is:

***2 MON
03 09 31

In this case, points 3, 9 and 31 are stored in memory.

To access the trip data, enter the following at the keyboard:

(TRIP)

Assume the response is:

***2 TRIP
06 20 21 22 25 37

06 20 21 22 25 37

The first line of data is for the most recent trip, while the last line is for the earliest trip in memory. In this example data are shown for two trip events, but up to 5 events could be present.

If a different Continuous Monitor module served by the same link is to be accessed at this time, it will be necessary to deselect the present module by issuing a QUIT command, and then to address the next module. To quit a module, enter the following at the keyboard:

(QUIT)

The QUIT command does not erase the memory of the currently addressed module. It does deselect and return to normal mode any unit receiving the command, whether selected or not.

Clearing the Stored Data

The data can be cleared from memory either locally, via the module's front panel, or remotely, via the serial data link. Local clearing is accomplished by pushing the CLEAR DATA button located on the front of the module. The LED numeric display will show C/C until clearing is complete. Remote clearing of the selected unit is accomplished via the serial data link by entering the following command at the keyboard:

(CLEAR)

The CLEAR command, whether issued locally or remotely, clears both monitor and trip data from memory, and it resets the two contacts associated with the monitor alarm. When issued remotely, the CLEAR command also deselects the present module. If there is only one Continuous Monitor on a communications link, then either QUIT or CLEAR can be used as the final command after interrogation.

If there are multiple Continuous Monitor modules, then QUIT should be used, since it will return all the units on the communication line to the normal state. QUIT will not clear the memory, whereas CLEAR will. If the memory is to be cleared in such cases, CLEAR should be sent to each module, then one QUIT command to return all to the normal state. The monitor alarm contacts close when monitor data is stored in memory, and stay closed until a CLEAR command is issued.

MODES OF OPERATION

The Continuous Monitor module can be thought of as having three modes of operation: (1) monitor mode, (2) local-display mode, and (3) serial-data-link-access mode. Note that regardless of which mode the monitor is in, a relay-system trip will interrupt the program and trip data will be stored. The module is then returned to the monitor mode. Normally the module is in the monitor mode with no local- display-mode bits set. In this condition the module's front panel LED numeric display will show 0/0.

Local-Display Mode

To enter the local-display mode the operator places the DATA SELECT switch at either the MON DATA or the TRIP DATA position and pushes the STEP DISP. pushbutton. If there has been no trip since the last pass through the program, the program looks at the status (local-display mode) word to see if a display bit is set. There are two local-display-mode bits. One indicates that monitor data is to be displayed on the front panel LED numeric display. The other bit signifies that trip data is to be displayed. Only one of the two bits can be on at one time, and the presence of either bit will prevent use of the serial data link. To exit the local-display mode and return to the monitor mode, the operator changes the position of the DATA SELECT switch and pushes the STEP DISP. pushbutton once so that the LED numeric display shows 0/0. Pushing the CLEAR button will also return the module to the monitor mode but will erase the data. After a 5 minute delay, initiated when the local display mode is first entered, the module will automatically revert to the monitor mode. If an operator happens to leave the module in the local display mode, this automates reversion will prevent the loss of all but the first five minutes of data. While in the local-display mode, the module continues its monitoring, as in the monitor mode, except on those program passes when it sees the STEP DISP. pushbutton operated or when a trip has just occurred.

Serial-Data-Link-Access Mode

When in the serial-data-link-access mode the module does not continue the monitoring it performs in the monitor mode; however, it will record the trip data, then leave the serial-data-access mode. While the Continuous Monitor module is sending or receiving data, local access via the module's front panel is also denied.

Assuming that there is only one Continuous Monitor module that can be addressed by the remote terminal, the normal way to terminate this mode and return to the monitor mode is to issue a CLEAR or QUIT command. If neither command is received, after a 5 minute delay, initiated when the serial-data-link-access mode is first entered, the module will automatically revert to the monitor mode, preventing the loss of all but the first five minutes data.

When addressing several Continuous Monitor modules via one serial data link, all the modules will go to the serial-data-link-access mode when a signal is received over the link. In this case, QUIT will not only deselect the presently addressed module, but also act as a "site global" command, since all of the Continuous Monitor modules will return to the monitor mode. CLEAR will deselect the presently addressed module and clear its memory, but it will not cause all the modules to revert to the monitor mode. If the terminal operator forgets to issue a QUIT command, each module will automatically revert to the monitor mode following expiration of its individual 5 minute delay.

CONTINUOUS MONITOR ADJUSTMENTS

The only adjustment on this board is the address-setting switch. The location of this switch and the bit values of the individual switches are shown in Figure MO-13. The setting is the sum of the switch values. The setting can range from 0 to 15. Values from 10 to 15 correspond to addresses from Capital A to Capital F. This address is used to select a particular Continuous Monitor using the serial data link.

The front panel controls are as follows:

Panel Marking	Description
Point Number	Two-digit LED to display abnormal point input number. Top digit is the most significant.
Step Disp.	Pushbutton to step Point Number to next point (in numerical order).
Trip Data	LED that indicates, when lit, that trip data has been stored.
Mon. Data	LED that indicates, when lit, that monitor data has been stored.
Data Select	Two-position switch to select either trip or monitor data on Point Number display.
Clear Data	Recessed pushbutton that clears all memory data when operated.

CONTINUOUS MONITOR SERIAL LINK USE

The continuous monitor serial data link has the following characteristics:

Baud rate	300
Data bits	7
Parity	odd
Stop bits	1

When shipped, the TYS relay system chassis containing the Continuous Monitor is always wired to operate with the serial data link. To provide serial data transmission, a small fiber-optic transmitter/ receiver module can be installed on the 25-pin connector on the rear of the chassis. This connector resembles an RS-232 connector, but it is **not** RS-232 compatible. This fiber-optic transmitter/receiver module (FOM101) is made by GE and contains only the optical transmitter and receiver to couple to and from the fiber- optic cables. The optical transmitter and receiver are standard Hewlett-Packard devices, HFBR1402 and HFBR2402, which use SMA connectors. The other end of the fiber-optic cables (HFBR-3000 or equivalent) can be coupled to any suitable optical devices. Under normal conditions (no transmission) the fiber-optic transmitter at the chassis is OFF. The receiver at the chassis expects a similar "OFF" signal.

The simplest means of using the fiber-optic link is to purchase commercially available fiber-optic-to-RS-232 converters and related communications equipment. Figures CM-4 and CM-5 show two communication schemes that have been implemented.

CHECKSUM

There is a checksum routine that continually checks for EPROM memory errors. If it detects a failure, the front-panel display will reach "C5". The monitor alarm will operate and monitor bit 16 will be set. If this occurs, the Continuous Monitor module should be replaced.

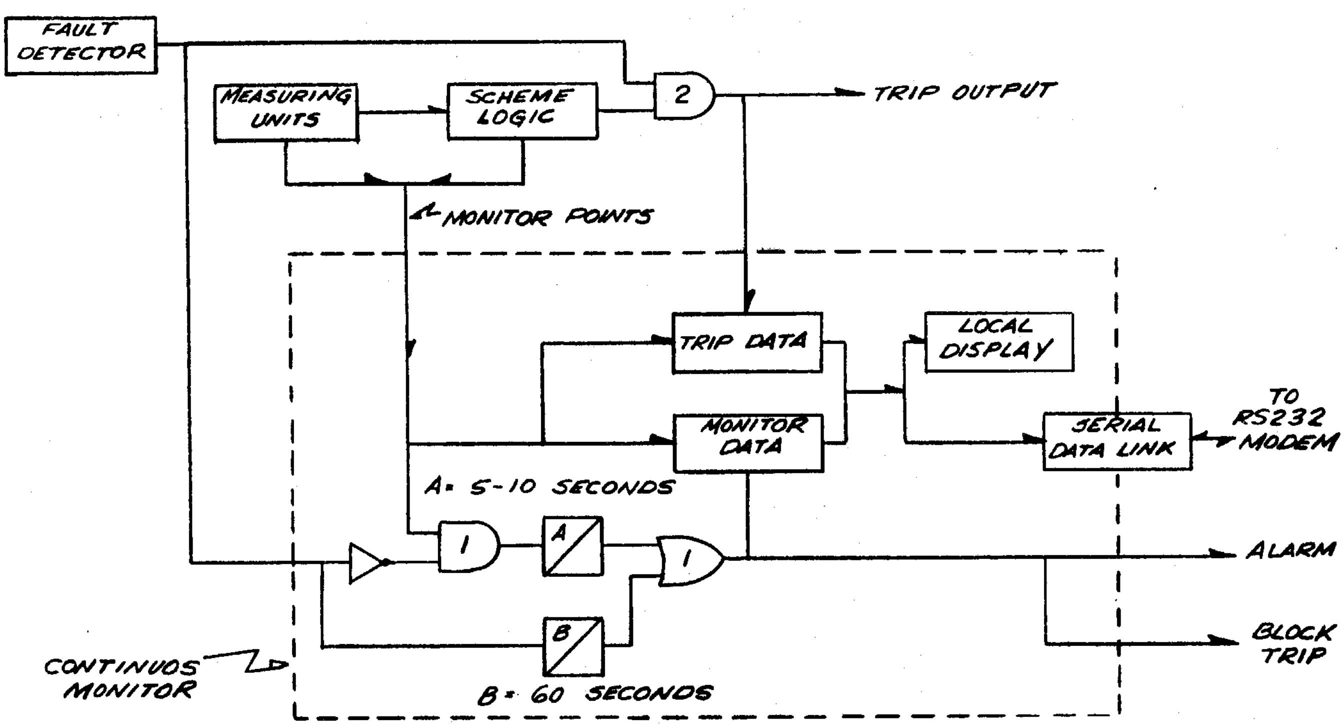


Figure CM-1 (0285A9897) Simplified Functional Diagram Depicting Continuous Monitor Operation

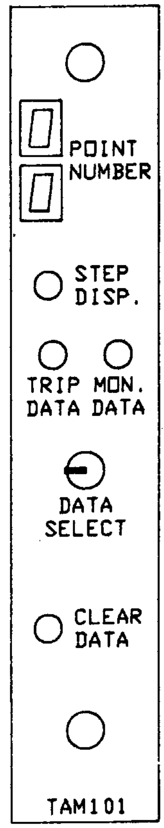


Figure CM-2 (0285A9898) Continuous Monitor Module Front Panel

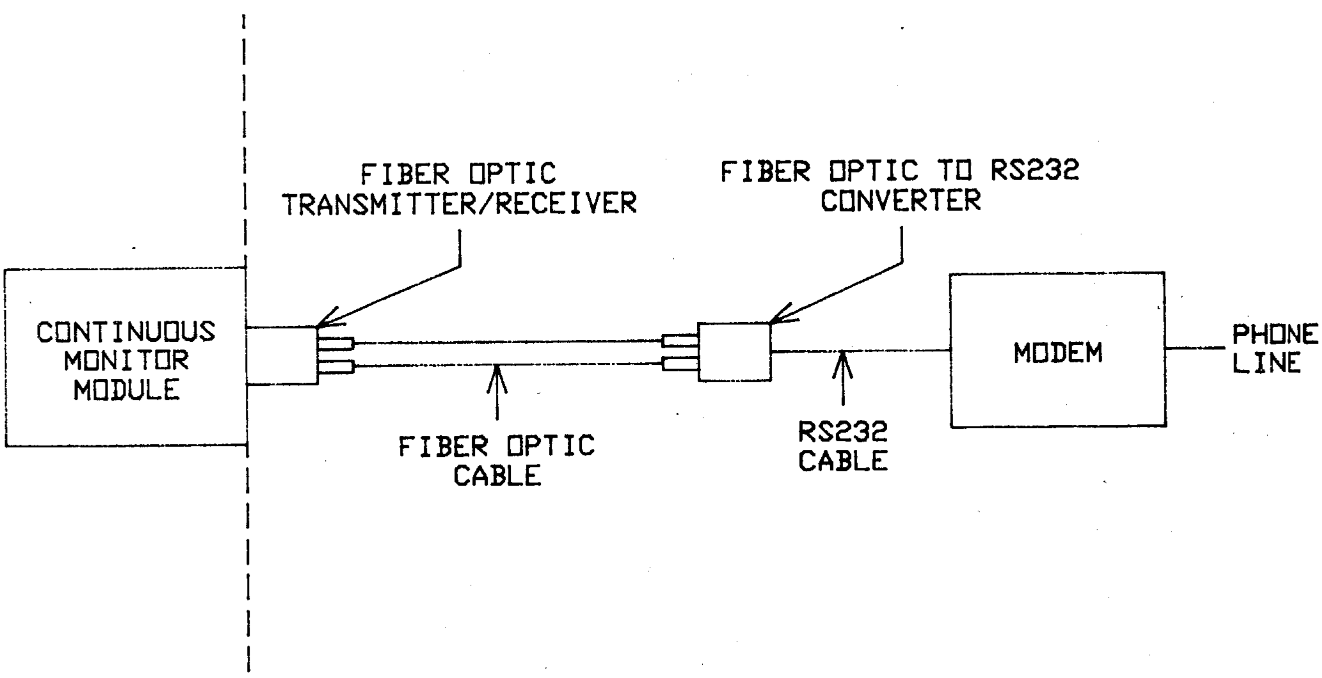


Figure CM-3 (0285A9899 [2]) Serial Data Link Connection

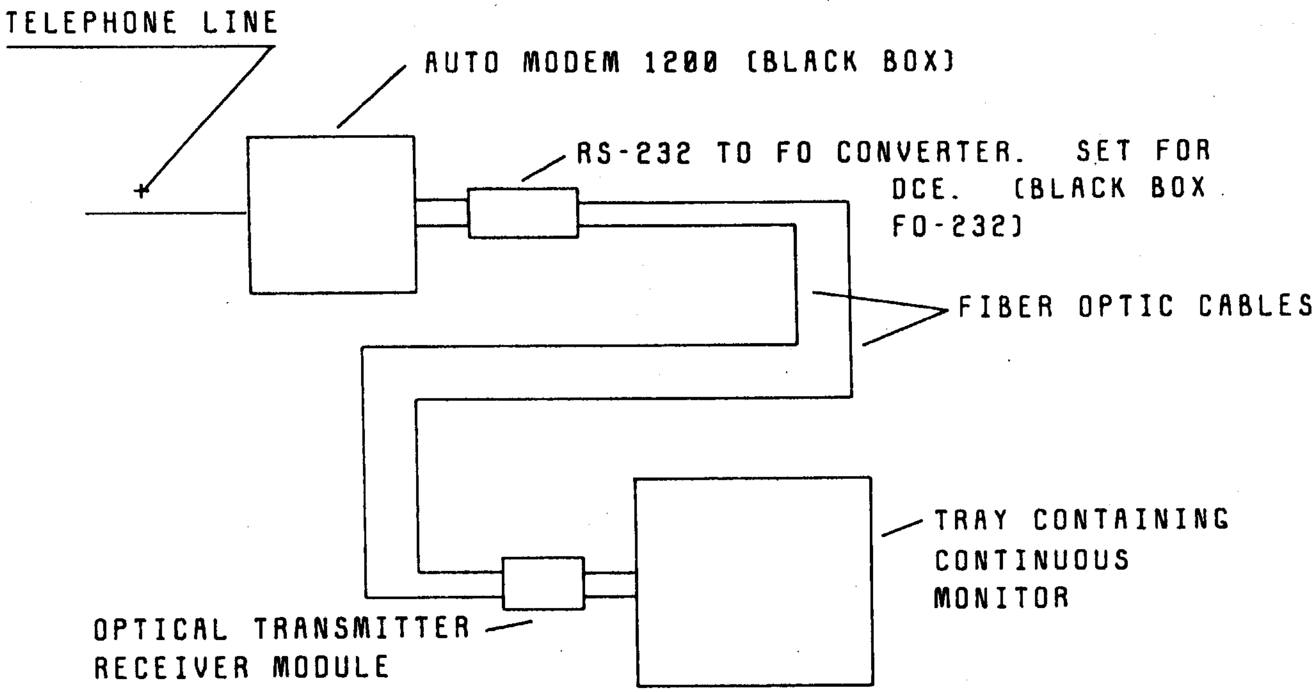


Figure CM-4 (0285A9836 [1]) Continuous Monitor Phone Connection

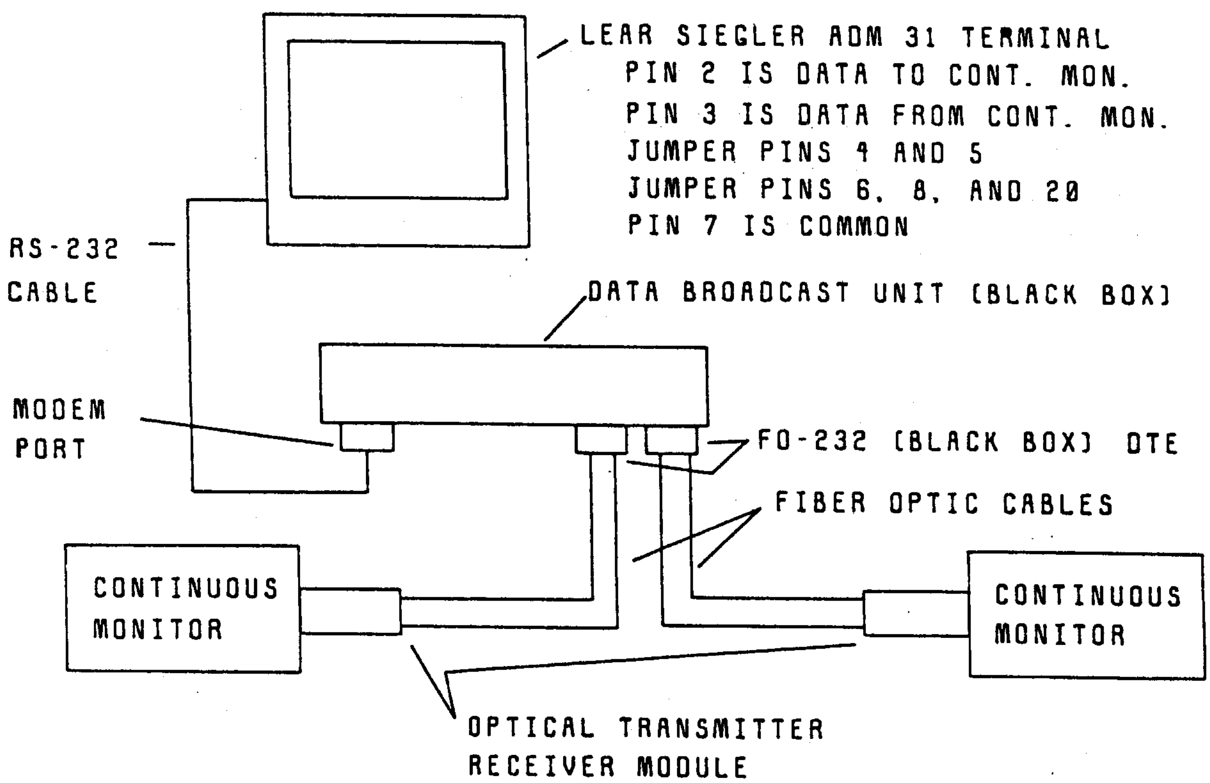


Figure CM-5 (0285A9837 [1]) Connection for Multiple Continuous Monitors

SOFTWARE

The following program is provided on a 5.25 inch disk. A 3.5 inch disk will be supplied upon request.

TLSTEST.exe

This program can be used to calculate specific test values to be used in testing the TLS1 system with any specific setting. After the program has been run, a complete listing of the test values will be provided. This listing can be viewed on the screen, or it can be printed out if a printer is available.

Running the programs

An MS-DOS-compatible computer is required to run the program. The computer must be booted up before the program can be run. To run the program, insert the disk in the drive to be used and then type the following:

d:tlstest

Where:

d = drive where program disk is inserted

Since the last edition of this instruction book, changes have been made in the following places:

Table of Contents updated
IN-2, Model Number Breakdown, Revision level
SD-23, Out-of-Step-Blocking, 9th function added
SD-26, Target Lamps, IN SERV target lamp added
SD-29, Table SD-5, ULM121/122 Module, L121A-8, L121B-5
SD-36, Figure SD-14B added
SD-40-42, Figure SD-22 changed
SD-43, Figure SD-23 revised
CS-1, ISM101/2, IT and IB
CS-14, ETM101, Zone 1, I0 SENS and $I\phi-\phi$
CS-15, ETM101, Zone 2, I0 SENS and $I\phi-\phi$
CS-16, ETM102, Zone 3, $I\phi-\phi$
CS-21, VMM101/102, I2LD
CS-22, ULM121/122, TL6
CS-23, ULM141, TL14 added
CS-35, ULM121/122
MO-9, ULM121
MO-10, 121B-5 added, Timer setting
MO-13, UTM102 ø font corrected
MO-15, Figure MO-1 revised
MO-21, Figure MO-12 revised
MO-23, Figure MO-16B added
AT-3, Table AT-1. ULM number
AT-6, Level-Detector Tests numbers 3, 5, 6
AT-7 & 8, Table AT-4 revised
AT-9, Figure AT-1 revised
SE-6-13, Figure SE-1 added
SP-2, Table SP-3, ULM121/122
SP-3, Table SP-4, TL6 footnote added

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