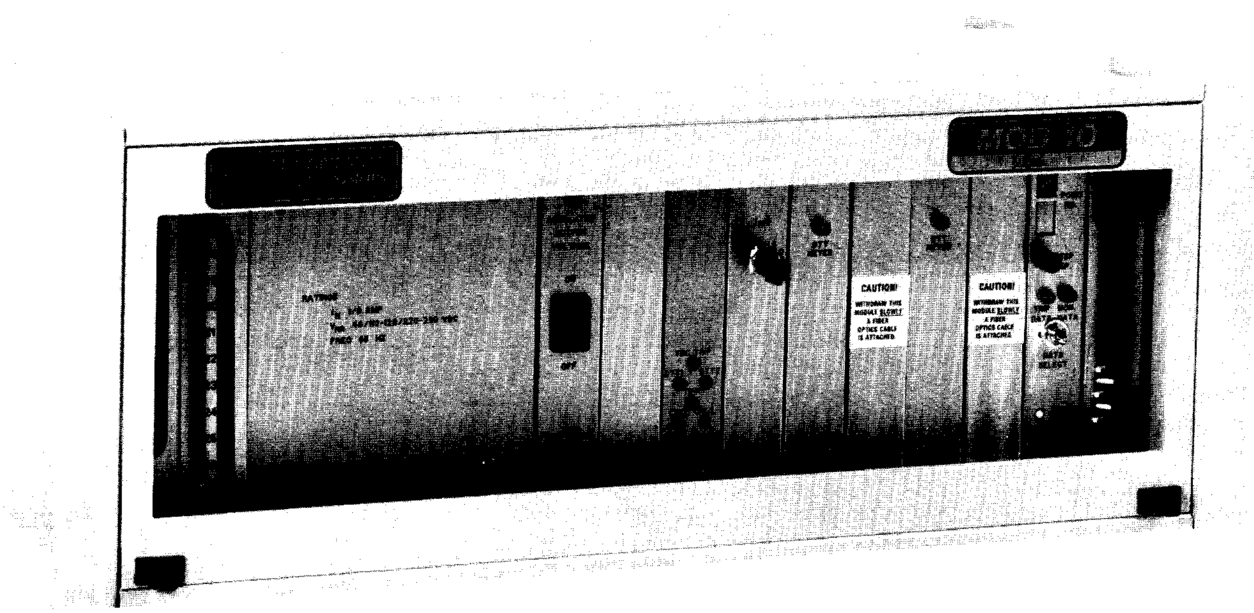
GEK-99341C

INSTRUCTIONS

DLS3
CURRENT DIFFERENTIAL
PROTECTIVE RELAYING SYSTEM



MULTILIN

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

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

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MOD-10™ DLS3 CURRENT DIFFERENTIAL LINE PROTECTION SYSTEM

DLS3 MOD-10 Current Differential Protection System

The DLS3 MOD-1O System for three-pole tripping applications can be supplied for either two or three terminal line applications. Systems for two terminal applications can be readily extended to three terminal line applications. This system provides high speed line fault protection, direct transferred tripping, optional definite time-over-current backup, and continuous channel monitoring. The communication modems are an integral part of the DLS3 current differential system which is mounted in a 7" high by 19" wide case featuring draw out construction of all functional modules. A unique load memory scheme is utilized allowing greater fault sensitivity than was possible with previous conventional current differential schemes.

A comparison signal proportional to (I_2 - ΔkI_1) in which ΔkI_1 is essentially the positive sequence component of fault current is utilized in the DLS3. The ΔkI_1 signal is obtained by storing the pre-fault load current in a memory circuit and subtracting it from the total post-fault positive sequence current.

The DLS3 system can be applied on dedicated non-metallic telephone pairs, single mode or multimode fiber optic cables, power line carrier, or microwave paths, as well as conventional metallic wire pairs.

A Microprocessor Monitoring Interface (MMI) module is available to provide notification of abnormal conditions in the DLS3 as well as functional response data for each DLS3 trip operation.

DESIGN FEATURES

Load memory
- Increased sensitivity
- Simplified application
- Constant operating time
- Senses faults during power swings

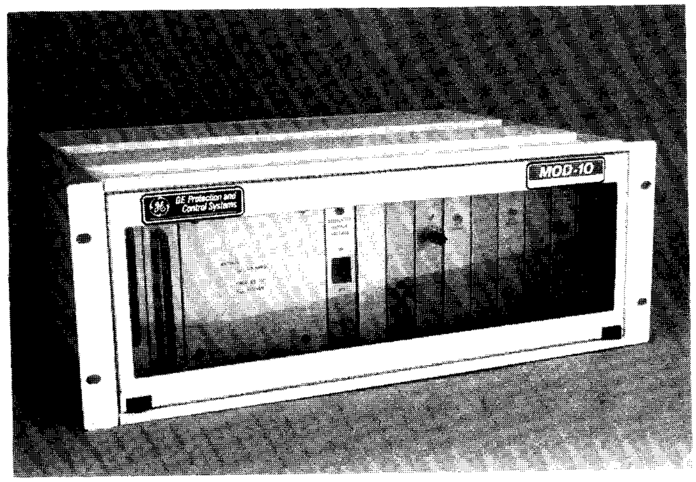
Security biased filtering
- Initial response faster in restraint than operate

Optional time overcurrent backup
- Remote backup and redundancy
- Increased sensitivity during channel outage

Optional pilot tone
- Frequency translation protection

Optional MMI continuous monitor module

The Microprocessor Monitoring Interface (MMI) module continuously monitors approximately 15 points in the DLS3 system. It compares the status of a level detector with the status of the monitored points to recognize abnormal conditions in the DLS3. This information is stored in non-volatile memory until accessed and/or cleared by the user. The MMI module is also activated when a trip occurs and stores in a separate area of non-volatile memory all of the monitored internal responses associated with the trip. Trip data for up to five events can be stored. Trip data and monitor data are accessed by pushing a button and viewing an LED display located on the front panel of the module. Data can also be accessed remotely via an optional RS232 interface available with the MMI.



OPERATING CHARACTERISTICS

High sensitivity
- Up to 500 ohms (or more) fault resistance accommodation
- 0.5 x tap pickup on 3 phase faults – radial feed
- 0.2 x tap pickup on unbalanced faults – radial feed

Fast fault clearing*
- Near end 1 cycle
- Remote end 1.5 cycles

Security biasing
- No fault restraint bias (load memory)
- Restraint before operate filter response
- Channel noise restraint with alarm
- Increased restraint on heavy external faults for two terminal lines

Application
- Two or three terminal lines
- Three-pole tripping
- Any voltage

* ± ¼ cycle; independent of load current; includes channel time; add ¼ cycle for contact tripping.

HARDWARE & PACKAGING

Draw-out modular construction
- Plug-in modules for test and maintenance
- Standard modular test and connection plugs for current/voltage injection testing

High-reliability components
- 168 hour burn-in of active semiconductors
- Conservative derating for long life

Suitable for harsh environment
- Temperature: –20°C to +65°C ambient
- IEEE/ANSI SWC surge tests (C37.90.1)
- GE RFI interference test
- IEC surge withstand test

MOD-10™ DLS3 CURRENT DIFFERENTIAL LINE PROTECTION SYSTEM

TECHNICAL DATA

Rated Frequency	• 50 or 60 Hertz
Rated Current	• I_N = 1 or 5 amperes
DC Control Voltage	• 48v range: 34 to 60 volts • 110-125v range: 88 to 156 volts • 220-250v range: 176 to 300 volts
Maximum Permissible Currents	
Continuous	• 2 × I_N
Three second	• 50 × I_N
One second	• 100 × I_N
Current Tap Range	• 0.8 to 2.4 x I_N
Current Sensitivity	• 0.5 x Tap for 3Ø faults • 0.2 x Tap for unbalanced faults
Time Overcurrent (TOC) Pickup Range	• 0.2 to 2.0 x Current tap, in steps of 0.1 x tap
Time Overcurrent Time Delay Range	• 0 to 1 second, in steps of 10 milliseconds
Time Overcurrent Sensitivity (Secondary Amps)	• For $I_1 \geq I_N$ $I_1 + I_2 = I_N$(Current tap)(TOC setting + 1.2) • For $I_1 < I_N$ $I_2 = I_N$ (Current tap) (TOC setting)
Time Overcurrent Curve Shape	• Definite Time
Insulation Test Voltage	• 2 kv 50/60 Hertz, one minute
Impulse Voltage Withstand	• 5 kV peak, 1.2/50 milliseconds, 0.5 joule
Interference Test Withstand	• 1 Mhz, 2.5 kV peak, decay time of 3 to 6 cycles to ½ value
Trip Outputs Contacts (3)	• Continuous rating = 3 amperes • Make and carry for tripping duty = 30 amperes (per ANSI C37.90) • Break 180 VA resistive @ 125/250 VDC • Break 60 VA inductive @ 125/250 VDC
Trip Test	• A trip test button is provided
Thyristor (2-SCR)	• Same as trip contacts except no interrupting rating - optional in lieu of normal trip outputs
Auxiliary Contact Outputs	• (3) BFI Breaker Failure Initiation • (3) RI Reclose Initiation • (1) Direct Transfer Trip; (2) Three Terminal • (1) Channel Monitor • (1) Channel Exalt • (1) TOC (optional) trip • (1) Trip • (1) Continuous Monitor Alarm (Optional)
Auxiliary Contact Ratings	• Continuous = 3 amperes • Make and carry for 30 seconds = 5 amperes • Break 25 watts inductive @ 125/250 VDC Maximum 250 v or 0.5 amperes
Hand Reset Targets	• Trip, Direct Transfer Trip, TOC Trip (Optional)
Ambient Temperature Range	• Storage −30 to + 75 degrees C. • Operation −20 to +65 degrees C.
Humidity	• 95 percent without condensing
Weight	• 15 Kilograms

NOMENCLATURE SELECTION GUIDE

DLS3 Model Numbers Three-Pole Tripping Models

DLS3 * * * * * * * * * *

A	4 Rack Unit Case
5	50 Hz Rated Frequency
6	60 Hz Rated Frequency
A	Two Terminal Line Application
B	Three Terminal Line Application
X	Special Application
0	48 VDC
1	110/125 VDC
2	220/250 VDC
C1	Audio Tone Channel Interface
C2	820 nm Fiber Optic Interface
C3	1300 nm Fiber Optic Interface
C4	C1 with Local Loop and Stub Bus*
C5	C2 with Local Loop and Stub Bus*
C6	C3 with Local Loop and Stub Bus*
1	Solid State Tripping Output (SCR)
2	Telephone Relay Tripping Output
C	Continuous Monitor
N	No Continuous Monitor
A	Pilot Tone Option
B	Pilot Tone and TOC Backup
C	TOC Backup
N	No Options
X	Special Customer Options
C	Revision Level

Examples:

DLS3A6A0C11NNC - DLS3 rated 60 Hz, 48 VDC, suitable for three-pole tripping on two terminal lines, with audio tone channel interface, SCR output module, no options, revision B.

DLS3A5B2C22CDCC - DLS3 rated 50 Hz, 250 VDC, suitable for three terminal lines, with 820 nm fiber optic channel interface, telephone relay tripping output, continuous monitor, time overcurrent backup, revision B.

*Local Loop Test Requires a GE XTC10 Test Panel

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SCHEME DESCRIPTION

GENERAL

Introduction

The DLS3 is a current-differential protective relaying system designed for the protection of transmission lines and feeders. The communication modem and interface module are an integral part of the system, which is completely contained within a single 7 inch high x 19 inch wide case featuring drawout construction of all modules.

The DLS3 can be applied with dedicated fiber-optic cable or nominal 4 kHz voice channels. The voice channels may be derived from microwave, single-sideband power-line carrier, metallic, non-metallic audio circuits, or multiplexing systems for fiber-optic channels. A "four-wire" channel is required; that is, a separate fiber or voice channel is required for each of the transmit or receive paths.

An optional pilot signal can be provided which is transmitted from each terminal to each other terminal to provide protection against frequency translation when the DLS3 is used with voice channel (telephone or microwave) links.

A bi-directional direct transfer trip function is a standard feature of the DLS3 system. Optional functions that are available include a backup definite-time overcurrent protection function, a pilot signal for voice channel application, and a Continuous Monitor (Microprocessor Monitoring Interface or MMI). The Continuous Monitor is available to provide rapid notification of abnormal conditions in the DLS3, as well as functional response data for each DLS3 trip operation. The DLS3 is applicable for either two-terminal or three-terminal operation.

DLS3 terminals for two-terminal operation may be readily extended to three-terminal operation with the addition of the third terminal and addition of the necessary cards to the first two terminals.

Logic diagram 0179C8272 (Figure 1-3) is for a DLS3 terminal for a three-terminal-line application. Logic diagram 0179C8271 (Figure 1-4) is for a DLS3 terminal for a two-terminal-line application.

Current-Differential Scheme

The differential-comparison circuits used in the DLS3 are similar in operation to certain percentage restraint BDD and STD transformer-differential relays. The operate quantity is proportional to the phasor difference in current entering one end and leaving the other end in a two-terminal application or entering one end and leaving both other ends in a three-terminal application. Under theoretically ideal conditions, the operate quantity is zero for through-fault or load conditions. The restraint quantity is proportional to the sum of the absolute values of the local and the received remote comparison quantity for a two-terminal application, and to the sum of the local and both of the received remote comparison quantities for a three-terminal application. The formation of both quantities is shown in the logic diagrams of Figures 1-3 and 1-4. The normal percentage restraint value is 30% for two-terminal line applications. The normal percentage restraint value for three-terminal applications is 40%.

Comparison Signal

Like many current differential schemes, the DLS3 utilizes for comparison a single-phase signal that is derived from the three-phase currents. This signal is an extension of the principle used successfully for many years in GE phase-comparison schemes.

These previous schemes use a single-phase signal proportional to the negative-sequence current minus a portion of the positive-sequence current ($I_2 - \Delta K I_1$) where I_2 and I_1 are referenced to I_A. This signal permits the scheme to operate for all fault types but it is de-sensitized by heavy load flow. To eliminate this de-sensitizing effect and simplify the application, the DLS3 uses a comparison signal proportional to (I_2 - ΔKI_1), where ΔKI_1 is essentially the positive-sequence component of fault current. The ΔKI_1 signal is obtained by storing the pre-fault load current in a memory circuit and subtracting it from the total post-fault positive-sequence current.

By setting the relay input tap equal to or greater than load current, the value of (I_2 - ΔKI_1) is zero under normal load conditions, eliminating the possibility of operation due to load, as opposed to earlier phase-comparison line-protection schemes that required a level detector setting above load current. However, the transient output of the ΔKI_1 circuit permits tripping for internal three-phase fault-current magnitudes down to approximately 40% of the tap value without loss of security under steady-state load conditions. It should be noted that this level can only be tested on a dynamic power system simulator. For two-terminal line applications, a steady-state trip signal is produced for three-phase internal-fault currents that exceed approximately 1.2 times tap value. In the three-terminal line applications there is no steady-state output for a three-phase fault.

Communications

The DLS3 transmitter is frequency modulated by the analog (I_2 - ΔKI_1) comparison signal, using a voltage-to-frequency converter. For demodulation, a frequency-to-voltage converter is used. The nominal unmodulated frequency is 1800 Hertz and the maximum frequency excursion is 1000 Hertz. When keyed, the integral direct-transfer-trip function (DTT) switches the unmodulated frequency to 3000 Hertz and prevents modulation by the comparison signal. Since the nominal frequency range is 800 to 3000 Hertz, the DLS3 may be used with standard 4 kHz voice channels as well as fiber-optic cables.

By selecting the appropriate interface module, the DLS3 can communicate over 820 nanometer fiber-optic cable, 1300 nanometer fiber-optic cable, or a nominal 600 ohm 4 kHz voice channel. A separate fiber or voice channel is required for each of the transmit and receive paths.

OPTIONS

The DLS3 has the following optional functions:

- Time-Overcurrent Backup
- Continuous Monitor
- Pilot Tone

Time Overcurrent Backup

An optional time overcurrent protection function is available for use with the DLS3 system. This function has a definite-time characteristic and operates from a signal proportional to $I_2 + I_1$. Protection is provided against both multi-phase and single-line-to-ground faults. When $I_1 < I_N$, the function operates from a signal proportional to I_2 to avoid picking up on load current.

This function is non-directional and will trip for faults in either direction. It is intended for use as a backup to the current-differential protection. An adaptive feature is included so that the definite-time setting will be halved automatically in the event the communication channel is lost to the remote DLS terminal, or to either or both of the remote DLS terminals in a three-terminal line application.

The time-overcurrent function can be enabled for, or disabled from, tripping, by placing Link TOC on the AMM1(--) module in the IN or the OUT position.

Continuous Monitor (Microprocessor Monitoring Interface)

An optional Continuous Monitor (MMI) is available for use with the DLS3 system, and the Continuous Monitor points are shown in the logic diagram of Figures 1-3 and 1-4 as CM1 through CM13, and CM45, CM47, and CM48.

The Continuous Monitor function works on the principle of recognizing a change in state of one or more of the approximately 17 monitored points (reference Table 7-I) 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 level detector that looks at the (I_2 - ΔKI_1) signal is used to determine whether the power system is in the quiescent or fault state.

A microprocessor, software stored in an EPROM, and other required support chips are the hardware/software that comprise the Continuous Monitor Module. If one or more of the monitored points changes state and the level (fault) detector has not operated, and if this condition persists for a minimum of 5 seconds, then an alarm output is issued. These abnormal points are stored in non-volatile memory for later retrieval. The Continuous Monitor also acts to store in non-volatile memory those monitored points that have changed state within 10 milliseconds of a relay-system trip output. This can be useful in analyzing DLS3 response to power-system faults. Data for the five most recent events are stored sequentially. Necessary software is included for the Continuous Monitor to operate with a serial data link, and data may be accessed locally at the DLS3.

Pilot Tone

Audio links (including microwave) are sometimes subject to frequency translation errors, which can cause false trips. An optional pilot tone is available, with the DLS3 with voice channel links, to guard against this problem. Pilot tones are transmitted continuously to check that frequency translation errors have not occurred. The pilot tone is transmitted at 400 Hz and its power level is approximately equal to that of the wide-band FM current-differential signal. At the receiver, the two signals are separated using filters. The two signals are rectified, filtered, and compared in strength. As long as there is no appreciable frequency translation error, the strength of the two signals will remain approximately equal. If the ratio of the strength of the two signals deviates too far from unity, then tripping is blocked and an alarm is given. The use of exalt is not recommended with pilot tone since the combination reduces the permissible received signal dynamic range.

APPLICATION

The DLS3 system can be used in the following applications:

- Two- or three-terminal lines
- Any voltage
- Three-pole tripping

The DLS3 relay system provides high-speed current-differential protection for transmission lines and feeders. The DLS3 system may be applied on either a two-terminal- or a three-terminal-line application. If the DLS3 is applied initially in a two-terminal application, it will be necessary to add several cards to each of the two original terminals when a third terminal is added.

This section and the CALCULATION OF SETTINGS section present the application considerations and setting criteria for the DLS3 relay for operation on a two-terminal line and also for the three-terminal line. These are based on a three-pole trip scheme and application on lines that do **not** contain series capacitors.

Two-Terminal Line

The DLS3 can produce a trip output at both ends of the line for fault-current infeed at one terminal only, provided the weak-(or zero)-infeed end DLS is properly configured and that the fault current at the strong-infeed end is above a certain level. At the weak-infeed terminal, the CURRENT SUPERVISION link on the IOM153 module must be set at the OUT position. Assuming an internal phase-to-ground fault with zero fault-current contribution at the weak-infeed end, the sensitivity of the strong-infeed end DLS is

0.2 x INPUT TAP. However, at the weak-infeed end, the (I_2 - ΔKI_1) level detector cannot operate to switch out the fixed restraint bias, and this additional restraint must be overcome by a higher level of fault current at the strong-infeed end. The incremental fault-current level required at the strong-infeed end to trip both terminals is 0.15 x INPUT TAP when the percentage restraint is 30%.

To illustrate the above considerations, assume the DLS at the strong-infeed end is set with a 0.8x5 = 4 amps input tap. For this case, 0.2x4 = 0.8 amp is required to trip the strong-infeed end. However, (0.15x4) + 0.8 = 1.4 amps is required to trip both ends for the assumed phase-to-ground fault.

As with any current differential relay, the current transformers (CTs) at the two ends of the line should have the same ratio. If it is not possible to obtain the same CT ratios at each end, then it may be possible to use the input taps of the DLS3 to balance the differential circuit. Since the input tap range is from 0.8 to 2.4 x I_N, the CT ratio mismatch between the two ends cannot exceed a 3:1 ratio difference. The input taps are discrete selections (0.8, 1.0, 1.2, 1.4, 1.6, 2.0, and 2.4), and it will not be possible to match exactly all possible CT ratio mismatches.

The CTs should also be matched in type and capability to reduce the possibility of wide variations in output between the two ends for an external fault. A major cause of divergence in response to an external fault is unequal CT saturation at the two ends. If the CTs at each end are identical (e.g. bushing type, rated 10C200), then the likelihood of a CT saturating at one end but not at the other during an external fault is greatly reduced. However, widely different levels of remnant flux in the CTs at one end versus the other end may still result in a CT saturating at one end but not at the other, despite the use of identical CTs. Such an occurrence is statistical in nature and does not diminish the reason to use identical CTs at each end.

The worst-case scenario occurs when one or more CTs saturate completely at one end while the CTs at the other end do not saturate at all. It is virtually impossible to design a current-differential relay that will be secure (not operate) for an external fault, and maintain dependability (operate) for an internal fault under this worst case scenario. The DLS3 has been designed to provide an optimal balance between security and dependability during CT saturation, and can operate for an internal fault that results in CT saturation. A conservative application rule is presented later to permit a user to determine if the saturating CT will produce sufficient output, prior to complete secondary collapse, to permit the DLS3 to operate.

The DLS3 contains the communication modem as well as the relay scheme. Because the nominal bandwidth of the FM modulation is limited to 800 to 3000 Hz, the DLS3 may be used with any derived 4 kHz voice channel as well as dedicated fiber-optic cable. However, certain derived voice channels exhibit variable propagation delays because the associated communication system (e.g. microwave or leased circuit) is configured for alternate path routing. Since the DLS3 utilizes a fixed time delay (LOCAL PHASE SHIFT) on the AFM113-116 module to compensate for channel propagation delay, a derived voice channel that exhibits variable propagation delay should **not** be used with the DLS3. For a voice-channel application, the channel-noise-restraint link should be set at the 2.5 position.

The optional time-overcurrent-protection function operates from a signal proportional to $I_2 + I_1$ and has a definite-time characteristic. The settable pickup range is from 0.2 to 2.0 times the current-differential INPUT TAP in steps of 0.1 times the INPUT TAP. The settable time delay for this function is from 0 to 1 second in steps of 10 milliseconds. An adaptive feature is included so that the time-delay setting is reduced by one-half in the event of the loss of the communication channel. Choice of pickup and time-delay setting should be based on coordination with other protective devices on adjacent line sections, on the basis that the time-overcurrent function is a backup to the current-differential function.

Three-Terminal Line

Normally, in setting the DLS3 for either two- or three-terminal operation, it is necessary to set the INPUT TAP above load current. However, with three-terminal lines, it is sometimes possible that there will be outfeed at one of the terminals for an internal fault on the protected line. This condition imposes a restriction on the setting of the INPUT TAP at each of the three terminals to ensure that the DLS3 will trip for the internal fault condition. This is described in the section entitled CALCULATION OF SETTINGS.

The DLS3 can provide a trip output at all three terminals for fault-current infeed at only one or two terminals, provided that the weak-(or zero)-infeed terminals are properly configured and that the fault-current level at the strong-infeed terminal is above a certain level. Assuming an internal phase-to-ground fault with zero fault contribution at two weak terminals, the sensitivity of the strong-infeed DLS is 0.2 times INPUT TAP. The incremental fault current level required at the strong terminal to trip all terminals is 0.2 x INPUT TAP for the single-phase-to-ground fault.

For a three-phase internal fault, the sensitivity of the strong-infeed DLS is 0.4 times INPUT TAP. The additional increment of fault current required at the strong-infeed terminal to trip the weak-infeed terminals is approximately 0.3 times INPUT TAP.

Current Transformer Saturation Considerations

The DLS3 has been designed to provide an optimal balance between security and dependability during CT saturation. The DLS3 can operate for an internal fault that results in CT saturation, providing the CTs faithfully reproduce at least one full cycle of fault current prior to saturation. It is suggested that the user refer to IEEE Publication 76 CH 1130-4 PWR, entitled "Transient Response of Current Transformers" for a simplified method to determine the time to saturation. This 1976 publication is a report sponsored by the IEEE Power System Relaying Committee. It provides time-to-saturation curves that minimize the analytical work.

Fiber-Optic Link Considerations

If fiber-optic data links are to be used with the DLS, there are certain engineering decisions to be made. One of the first is whether to use 820 nanometer (nm) or 1300 nanometer links.

In general the 820 nanometer links offer the lowest cost and easiest use. They are best suited for shorter distances because the attenuation of the fiber-optic cable is higher. Over short distances they have advantages compared to the 1300 nm links. The transmitters have a longer operating life and are more tolerant of temperature changes. Furthermore, connectors can be used more freely. This is advantageous in installation and in maintenance.

The 1300 nanometer links use a fiber-optic cable whose core is only 8 to 9 microns in diameter, compared to 50 to 100 microns in 820 nm cable. Transmitters for both frequencies are light-emitting diodes that emit a relatively wide beam of light. The fiber-optic cable is positioned in the beam to pick up the maximum amount of light. More light will fall on the end of the large 820 nm core than on the end of an 8-9 micron 1300 nm core. Thus the optical power into the core is generally lower in 1300 nm transmitters.

The 1300 nm optical signal starts out at a lower power level, but the lower cable losses make longer fiber-optic links possible. In 1988 the typical attenuation of 1300 nm cable was approximately .75 dB/km. For 820 nm cable, the attenuation ran approximately an additional 1.5 dB/km. On long links this difference can be critical.

As already mentioned, the 1300 nm transmitters may have a shorter operating life.

This life is greatest at normal temperatures; under adverse conditions (e.g. high temperatures) it could be as low as 5 to 10 years. In addition, the transmitter power drops with increasing temperature. For this reason, it is advisable to avoid placing a DLS relay with 1300 nm data links in high ambient temperatures.

The small core diameter (9 micron) makes it difficult to fabricate connectors that will line up the faces at the ends of such small cores. The result is that losses in the same connector may vary from 0.5 dB to 3 dB when it is disconnected and reconnected. To avoid this problem, most users of 1300 nm links use splices to join cables, and not connectors. Splice losses are normally no more than 0.2 dB each.

The actual design of the fiber-optic link and its installation is a separate field of engineering. Obviously a fiber must be chosen with losses low enough to have usable signal levels at the receiver. However, it is usually necessary to provide at least a few connectors to permit cable and equipment test. These losses must be accounted for. Splice losses, both initial and those required during the cable's lifetime, must be added. Since the installation cost of the fiber-optic cable will probably be many times the cable cost, it is customary to include spare fibers in the event some of them are defective or break during installation. Specialized equipment and training are needed to install fiber-optic connectors and to make splices. Special precautions are needed during installation to avoid bending the cable too sharply or pulling it with too much force; either of these can damage the cable. The design of the cable that includes the optical fibers varies with the application. Suspended cables differ from buried cables. The cables inside buildings making long vertical runs differ from those that lie horizontal in ducts. This cable engineering and installation is done by the user, or contracted out.

COMPUTATION OF 1300 NM LOSS BUDGET

There is a maximum permissible fiber optic link loss for a particular fiber optic wavelength (820 or 1320 nm) and cable type (50/125 or 100/140 µm). The following example shows how this is calculated.

• DLS3 Receiver:	
Receiver Sensitivity at 25°C	-63 dBm
Required Signal-to-Noise Ratio	6 dB
Sensitivity Loss at High Temperature (50°C)	3 dB
Minimum Receiver Signal (Worst Case)	-54 dBm
• DLS3 Transmitter:	
Minimum Transmitter Power (8µW)	-21 dBm
Transmitter Operation at 50°C	-3 dB
Aging of Transmitter Diode (5-10 years)	-3 dB
Minimum Transmitter Power (Worst Case)	-27 dBm
• Loss Budget (Worst Case) -54 dBm - (-27 dBm)	-27 dB

EXAMPLE OF USE OF LOSS BUDGET:

To determine if the loss budget is met in a particular application, proceed as shown in the following example.

Current-Differential Relay Application, 1300 nm Fiber-Optic Channels
Longest Path = 40 km.

Light Path Budget (0.4 dB/km cable loss assumed)

Cable: 40 km (0.4 dB/km)	16 dB
Splices:	2 dB
Connectors: (2 × 0.5 dB/connector	1 dB
Patch panels (4 × 1 dB/panel	4 dB
Total	23 dB

Margin (Loss budget - loss)
27-23 = 4 dB (satisfactory)
Loss must not exceed loss budget.

Note: Under laboratory test conditions (e.g. room temperature and with new transmitter diode), the attenuation required for loss of channel is approximately 34 to 36 dB.

LOGIC DESCRIPTION

Basic Operation

As shown in Figures 1-3 and 1-4, the local (I_2 - ΔKI_1) comparison signal phasor is applied to the FM modulator of the local transmitter, which, coupled with the proper channel interface, transmits this phasor information to the remote ends. The output of the local transmitter is also demodulated, phase delayed, and the resultant local operate signal is applied to one input of a summing amplifier. The remote operating quantity (quantities, for three-terminal lines) is received, demodulated, and applied to the second input of the summing amplifier, or second and third inputs for three-terminal lines. The output from this "total operate quantity" summing amplifier is rectified to produce an absolute value that is applied to a second summing amplifier that, when combined with an integrator/detector, comprises the comparator of the DLS3. The total operate signal is supervised prior to the comparator by the loss-of-signal (channel monitor) circuit and pilot monitor circuit from the remote terminal, or both remote terminals for a three-terminal line.

A link, INT'GR BLK, allows the user either to block relay operation upon loss of channel or to allow relay operation despite a loss of channel. Links are provided with the channel monitor and the pilot monitor circuits to allow for either two or three-terminal operation.

The local restraint signal and the remote restraint signal(s) (two remote restraint signals for three-terminal lines) are tapped off at the respective demodulator outputs, passed through absolute value circuits, summed, and applied to the comparator. For heavy faults, as determined by I_2 + I_1, the percentage restraint can be increased by switching in additional restraint to the comparator (two terminal lines only). A fixed restraint value (bias) is continuously applied to the comparator during quiescent (non-fault) conditions. In essence, this increases (or biases) the level detector setting of the integrator/detector. When the (I_2 - ΔKI_1) level detector picks up, the fixed bias is switched off and, after a time delay dependent upon the integrator time constant, the level detector setting is decreased. The overall operation is such that at the instant a fault occurs, a higher level of net operate signal is required to produce a trip output than is required a short time later. This adds to scheme security.

The remaining restraint input is from the channel-noise-detector circuit for a two-terminal line, or from the two channel-noise-detector circuits in the case of a three-terminal line application. With noise restraint set to 2.5, a poor channel signal to noise ratio cannot give a false trip (based on wideband noise).

Note that the local comparison signal is modulated and demodulated prior to tapping off outputs for the local operate and restraint signals. This assures a compatible transient response to that of the remote signal or signals.

Direct Transfer Trip

A bi-directional direct transfer trip function, DTT, is a standard feature of the DLS system. The DTT function is activated by closing an external contact connected to contact converter 1, CC1. In the three-terminal application there are two CC1s, and the transfer trip signal is transmitted to both remote terminals. The resulting logic level output from CC1, or from the two CC1s in the three-terminal application, switches the unmodulated frequency to 3000 Hz and prevents modulation by the comparison signal (I_2 - ΔKI_1). This 3000 Hz signal is received at the remote DLS terminal, or terminals, and results in a DTT output at the remote terminal or terminals. Links are provided to permit or inhibit direct transfer tripping at the local DLS terminal from either or both of the remote terminals in a three-terminal application, or from the remote terminal in a two-terminal application.

With LINK DTT2 in the DTT2 OFF position, the direct-transfer-trip function from the DLS3 at remote location 2 will not be passed through to the trip circuit at the local DLS. With Link DTT2 in the PT NOT REQ position, the direct transfer trip function from the DLS at remote location 2 will be passed through to the trip circuit at the local DLS, regardless of the pilot monitor signal status. If LINK DTT2 is in the PT REQ position, then the pilot tone must be received without translation to permit transfer trip from the DLS at remote location 2. Alarm contact outputs and LEDs are provided for each direct transfer trip. The channel monitor inputs to AND7 must also be received to allow an output from AND7 to AND8. Another link, DTT2 IN/OUT must be in the 3T position to supply the top input to AND8 to allow a transfer trip signal from remote location 2 via OR1 and OR2. Link DTT1 has 3 positions similar to DTT2. The path for a received transfer trip signal from remote location 1 is via AND6, AND3, OR1, and OR2.

The only way the direct-transfer-trip function can be activated at the local terminal is by closing an external contact connected to CC1. When the current-differential portion of the DLS operates to produce a trip for an internal fault, the DTT function is not activated. When the DTT function is activated at one terminal, an output will occur only at the remote terminal, or terminals, not at the local terminal.

Integrator Trip

The INTG TRIP link will block current-differential pilot tripping if it is in the IN position and either pilot monitor signal is lost, since there would be no output from AND4 to AND5. Links INTG PILOT SUPV 2/3 and INTG TRIP SUPV 2/3 have two-terminal and three-terminal positions so that AND4 and AND5 can be satisfied for a two-terminal application since there is no received signal from remote location 2. The trip output for a current-differential trip is via AND1, and the CURR SUPV link in the IN position requires current above the level detector to allow a trip output to OR2.

Elementary Diagram

The elementary diagram for the DLS3 relay for three-terminal operation is shown in Figure 1-5. The elementary for the DLS3 relay for two-terminal operation is similar except for the omission of the channel interface to the second remote, etc.

Local Loop Test (Option)

The Local Loop Test optional feature allows the user to exercise the local DLS3 transmitter and receiver circuits. This test is initiated by a user-supplied contact closure to contact converter CC3. The transmitted 1800 Hz signal is looped back into the local receiver and an LED (Local Loop Test) is lit as long as the closed contact input to CC3 is maintained. Current differential operation at the local DLS3 is blocked while this test is in progress.

The transmitted signal is not sent to the DLS3 at the remote terminal. The DLS3 at the remote terminal will sense a loss-of-channel condition. If the Integrator Block Link (INT'GR BLK-L1) at the remote terminal is in the IN position, the current-differential circuit at that terminal will be disabled as long as the local loop test is in progress. If that link is in the OUT position, the current-differential circuit at that terminal is not blocked from operating. Normally, this link must be in the IN position with the Local Loop Test option. Refer to the Integrator Block Link description in the CALCULATION OF SETTINGS section of this instruction book for further details of this link setting.

STUB BUS PROTECTION (OPTION)

The Stub Bus Protection feature is initiated by a user-supplied contact closure to contact converter CC4. It causes the DLS3 at the local terminal to send an 1800 Hz signal (or summed 1800 Hz plus 400 Hz pilot tone, if applicable) to the DLS3 at the remote terminal and also feed this signal into the local DLS3 receiver. An LED (Stub Bus Protection) is lit as long as the contact closure to CC4 is maintained.

The purpose of the Stub Bus Protection feature is to provide protection for a stub bus section when the transmission line to the remote terminal is opened, e.g. by a disconnect switch in the line at the local end. In this case, a contact from the disconnect switch might be used as the input to CC4.

While the Stub Bus Protection feature is enabled, the constant-frequency signal will be transmitted from the local DLS3 to the remote DLS3 terminal. This signal is also looped back into the local DLS3 terminal. If a fault should occur on the local stub bus section during this time, protection is provided by the current-differential circuit of the local DLS3 responding to the I_2-ΔKI_1 signal developed from the local current-transformer inputs. Similarly, protection is also provided for faults on the line section fed from the remote terminal that is receiving the constant-frequency signal from the local DLS3.

Outputs

Three "a" contacts or three SCRs (semiconductor-controlled rectifiers) are provided for tripping duty. Refer to the specific model number and to the Nomenclature Selection Guide located in the INTRODUCTION of this instruction book to determine which outputs have been supplied.

Three "a" contacts or three SCRs (BFI) are provided for use in the breaker-failure-initiate circuits (trip rated). Refer to the specific model number and to the Nomenclature Selection Guide located in the INTRODUCTION of this instruction book to determine which outputs have been supplied.

Three "a" contacts (RI) are provided for use in the reclose-initiate circuits (trip rated).

Five "a" contacts (DTT) are provided for Direct Transfer Tripping (trip rated).

Auxiliary contact outputs are provided for the following:
- Trip Alarm
- Time Overcurrent (TOC) Trip (optional)
- Direct Transfer Trip from Remote #1
- Direct Transfer Trip from Remote #2
- Channel Monitor
- Continuous-Monitor Alarm (optional)
- Channel Exalt
- Power-Supply Alarm
- Any Direct Transfer Trip

Target Lamps

Red LED targets will light and be sealed in whenever a trip occurs. These target lamps can be reset via a pushbutton located on the front of the IOM153 module. They indicate:

- Trip
- Direct Transfer Trip Signal Received
- TOC Trip (optional)

Yellow and green LED targets are not sealed in. Yellow LEDs indicate:

- TOC timing
- Contact Converter(s) Energized for Direct Transfer Trip Signal to Remote(s)
- Stub Bus or Local Loop Test energized

Green LED targets are provided for:

- Pilot Monitor(s)
- Channel Monitor(s)

Trip Test

A trip test button is provided in the IOM153 module. It is recessed to prevent accidental tripping while the DLS3 is in service. The pushbutton activates the Current Differential trip logic only.

MOD 10 MNEMONIC LEGEND

BFI	BREAKER FAILURE INITIATE
BLK ZN	BLOCKING ZONE
CC	CONTACT CONVERTER
CFA	CHANNEL FAILURE ALARM
CHTR	CHANNEL TRIP
CK, CLK	CLOCK
CM	CONTINUOUS MONITOR POINT
DLA	DATA LOGGING ALARMS
FD	FAULT DETECTOR
FDP	FAULT DETECTOR SUPERVISION
FF	FUSE FAILURE
$I_{\emptyset\emptyset}$	PHASE TO PHASE CURRENT (MT OVERCURRENT SUPERVISION)
I_1	LINE PICKUP SUPERVISION
I_{1S}	POSITIVE-SEQUENCE SUPERVISION
I_{1T}	POSITIVE -SEQUENCE TRIPPING SUPERVISION
I_B	BLOCKING OVERCURRENT SUPERVISION
IDT	DIRECT TRIP OVERCURRENT
IM	OVERCURRENT SUPERVISION
IMA	PHASE A SENSITIVE OVERCURRENT FUNCTION
IMB	PHASE B SENSITIVE OVERCURRENT FUNCTION
IMC	PHASE C SENSITIVE OVERCURRENT FUNCTION
I_0	ZERO-SEQUENCE OVERCURRENT SUPERVISION
I_0-KI_1	ZERO-SEQUENCE OVERCURRENT WITH POS. - SEQUENCE RESTRAINT
IPB	PILOT BLOCKING
IPT	PILOT TRIPPING
IR	RECLOSE INHIBIT
IT	TRIPPING OVERCURRENT SUPERVISION
ITOC	TIME OVERCURRENT SUPERVISION
LR	LOCKOUT RECLOSE
M1	PHASE-PHASE ZONE 1 DISTANCE FUNCTION
MB	MHO BLOCKING FUNCTION
MG1	PHASE-GND ZONE 1 DISTANCE FUNCTION
MOB	MHO OUT OF STEP BLOCK FUNCTION
MT	PHASE-PHASE OVERREACHING PERMISSIVE TRIP FUNCTION
MTG	PHASE-GND OVERREACHING PERMISSIVE TRIP FUNCTION
NB	NEGATIVE-SEQUENCE BLOCKING DIRECTIONAL FUNCTION
ND	NEGATIVE-SEQUENCE DISTANCE FUNCTION
NDD	PERMISSIVE NEGATIVE-SEQUENCE DISTANCE FUNCTION
NT	NEGATIVE-SEQUENCE TRIPPING DIRECTIONAL FUNCTION
OS	OUT OF STEP
OSB	OUT OF STEP BLOCKING
PD1	POSITIVE-SEQUENCE ZONE 1 DISTANCE FUNCTION
PDB	POSITIVE-SEQUENCE BLOCKING DISTANCE FUNCTION
PDT	POSITIVE-SEQUENCE OVERREACHING DISTANCE FUNCTION
PDX	AUXILLARY ZONE POSITIVE-SEQUENCE DISTANCE FUNCTION
POSB	POSITIVE-SEQUENCE OUT-OF-STEP BLOCKING FUNCTION
PTFF	POTENTIAL FUSE FAILURE FUNCTION
RB	RECLOSE BLOCK
RCVR	CHANNEL RECEIVER
RI	RECLOSE INITIATE
SUP	SUPERVISION
TAR	TARGET
TH	THRESHOLD
TOC	TIME OVERCURRENT BACKUP
TP	TEST POINT
TR BUS	TRIP BUS
TT	TRANSFER TRIP
V_1	POSITIVE-SEQUENCE UNDER VOLTAGE FUNCTION
V_A	PHASE A UNDER VOLTAGE FUNCTION
V_B	PHASE B UNDER VOLTAGE FUNCTION
V_C	PHASE C UNDER VOLTAGE FUNCTION
V_P	POLARIZING VOLTAGE
WI	WEAK-INFEED TRIP
XMTR	CHANNEL TRANSMITTER

Figure 1-1 (0286A2774 [4]) MOD 10TM Mnemonic Legend

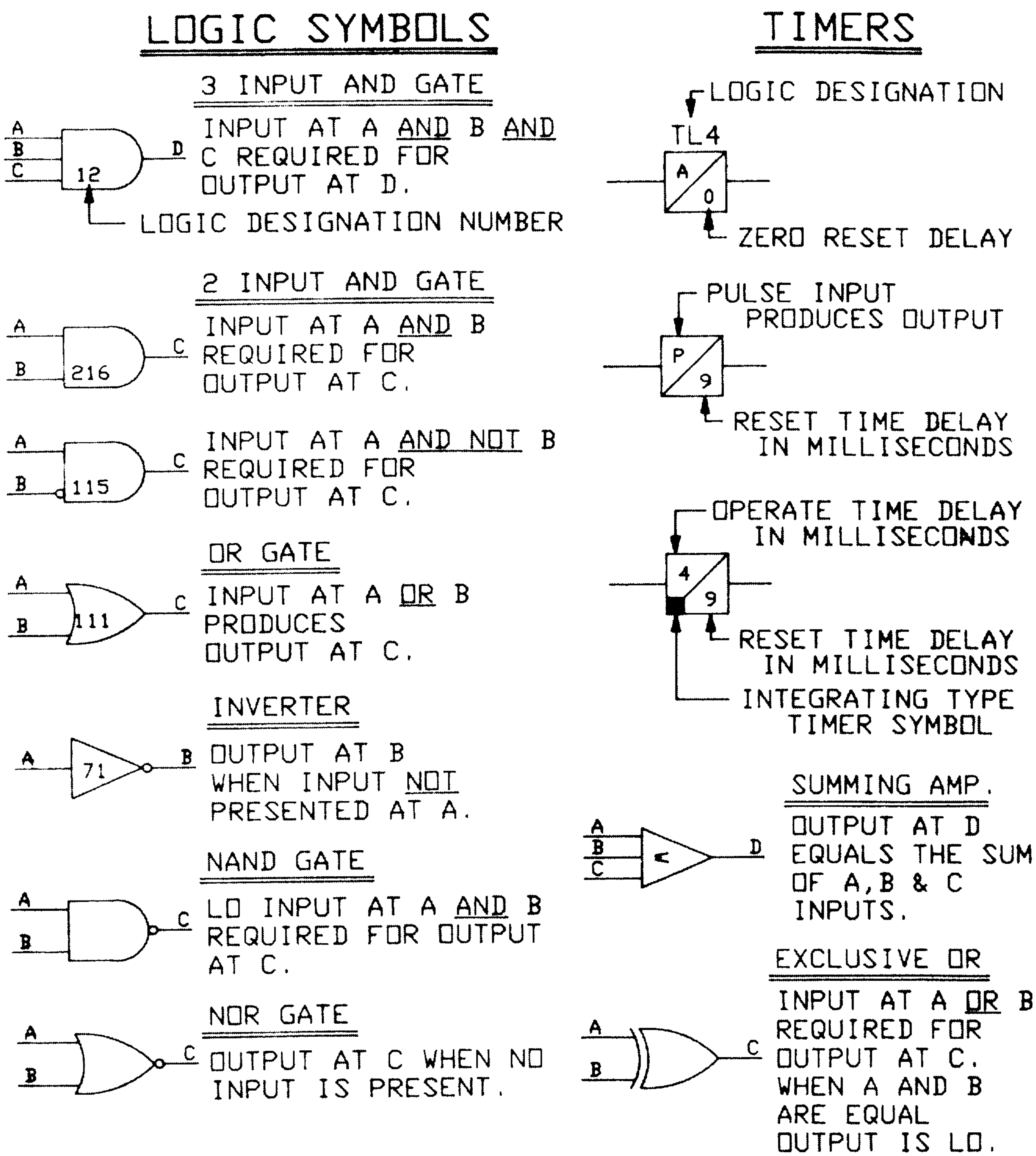
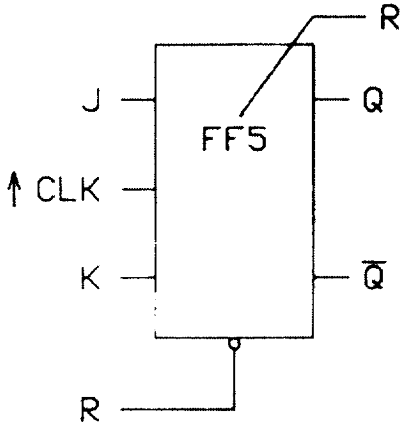


Figure 1-2 (0286A2775 Sh. 1 [3]) Logic and Internal Diagram Legend

FLIP FLOPS



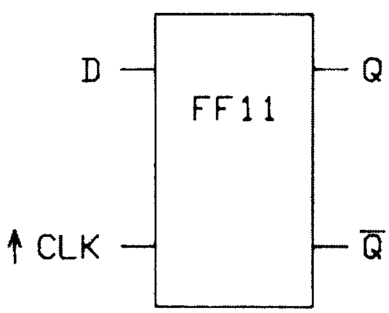
REFERENCE NO.

JK FLIP FLOP

Q & $\overline{Q}$ OUTPUTS OCCUR ON POSITIVE EDGE OF CLOCK. R MUST BE LOW FOR OPERATION.

TRUTH TABLE

J	K	Q
L	L	NC
L	H	H
H	L	L
H	H	TOGGLE

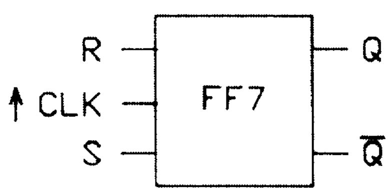


D FLIP FLOP

Q & $\overline{Q}$ OUTPUTS OCCUR ON POSITIVE EDGE OF CLOCK.

TRUTH TABLE

D	Q
L	L
H	H



RS FLIP FLOP

Q & $\overline{Q}$ OUTPUTS OCCUR ON POSITIVE EDGE OF CLOCK.

TRUTH TABLE

R	S	Q
L	L	NC
H	L	L
L	H	H
H	H	?

NOTE:
- H=1 (HIGH INPUT)
- L=0 (LOW INPUT)
- NC= NO CHANGE
- $\overline{Q}$=INVERSE OF Q

Figure 1-2 (0286A2775 Sh. 2 [3]) Logic and Internal Diagram Legend (continued)

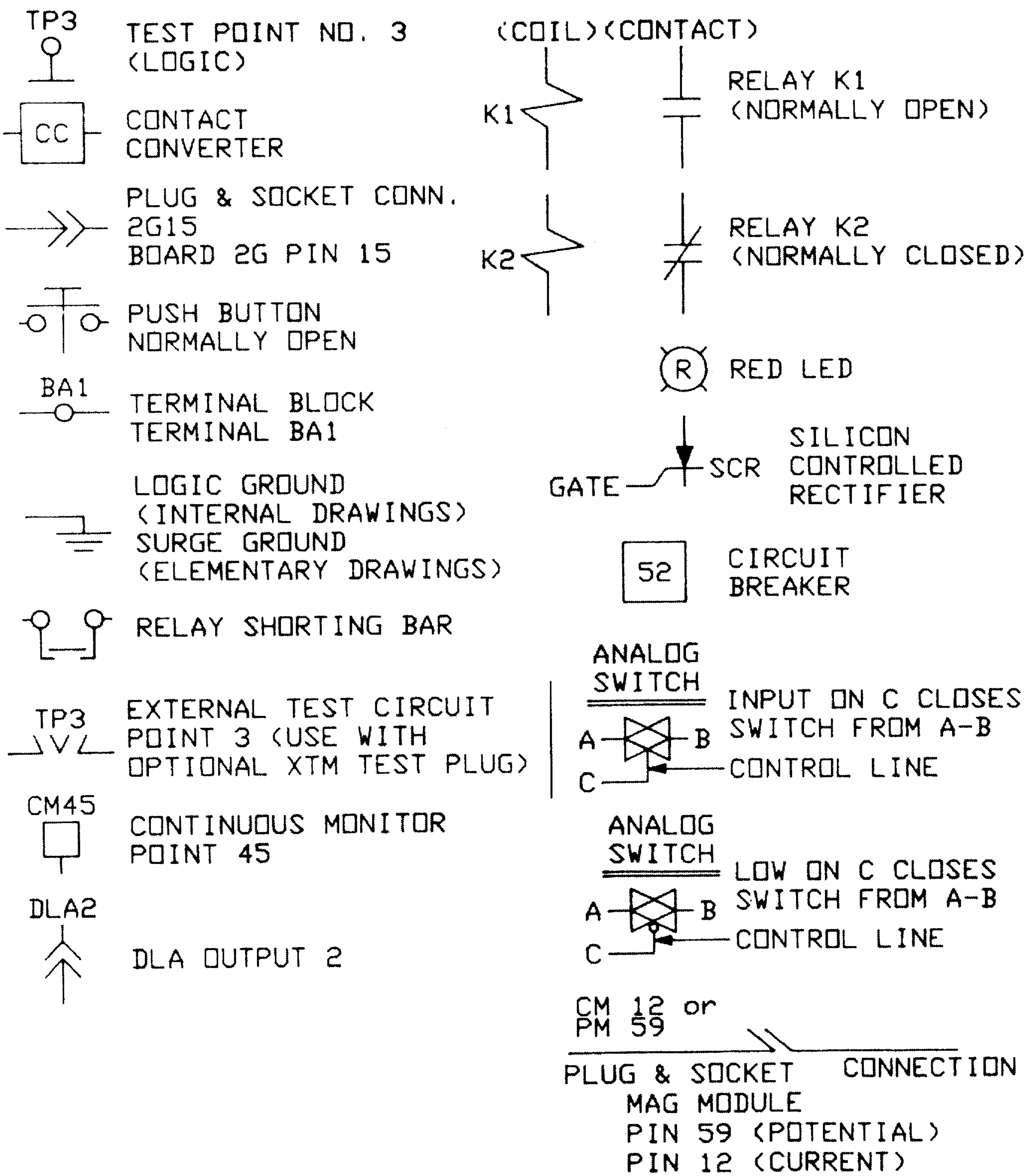
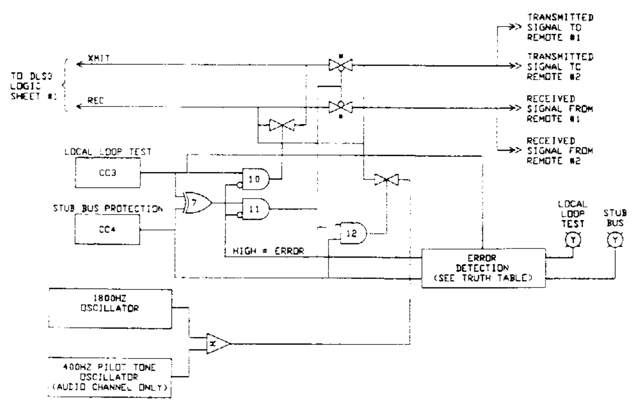


Figure 1-2 (0286A2775 Sh.3 [3]) Logic and Internal Diagram Legend (continued)



* DIRECT CONNECTION IN UNITS WITHOUT STUB BUS PROTECTION AND LOCAL LOOP TEST OPTIONS

TRUTH TABLE
O=OPEN C=CLOSED

CC3	CC4	CONDITION
O	O	NORMAL, NO ERROR INDICATION
C	O	LOCAL TRANSMITTED SIGNAL LOOPED DIRECTLY BACK ONTO LOCAL RECEIVER. NO REMOTE TRANSMITTED SIGNAL. LOCAL LOOP TEST LED LIT.
C	C	SUMMED 1800HZ & 400HZ (IF APPLICABLE) SIGNAL TRANSMITTED TO REMOTE & FED INTO LOCAL RECEIVER STUB BUS LED LIT
C	C	NORMAL TRANSMIT & RECEIVE. LOCAL LOOP TEST & STUB BUS LED'S FLASH. ERROR INDICATION

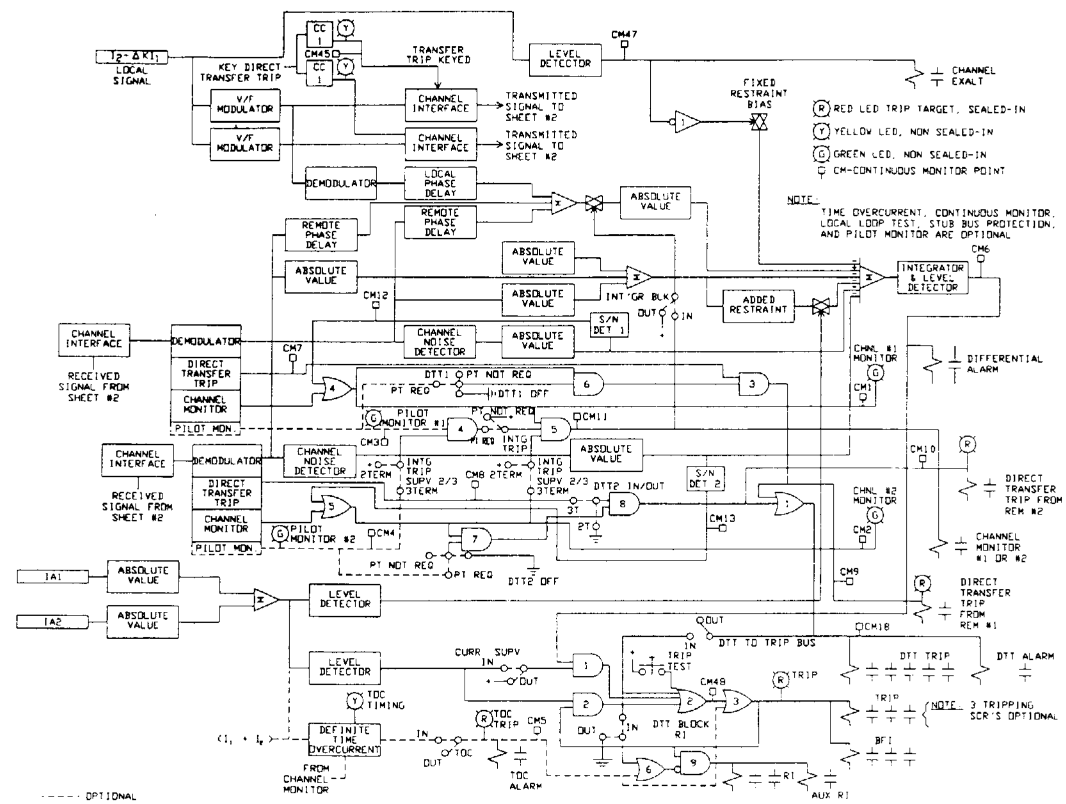
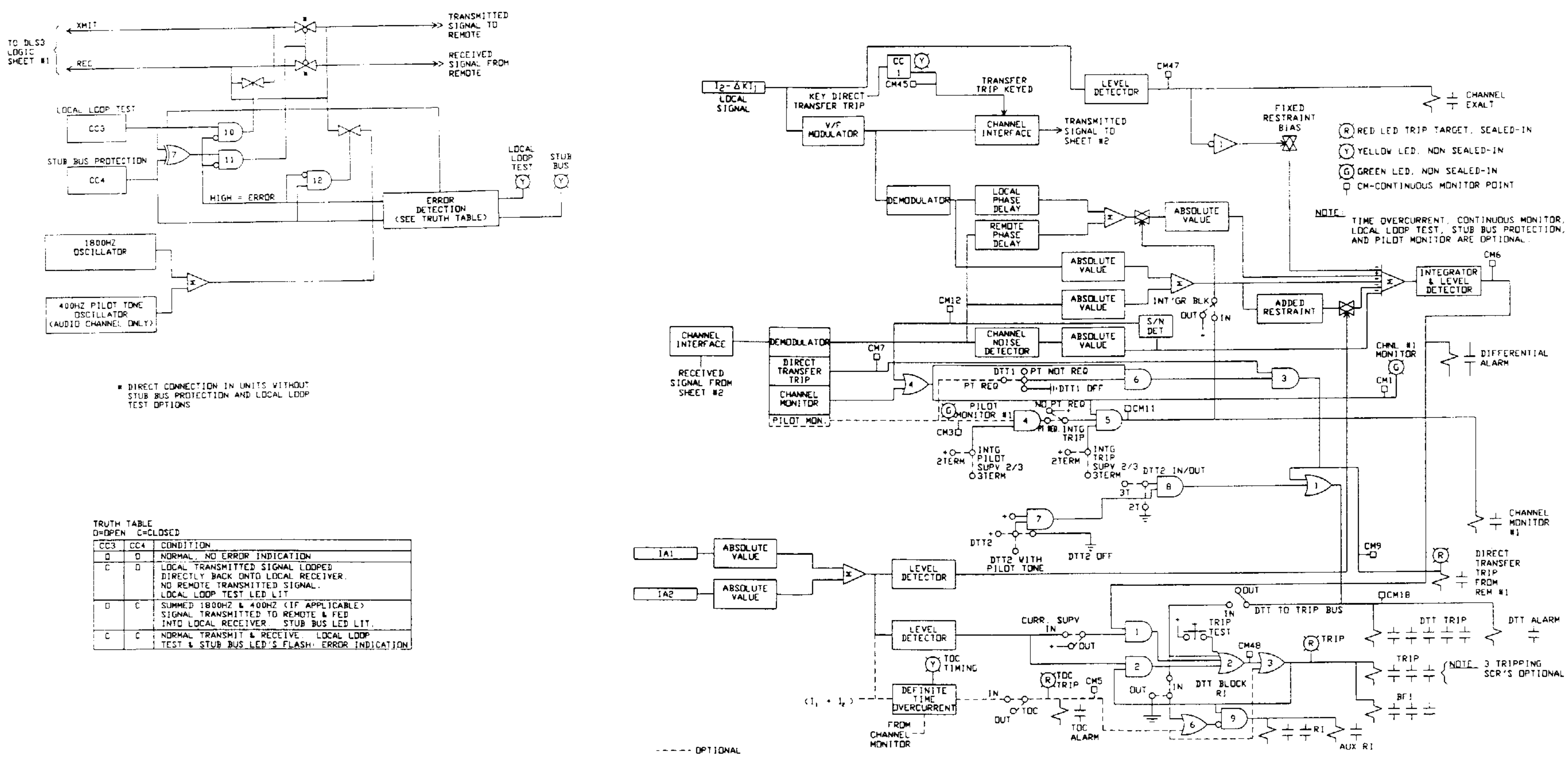


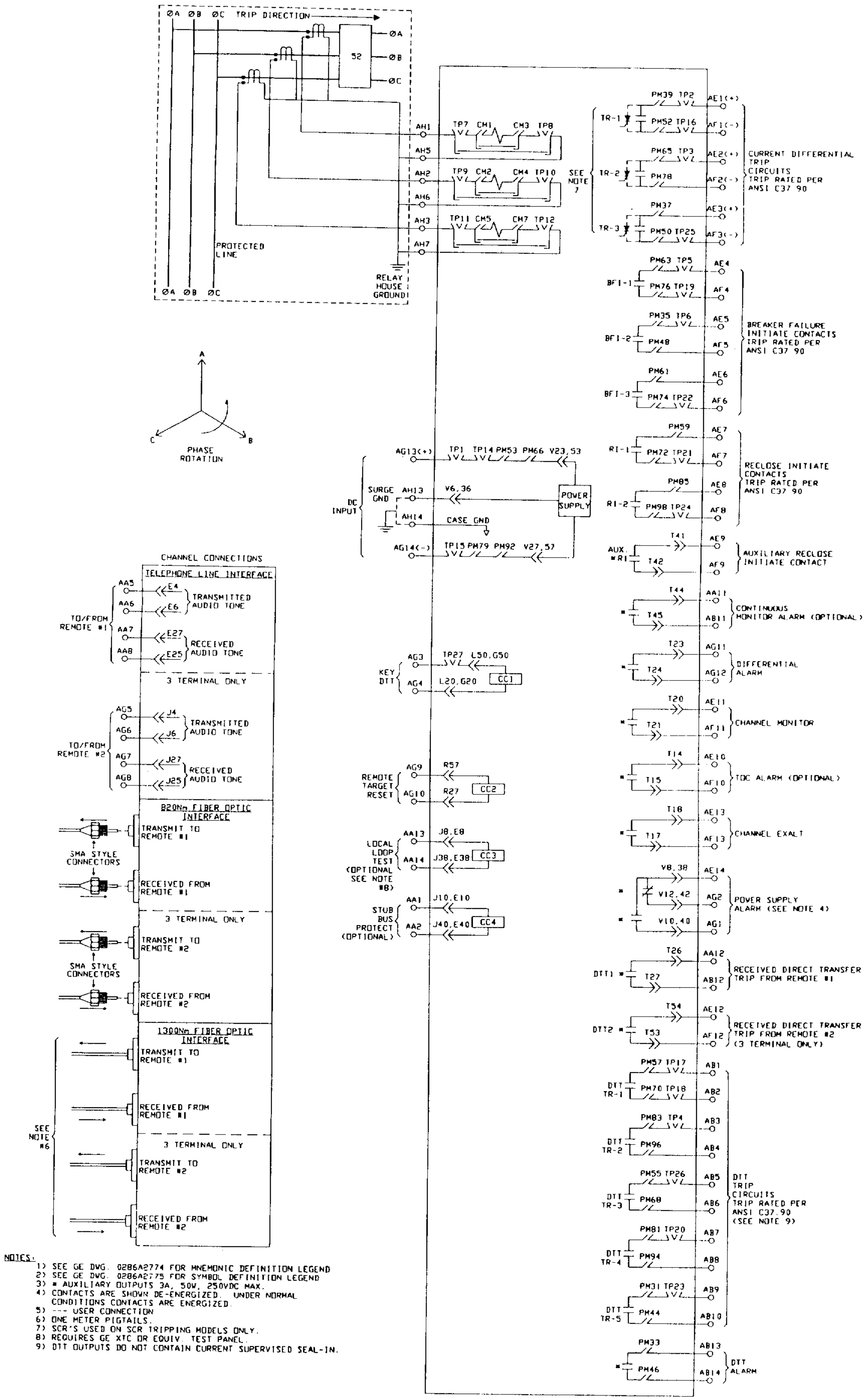
Figure 1-3 (0179C8272 Sh.1 [2] and Sh. 2 [1]
Logic Diagram – DLS3 for Three-Terminal Application



TRUTH TABLE
O=OPEN C=CLOSED

CC3	CC4	CONDITION
O	O	NORMAL, NO ERROR INDICATION
C	O	LOCAL TRANSMITTED SIGNAL LOOPED DIRECTLY BACK ONTO LOCAL RECEIVER. NO REMOTE TRANSMITTED SIGNAL. LOCAL LOOP TEST LED LIT
O	C	SUMMED 1800HZ & 400HZ (IF APPLICABLE) SIGNAL TRANSMITTED TO REMOTE & FED INTO LOCAL RECEIVER. STUB BUS LED LIT.
C	C	NORMAL TRANSMIT & RECEIVE. LOCAL LOOP TEST & STUB BUS LED'S FLASH: ERROR INDICATION

Figure 1-4 (0179C8271 Sh. 1 [2] and Sh. 2 [1])
Logic Diagram – DLS for Two-Terminal Application



NOTES:

1) SEE GE DWG. 0286A2774 FOR MNEMONIC DEFINITION LEGEND
2) SEE GE DWG. 0286A2775 FOR SYMBOL DEFINITION LEGEND
3) * AUXILIARY OUTPUTS 3A, 50W, 250VDC MAX.
4) CONTACTS ARE SHOWN DE-ENERGIZED. UNDER NORMAL CONDITIONS CONTACTS ARE ENERGIZED.
5) --- USER CONNECTION
6) ONE METER PIGTAILS.
7) SCR'S USED ON SCR TRIPPING MODELS ONLY.
8) REQUIRES GE XTC OR EQUIV. TEST PANEL.
9) DTT OUTPUTS DO NOT CONTAIN CURRENT SUPERVISED SEAL-IN.

Figure 1-5 (0153D7884 [3]) Elementary Diagram

CALCULATION OF SETTINGS

There are relatively few settings to be made on the DLS3 relay system. One front-panel setting, which selects the input tap value, is made via the rotary switch, $I_{N\Phi}$, on the ACM103/104 module . Other front-panel settings are the Time-Overcurrent Pickup and the Time-Overcurrent Time Delay settings on the AMM101/2/3/4 module when the optional Time-Overcurrent Protection function is included. All other settings are made on the modules after they are withdrawn from the case. The particular selections and setting criteria are given below, on a module-by-module basis. See the Settings Checklist Form in Table 2-1.

Settings for the DLS3 are discussed for each module in the order shown in Table 2-1. Note that several different modules are shown in Table 2-1; e.g. MGM181/191, ACM103/4, etc. The module or modules used in a specific DLS3 will depend on the options selected, power system frequency, and type of communication channel.

For operation of the Continuous Monitor (MMI), refer to the Continuous Monitor section of this book.

MGM181/186 OR MGM191/196 MODULE

Nominal Current Taps (1/5)

At the bottom of the MGM module, move the three (3) connector-terminated leads to the appropriately-marked tap-block positions and secure with the screws provided. All three leads will either be placed at the tap positions marked 1 or at the tap positions marked 5. If the associated current transformers have a secondary rated one (1) ampere, use the taps marked 1. If the associated current transformers have a secondary rated five (5) amperes, use the taps marked 5. The MGM18(-) series contain contact tripping outputs. The MGM 19(-) series contain SCR tripping outputs.

ACM103/104 MODULE

2

Front-Panel Input Taps (Two-Terminal-Line Operation)

Switch $I_{N\Phi}$, located on the front panel, is a seven-position rotary switch that selects input taps of (0.8, 1.0, 1.2, 1.4, 1.6, 2.0, 2.4) times I_N. I_N is either 5 amperes or 1 ampere, depending on its setting in the magnetics module MGM. Assuming equal CT ratios at the two ends, the setting criterion is based on the magnitude of pre-fault load flow. The basis for the setting is to assure that the ΔKI_1 portion of the $(I_2 - \Delta KI_1)$ comparison signal will be zero for the maximum load flow. This is accomplished by setting the input tap value greater than the maximum load flow.

Consider the simple equivalent system in Figure 2-1, where the maximum load flow is 384 primary amperes. Assuming 600/5 ampere CTs at each end, the DLS3 selected will have an $I_N = 5$. Since the secondary load current is 3.2 amperes, the 0.8 input tap (0.8 x 5 = 4) is sufficient to meet the above criteria.

Next assume that it is necessary to use the DLS3 input taps to balance the differential circuit with a 600/5 CT ratio at A and a 1200/5 CT ratio at B. The relationship is:

INPUT TAP (A)/ INPUT TAP (B)
= CT RATIO (B)/CT RATIO (A)

For the case cited:

INPUT TAP (A) = 2 x INPUT TAP (B)

If INPUT TAP (B) = 0.8 (I_n) is selected, then INPUT TAP (A) = 1.6 (I_N). Assume that the maximum primary load current is 504 amperes. At A, the secondary value of load current is 4.2 amperes, well below the (1.6)(5) = 8 tap value. The same is true at B where 504/240 = 2.1 amperes is well below the (0.8)(5) = 4 tap value.

Always choose the lowest tap values permitted by the application rules above, since the lower the tap, the greater the sensitivity. Current sensitivity for three-phase faults is approximately 0.4 times the tap value for a transient response (i.e., trip output is not sustained for the fault duration) and 1.2 times tap value for a steady-state response (i.e., trip output is sustained for the fault duration).

Note that even a transient response will result in a sustained trip output, since the $I_1 + I_2$ level detector associated with the trip seal-in circuit will stay picked up until the fault is cleared. Current sensitivity to single-line-to-ground faults is 0.2 times tap value, based on a radial feed (i.e., $I_1 = I_2 = I_0$).

Front-Panel Input Taps (Three-Terminal-Line Operation)

The circuitry of the DLS3 is designed to accept fault currents (I_2 - ΔKI_1) in magnitudes up to approximately 5.5 per-unit of the INPUT TAP setting without limiting these signals. Above this magnitude, the signal levels are clipped. For those systems where outfeed is possible for a fault condition, it is necessary to choose the INPUT TAP setting so that signal limiting does not occur at the terminal where current outfeed occurs. It is also necessary to make sure that the current-signal level at the terminal that has the outfeed does not exceed a specified level for the sum of the signals at the other two terminals. If these criteria are not satisfied, the DLS3 will fail to trip for the internal fault.

To illustrate the above, the three-terminal line in Figure 2-2 is assumed, with Terminals A, B, and C. A three-phase internal fault is assumed near Terminal B, with infeed to the fault from Terminal A, but with outfeed from Terminal C. For the DLS3, the operate quantity is proportional to the phasor difference in current entering one terminal and leaving the other two terminals. The restraint quantity is proportional to the sum of the absolute values of the local comparison quantity and the two received remote quantities.

For the condition assumed in Figure 2-2, the outfeed current at terminal C must be less than approximately 30% of the sum of the fault currents at terminals A and B for a three-phase internal fault, assuming a noise-restraint setting of 1.0. The outfeed current should not exceed approximately 3.3 per-unit of the INPUT TAP setting under any conditions.

When a noise-restraint setting of 2.5 is used, the outfeed current at Terminal C must be less than approximately 15% of the sum of the fault currents at Terminals A and B for a three-phase internal fault. The outfeed current should not exceed 1.65 per-unit of the INPUT TAP setting when the noise restraint is set to 2.5.

Current sensitivity for three-phase faults is approximately 0.4 times the INPUT TAP setting for a transient response. In three-terminal-line applications, the comparator output is not sustained for a three-phase fault since the transition from ΔKI_1 to I_1 is omitted in the quantity (I_2 - ΔKI_1). The transient response will still result in a sustained trip output, since the $I_1 + I_2$ level detector associated with the trip seal-in circuit will stay picked up until the fault is cleared.

High-Current Restraint Link

For two-terminal-line applications the HI CUR REST link (L10 on the ACM10(-) module) has two positions: IN and OUT. When set at the IN position, the percentage restraint is increased to 40% for all fault-current levels. When set at the OUT position, the $I_1 + I_2$ level detector changes the percentage restraint from 30% to 40% when it picks up. This link should normally be set at the OUT position for a two-terminal-line application.

For three-terminal-line applications, the HI CUR REST link is set at 40% (HI) for all fault-current levels.

Integrator Block Link

* The INT'GR BLK link (L11 on the ACM10(-) module) has two positions: IN and OUT. This link selects between dependability

or security on channel failure. In the IN position, the current-differential circuit is blocked from operating if the channel-monitor circuit detects a failed channel. In three-terminal-line applications, and with this link in the IN position, the current-differential circuit is blocked from operating if either channel-monitor-#1 circuit or channel-monitor-#2 circuit detects a failed channel.

In the OUT position, the DLS3 current differential circuit is not blocked from operating for a failed channel, nor for one or more failed channels (three-terminal-line applications).

The use of this link is predicated upon the adequacy of the backup protection to the DLS3 current-differential relay. If it is determined that the backup protection is adequate, then the link may be placed in the IN position to maintain security and to block DLS current-differential operation for the failed-channel condition. If the backup protection is not adequate, then the link should be placed in the OUT position to keep the DLS in service despite the failed channel condition. An operation of the DLS3 current-differential relay may occur for the case of an external fault with the link in the OUT position.

Another consideration in deciding whether to place this link IN or OUT is channel signal-to-noise ratio.

The DLS3 includes a signal-to-noise ratio threshold circuit which is set at 6dB. This can be used to block tripping when the signal-to-noise ratio is poor. As the signal-to-noise ratio drops toward 6dB, the DLS3 current sensitivity begins to decrease. If the channel signal-to-noise ratio is just above the 6dB threshold level, the fault current required to trip the terminal with the noisy channel is twice that normally required (i.e., 0.4 times INPUT TAP versus 0.2 times INPUT TAP). If the signal-to-noise ratio is reduced below the threshold level, tripping is blocked for all faults if the INT'GR BLK link is in the IN position. An alarm will be provided via the channel monitor alarm.

If the INT'GR BLK link is in the OUT position, the current differential relay will continue to trip with decreased signal-to-noise ratios on the communication channel. As the signal-to-noise ratio decreases, the relay becomes less sensitive which requires a higher operate current. This is illustrated in Figure 2-3. For example, the level of operate current required for a signal-to-noise ratio of 0dB is four times that required at a signal-to-noise ratio of 40 dB.

The minimum audio signal input level required for current differential operation is -26dBm. During normal anticipated conditions, this signal will be at least 30 dB above the channel noise (30 dB signal-to-noise ratio). The performance shown in Figure 2-3 is valid for audio input levels down to -26dBm. Low signal-to-noise ratios below 15dB represent a severely degraded channel. Audio input levels below -26dBm represent a loss of channel.

Input Grounding

Three GROUND JUMPERS, L6, L7, and L8 are provided to ground inputs that are not used in two-terminal-line applications. They should be placed in the 2T position for two-terminal applications and in the 3T position for three-terminal applications.

Bias Adjustment

The BIAS ADJ link (L9 on the ACM 10(-) module) has two positions: 0.05N and 0.1N. The link selects the pickup level of the detector that switches out the fixed restraint bias from the comparator when a fault occurs. The link should be set at 0.05N for applications where the negative-sequence current generated by the load flow across an unsymmetrical system is less than 5% of the load current. If the negative-sequence current due to load equals or exceeds 5%, the link should be set at 0.1N.

Limiter

There are three Berg Posts, LIMITER

IN/OUT, labeled L2, L3, and L4. They should be in the 2T position for two-terminal-line applications and in the 3T position for three-terminal-line applications. They enable the Limiter in two-terminal-line operation, so that the operate quantity (I_2 - ΔKI_1) becomes (I_2 - KI_1) at three-phase fault currents greater than approximately 1.2 times INPUT TAP value.

AFM113/116 MODULE

Phase Delay Links (Local and Remote)

The LOCAL PHASE SHIFT adjustment consists of two physical links, L6 and L7 on the AFM11(-) module. The phase shift is expressed in degrees, and is equal to the sum of the L6 setting plus the L7 setting. The L6 link may be set at eight distinct positions: 0, 10, 30, 50, 70, 90, 100, and 110. The L7 link may be set at seven distinct positions: 0, 20, 40, 60, 80, 100, and 120. These settings permit a total range of 0° to 230° with a resolution of 10°.

The local phase-shift setting compensates for the channel delay. Consider an application in which the channel delay is 5 milliseconds. The required delay in degrees for a 60 Hertz system is:

PHASE SHIFT = (0.005 sec) (60)(360) = 108°

Since the setting resolution is 10°, the actual setting would be 110°. L6 would be placed in the 110° position and L7 in the 0° position. Refer to the INSTALLATION section for recommended test methods to set the LOCAL PHASE SHIFT.

The REMOTE-PHASE-SHIFT circuit is identical to the local-phase-shift circuit, but it introduces a delay in the received signal rather than in the local signal. In the case of the three-terminal-line application, there are two REMOTE PHASE SHIFT circuits; REMOTE PHASE SHIFT #1 and REMOTE PHASE SHIFT #2. These are on different modules.

For a two-terminal-line application, links L4 and L5 on the AFM11(-) module should be set at the 0 position.

For a three-terminal-line application, set the links to the 0 positions for the channel with the longest channel delay. Set the links for the other channel to compensate for the difference in channel delay from the two remote terminals. The local phase-shift link (L6 and L7) should then be set for the longest channel delay of the two channels to the remote terminals.

These links are identified as L4 and L5 for the channel from remote terminal #1 on the link 1 AFM11(-) board in slot G, and L4 and L5 for the channel from remote terminal #2 on the link 2 AFM11(-) board in slot L.

Channel Input Links

The CHANNEL INPUT link is used to select between a fiber-optic application, REM OPTIC, or a voice-channel application, REM 600. The link must be in the proper position for the type of channel used. In the case of a three-terminal-line application, it is necessary to set both CHANNEL INPUT AFM115 Modules, CHANNEL INPUT #1 in slot G and CHANNEL INPUT #2 in slot L, links for the channels to both remote terminals. These links are both identified as L1.

Noise Restraint Links

The NOISE RESTRAINT link has two positions: 1.0 and 2.5. This link sets the magnitude of the channel-noise-restraint signal. For fiber-optic applications, the link should be set at the 1.0 position. For voice channel applications, the link should be set at the 2.5 position.

For three-terminal-line applications, the NOISE RESTRAINT links on both AFM113/116 Modules must be set, one for each channel. These are identified as L2 on both boards.

Direct-Transfer-Trip Contact-Converter Links

There is a DTT INPUT link on each

AFM11(-) module. The DTT INPUT link has three positions: 48V, 125V, and 250V. Each link is associated with an input contact converter for the direct-transfer-trip function. In three-terminal applications, one is for transfer trip to Remote #1 and the other is for transfer trip to Remote #2. The setting is the rated battery voltage used to wet the external contact that keys the direct-transfer-trip function.

IOM153 MODULE

Overcurrent-Supervision-of-Trip Link

* The CURRENT SUPRV link (L1 on the IOM153 module) has two positions: IN and OUT. At the IN position, a level detector ($I_2 + I_1$) supervises the comparator trip signal. This link should be at the IN position unless the minimum fault current at a terminal is below the level detector sensitivity. The phase-current sensitivity of this level-detector for single-line-to-ground faults and three-phase faults is 0.10 times tap value.

External Target Reset Voltage Link

The EXT TARGET LED RESET (L3 on the IOM153 module) link has three positions: 48V, 125V, and 250V. This link is associated with the input contact converter used to reset the LED targets. The setting is simply the rated battery voltage used with the external contact to reset the target LEDs.

Direct Transfer Trip to Trip Bus

The DTT link (L6 on the IOM153 module) has two positions. In the IN position, a received transfer-trip signal from a remote terminal is allowed to trip the local end. In the OUT position, a received transfer-trip signal cannot trip the local end.

DTT Block RI Link

The DTT Block RI Link has two positions, IN and OUT. When in the IN position, a Reclose Initiate, or RI, output will not occur on a Direct Transfer Trip. When the Links is set to OUT, a reclose-initiate output will occur for a Direct Transfer Trip. Link L6, DTT TO TRIP BUS, must be set to IN for this function to operate.

Exalt Gain dB

Two separate links, 2ND TERM EXALT and 3RD TERM EXALT, each have three positions: 0 (OUT), 6 (LOW), and 10 (HI). These links are of concern only if the DLS3 is configured for use with a voice channel. For modulation systems where the power amplifier is shared (as in PLC single-sideband), the power available per channel is inversely proportional to the square of the number of voice channels applied. In such systems there may exist a provision to boost (exalt) the power output of the relay channel at the time a fault occurs. If this is the case, the 2ND TERM EXALT (L4 on the IOM153 module) selects the amount of boost (exalt) in dB for channel #1. 3RD TERM EXALT (L5) is used only for three-terminal applications and should be set at zero for other applications.

Gain-Adjust Potentiometers

The two potentiometers, communication link 1 GAIN ADJUST (R3) and communication link 2 GAIN ADJUST (R2), are used to make a 0 to -5 dB adjustment on the audio output signal routed to the line interface module. The maximum level is 0 dBm and the minimum is -5 dBm. This level, in conjunction with the output attenuation on the FFM101 module, determines the audio output level delivered to the voice channel.

Direct Transfer Trip Links

These links, DTT #1 (L9 on the IOM153 module) and DTT #2 (L8), each have three positions. They are PT NOT REQ, PT REQ, and OFF. In the PT NOT REQ position for DTT #1, receipt of a pilot tone from remote terminal #1 is not required in conjunction with receipt of a transfer-trip signal from remote terminal #1 to permit tripping at the local terminal by the received transfer-trip signal. If the link is in the PT

REQ position, then the pilot tone must be received at the time of receipt of the transfer-trip signal to allow tripping at the local terminal. Similar operation applies for DTT #2 and the pilot tone from remote terminal #2 in conjunction with a received transfer-trip signal at the local terminal. If these jumpers are in the OFF position, a received direct-transfer-trip signal will not cause a trip.

Integrator Trip Pilot Supervision

This link, labeled INTG TRIP (L11 on the IOM153 module), has two positions. They are PT REQ and PT NOT REQ. In the PT REQ position, the pilot tone signal must indicate no frequency translation error before an integrator (current-differential) trip can occur.

Integrator Trip Supervision Select (2 TERM, 3 TERM)

The INTG TRIP SUPV 2/3 (L13 on the IOM153 module) link has two positions: 2T and 3T. It should be set to the 2T position for two-terminal-line applications and in the 3T position for three-terminal-line applications. It is used to specify whether the pilot tone for one channel (2T) or for two channels (3T) is required for a trip.

Integrator Trip Supervision By Pilot Tone Select (2 TERM, 3 TERM)

The INTG PILOT SUPV 2/3 (L10 on the IOM153 module) link has two positions; 2 TERM and 3 TERM. Place it in the 2 TERM position for two-terminal-line applications and in the 3 TERM position for three-terminal-line applications.

Direct Transfer Trip Select (2 TERM, 3 TERM)

The DTT2 IN/OUT (L7 on the IOM153 module) link has two positions; 2 TERM and 3 TERM. Place it in the 2 TERM position for two-terminal-line applications and in the 3 TERM position for three-terminal-line applications.

CHNL2 Indicator Disable

This link (L12 on the IOM153 module) is used to enable or disable the channel 2 link monitor indicator for three-terminal or two-terminal operation.

FFM101/5/6 MODULE

Audio-Output-Level Links

A set of five TRANSMIT-DB links (1, 2, 4, 8, 16) are used to set the output attenuation from 0 to -31 dB, with a resolution of 1 dB. Various voice channels can tolerate different maximum-power input levels. These links, coupled with the GAIN ADJUST potentiometer on the IOM153 module, are used to set the required dBm level between 0 dBm and -36 dBm with no channel exalt.

Audio-Input-Level Links

A set of five RECEIVE-DB links (1, 2, 4, 8, 16) are used to set the input attenuation from 0 to -31 dB, with a resolution of 1 dB. The amount of input attenuation should be set to establish a maximum received level of -10 dBm, as measured at a point in the circuitry just after the attenuation stage. Refer to the Installation section of HARDWARE DESCRIPTION for the procedure used to set the RECEIVE-DB links.

FFM111/2/3 MODULE

Audio-Output-Level Links

A set of five TRANSMIT-DB links (1, 2, 4, 8, 16) are used to set the output attenuation from 0 to -31 dB, with a resolution of 1 dB. Various voice channels can tolerate different maximum-power input levels. These links, coupled with the GAIN ADJUST potentiometer on the IOM153 module, are used to set the required dBm level between 0 dBm and -36 dBm with no channel exalt.

Audio-Input-Level Links

A set of five RECEIVE-DB links (1, 2, 4, 8, 16) are used to set the input attenuation from 0 to -31 dB, with a resolution of 1 dB. The amount of input attenuation should be set to establish a maximum received level of -10 dBm, as measured at a point in the circuitry just after the attenuation stage. Refer to the Installation section of HARDWARE DESCRIPTION for the procedure used to set the RECEIVE-DB links.

Stub Bus Protection Gain Adjustments

Two Potentiometers, R29 and R30, are used to set 400 Hz transmitted Pilot tone to 1800 Hz carrier Ratio on models with audio channels. See the HARDWARE DESCRIPTION section for instructions on how to set these levels.

Local Loop Test and Stub Bus Protection Contact Converter Links.

There are one Stub Bus and one Local Loop voltage link per FFM11(-) module. These should be set to their respective battery input voltages. Selections are: 48V, 125V, and 250V.

AMM101/2/3/4 MODULE

Pilot Tone Level

In a two-terminal-line application POT #1 must be set. In a three-terminal line, both POT #1 and POT #2 must be set. These adjustments are made to set the level of the received pilot tone at the remote terminal, or at both remote terminals in the case of a three-terminal line. The settings are determined during installation. They are used to compensate for the differing channel attenuation at 400, 1800, and 3000 Hz.

Time Overcurrent Pickup

The range of pickup values is from 0.2 to 2.0 times the current differential INPUT TAP in steps of 0.1. The time-overcurrent-protection function operates from a signal derived from $I_2 + I_1$ and has a definite time characteristic. The function is non-directional and is intended for use as a backup to the current-differential function. Current sensitivity for the time-overcurrent function is given below:

For $I_1 \geq I_N$ (Positive Sequence)
$I_1 + I_2 = I_N$ (TAP SETTING) (1.2 + TOC Setting)

For $I_1 < I_N$ (Negative Sequence)
$I_2 = I_N$ (INPUT TAP)(TOC SETTING) in secondary Amps. This sensitivity is used when $I_1 < I_N$, to avoid picking up on load current.

Time Overcurrent Time Delay

The range of settings for the time delay is from 0 to 0.99 second in steps of 10 milliseconds. The time delay is reduced to one-half of the setting on loss of channel from the remote terminal, or from either remote terminal in the case of a three-terminal-line application. The time delay would normally be set so that it would not operate in less than approximately 100 milliseconds for an external fault.

Time Overcurrent (In/Out)

A TOC IN/OUT link (L1 on the AMM10(-) module) is included to enable, or disable, the output of the Time-Overcurrent-Protection function.

The TOC function will automatically reduce its operating time by half if the channel is lost, due to the operation of the Integrator Block signal.

TABLE 2-1 SETTING CHECKLIST FORM

	FUNCTION	NAME OF ADJUSTMENT	MODULE	SETTING
	CT-SECONDARY-RATING TAPS	1/5	MGM181/186 or 191/196	______
	INPUT TAPS	INϕ - FRONT PANEL	ACM103/104	______
	HIGH-CURRENT RESTRAINT	HI CUR. REST. - L10	ACM103/104	______
	INTEGRATOR BLOCK	INT'GR BLK -L11	ACM103/104	______
	INPUT GROUNDING (2T/3T)	GROUND JUMPERS - L6, L7, L8	ACM103/104	______
	BIAS RESTRAINT ADJUSTMENT	BIAS ADJUST - L9	ACM103/104	______
	LIMITER (2T/3T) L2, L3, L4	LIMITER IN/OUT	ACM103/104	______
	LOCAL PHASE DELAY	LOCAL PHASE SHIFT - L6, L7	AFM113-116	______
	REMOTE PHASE DELAY #1	REMOTE PHASE SHIFT- L4, 5	AFM113-116	______
†	REMOTE PHASE DELAY #2	REMOTE PHASE SHIFT- L4, L5	AFM113-116	______
	CHANNEL TYPE SELECTION #1	CHANNEL INPUT - L1	AFM113-116	______
†	CHANNEL TYPE SELECTION #2	CHANNEL INPUT - L1	AFM113-116	______
	CHANNEL NOISE WEIGHTING #1	NOISE RESTRAINT-L2	AFM113-116	______
†	CHANNEL NOISE WEIGHTING #2	NOISE RESTRAINT-L2	AFM113-116	______
	DIRECT TRANSFER TRIP CONTACT CONVERTER #1	DTT INPUT - L3 48, 125, 250 VOLTS	AFM113-116	______ VOLTS
†	DIRECT TRANSFER TRIP CONTACT CONVERTER #2	DTT INPUT - L3 48, 125, 250 VOLTS	AFM113-116	______ VOLTS
	OVERCURRENT SUPERVISION OF TRIP	CURR. SUPRV. - L1	IOM153	______
	TARGET-RESET CONTACT CONVERTER	EXT. TARGET LED RESET 48, 125, 250 VOLTS -L3	IOM153	______ VOLTS
	DIRECT TRANSFER TRIP TO TRIP BUS	DTT - L6	IOM153	______
	EXALT-GAIN ADJUSTMENT	2ND TERM EXALT - L4	IOM153	______
††	EXALT-GAIN ADJUSTMENT	3ND TERM EXALT - L5	IOM153	______
	GAIN-ADJUST POTENTIOMETERS	LINK 1 GAIN ADJUST - R3	IOM153	______
††	GAIN-ADJUST POTENTIOMETERS	LINK 2 GAIN ADJUST - R2	IOM153	______
	DIRECT TRANSFER TRIP #1, (PT NOT REQ., PT REQ., OFF)	DTT1 - L9	IOM153	______
	DIRECT TRANSFER TRIP #2, (PT NOT REQ., PT REQ., OFF)	DTT2 - L8	IOM153	______
	INTEGRATOR TRIP PILOT SUPER-VISION (PT NOT REQ., PT REQ.)	INTG TRIP - L11	IOM153	______

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TABLE 2-1 SETTING CHECKLIST FORM (CONT.)

	FUNCTION	NAME OF ADJUSTMENT	MODULE	SETTING
	INTEGRATOR TRIP SUPERVISION SELECT (2 TERM, 3 TERM)	INTG TRIP SUPV 2/3 L-13	IOM153	______
	INTEGRATOR TRIP SUPERVISION BY PILOT TONE SELECT (2 TERM, 3 TERM)	INTG TRIP PILOT SUPV 2/3 - L10	IOM153	______
	DIRECT TRANSFER TRIP SELECT, (2 TERM, 3 TERM)	DTT2 - 2T/3T - L7	IOM153	______
	CHNL2 INDICATOR DISABLE	2T/3T - L12	IOM153	______
	DTT BLOCK RI (IN, OUT)	IN/OUT L2	IOM153	______
	AUDIO OUTPUT LEVEL ADJUST	TRANSMIT-DB	FFM(101/5/6, 111-113)	______
	AUDIO INPUT LEVEL ADJUST	RECEIVE-DB	FFM(101/5/6, 111-113)	______
	400 Hz PILOT TONE LEVEL	POT R30	FFM111-113	______
	1800 Hz CARRIER LEVEL	POT R29	FFM111-113	______
	LOCAL LOOP & STUB BUS VOLTS	48, 125, 250	FFM1(--)	______ VOLTS
	PILOT TONE LEVEL #1	POT #1 (R144)	AMM101/2/3/4	______
††	PILOT TONE LEVEL #2	POT #2 (R172)	AMM101/2/3/4	______
	TIME OVERCURRENT PICKUP	FRONT PANEL	AMM101/2/3/4	______ AMPS
	TIME OVERCURRENT TIME DELAY	FRONT PANEL	AMM101/2/3/4	______ SECS
	TIME OVERCURRENT (IN/OUT)	TOC - L1	AMM101/2/3/4	______

NOTES:

† ADJUSTMENTS NOT REQUIRED AND NOT AVAILABLE IN TWO-TERMINAL DLS3.
†† ADJUSTMENTS AVAILABLE BUT NOT TO BE SET IN TWO-TERMINAL DLS3.

BOARDS FOR A SPECIFIC SYSTEM DEPEND ON FREQUENCY, CHANNEL AND OPTIONS, AS BELOW:

ACM103 - 60 HZ
AFM113 - 60 HZ, FIBER-OPTIC CHANNEL
AFM115 - 60 HZ, AUDIO CHANNEL
AMM101 - PILOT TONE AND TIME OVERCURRENT
AMM103 - PILOT TONE ONLY
FFM101 - AUDIO CHANNEL
FFM106 - 1300 NM FIBER
FFM112 - 1300 NM FIBER WITH STUB BUS AND LOCAL LOOP TEST
MGM18(-) - CONTACT TRIPPING

ACM104 - 50 HZ
AFM114 - 50 HZ, FIBER-OPTIC CHANNEL
AFM116 - 50 HZ, AUDIO CHANNEL
AMM102 - TIME OVERCURRENT ONLY
AMM104 - NO OPTIONS
FFM105 - 820 NM FIBER
FFM111 - AUDIO CHANNEL WITH STUB BUS & LOCAL LOOP TEST
FFM113 - 820 NM FIBER WITH STUB BUS AND LOCAL LOOP TEST
MGM19(-) - SCR TRIPPING

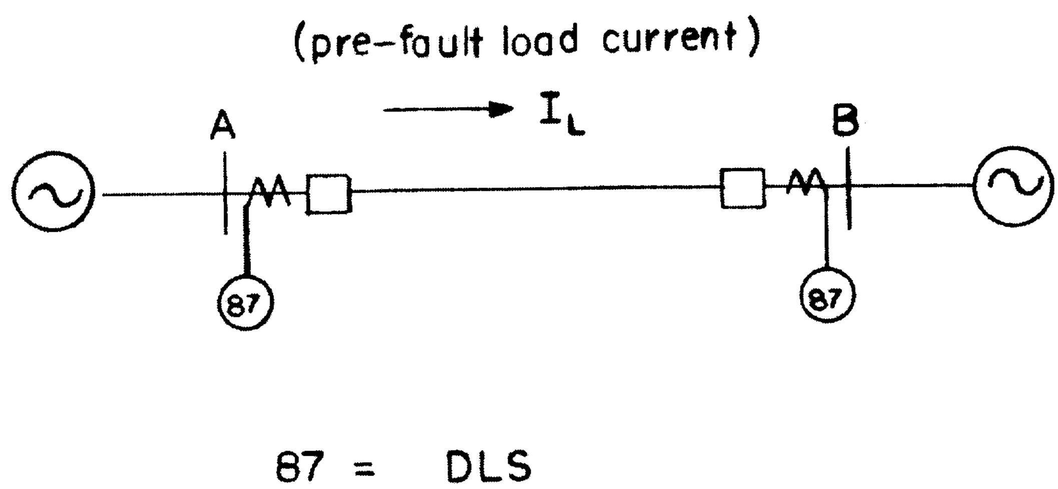


Figure 2-1 (0285A9131 [1]) Model System, Two-Terminal Application

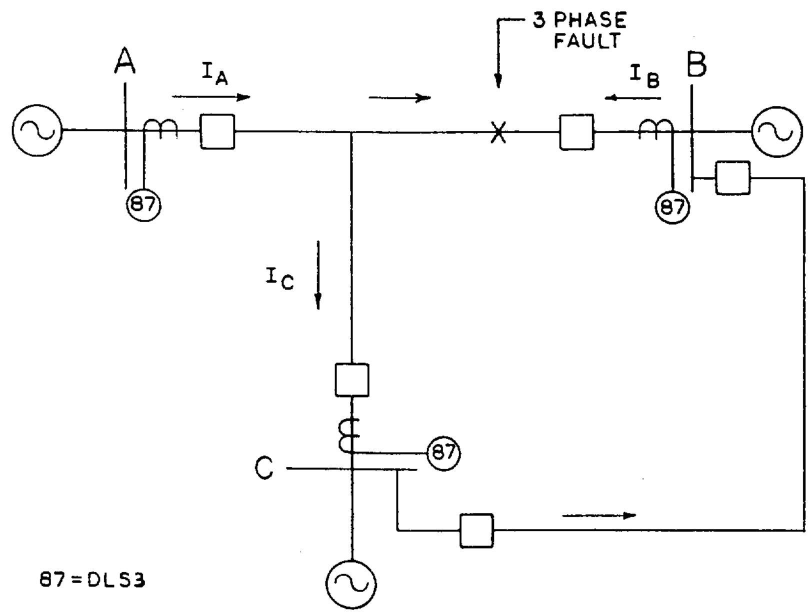


Figure 2-2 (0286A2748 [1]) Model System, Three-Terminal Application

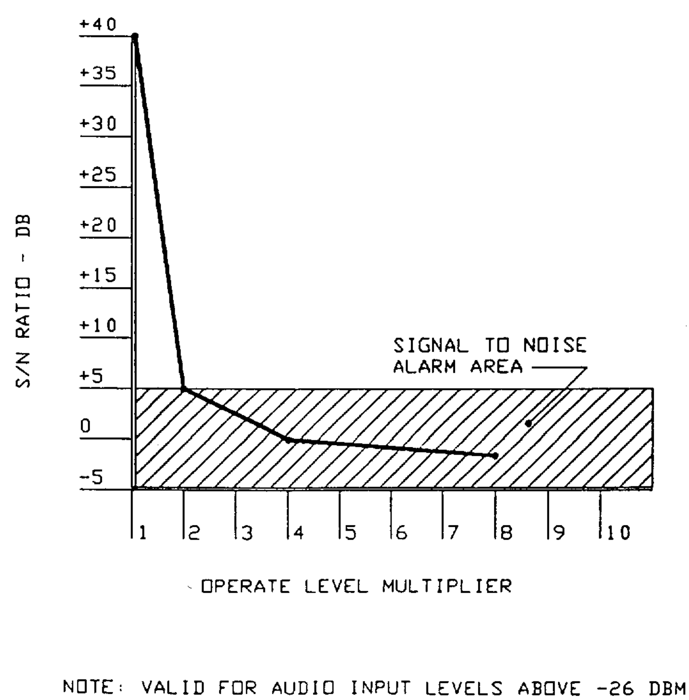


Figure 2-3 (0286A2858) Effect of Channel S/N Ratio on DLS Operate Level

HARDWARE DESCRIPTION

CASE ASSEMBLY

Construction

The case that houses the electronic modules is constructed from an aluminum alloy. It consists of a main frame with side mounting brackets, a front cover and a rear cover.

The front cover, comprised of a metal frame with plate glass, is pivoted on the top and is opened from the bottom by way of two spring-loaded latches. The door is constrained from coming off by tabs that require the door to be unlatched and lifted slightly in order to be removed.

The rear cover supports terminal blocks that are used in making external connections to the case.

The modules are mounted vertically inside the case and they are supported at the rear by sockets within the case. In addition to this mechanical support, the sockets also offer the means of making the electrical connection to the modules. The modules are further restrained inside the case by the card guides and the front cover.

Proper alignment of the module with respect to the socket is maintained by slotted guides, one guide above and one guide beneath each module, with the exception of the magnetics module, MGM, which requires two guides above and two beneath.

Electrical Connections and Internal Wiring

As mentioned earlier, electrical connections are made to the case through six 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 module is made by means of 60-pin edge connectors (socket). 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 system current transformer (CT) secondary currents, and they are shorted upon removal of the MGM module.

Identification

The DLS system model number label is located on the outside of the front cover, and on the right-hand sidesheet inside the case.

A marking strip indicating the name and position of every module in a case is included on the shelf. It is placed to be read when the front cover is removed. Figure 4-1 in the MODULES section shows the location of the modules.

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

Fiber-Optic Cable Connections

The fiber-optic cables enter the case via bushings in the rear cover plate. These bushings are large enough to accommodate connectors on the fiber-optic cables if the connectors are inserted one at a time.

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. In some models not all module locations within the case have a printed-circuit board; some locations have a blank board and a blank 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 front cover is removed.

XTM TEST PLUGS

Description

The XTM test plugs are designed specifically for post-installation testing of the DLS system. There are two plugs; XTM28L1 (left-hand plug) and XTM28R1 (right-hand plug), each providing access to fourteen relay-side and fourteen system-side points. The system-side points are designated "S" and the relay-side points are designated "R". 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 consist of number 8 screws threaded into flat contact plates. The handles each have a tab on the outside edge to guide the wire dress of the test leads.

CAUTION

Not all external connection to the DLS are wired through the test receptacle

Terminal Designation

The test receptacle and connection plugs are located to the left of the magnetics module (extreme 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 1-5 in the SCHEME DESCRIPTION section, 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.

Test Connections

Some diagrams indicate DLS terminal numbers (rear-cover terminals) and the corresponding XTM test-plug terminal terminals. For the acceptance tests, test connections should be made to the rear-cover terminals. The test plug is intended for post-installation testing, and its use is described in the **PERIODIC TESTS** section.

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 DLS.

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 DLS for those signals that are wired through the test receptacle (refer to TP points on the elementary diagram, Figure 1-5 in the SCHEME DESCRIPTION section). For the terminals connected to the current-transformer secondaries, shorting bars are included on the system side of the test receptacle. These are clearly visible through the transparent plastic face plate on the receptacle. The shorting bars make contact before the connection-plug contacts break during removal, so that the CT secondaries are never open-circuited.

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

When the test plugs are inserted into the receptacle, parts of the power system become isolated from the DLS. Refer to the elementary diagram for the TP points associated with each of the test plugs.

WARNING

IT IS CRITICAL THAT JUMPERS BE INSERTED ON THE SYSTEM-SIDE THEST PLUG TERMINALS THAT ARE CONNECTED TO THE CT SECONDARIES AS SHOWN IN FIGURE 1-5. 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 modules. The module can then be inserted into the connector on the extender.

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

CAUTION

Remove power from the DLS 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 power, turn OFF the power switch on the PSM power supply module and then remove both of the TPM connection plugs located in the positions, to the left of the MGM module (see Figure 4-1). **Extreme caution** is still required for inserting extender cards into the AFM, IOM, or PSM positions.

WARNING

CAUTION MUST BE EXERCISED WHENEVER A CARD EXTENDER IS INSERTED INTO AN "AFM", "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 SWITCH ON THE PSM MODULE AND REMOVING BOTH CONNECTION PLUGS DOES NOT REMOVE ALL EXTERNAL POWER TO THE RELAY.

RECEIVING, HANDLING AND STORAGE

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 GE Sales Office.

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

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 to make settings on the internal switches. The persons handling the modules should make sure that their body charge has been discharged by touching some surface at ground potential before touching any of the components on the modules.

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 DLS case has been designed for standard rack mounting. The case measures four rack units (4 RU) in height. Refer to Figure 3-3 for the outline and mounting dimensions.

External Connections

External connections are made according to the elementary diagram, Figure 1-5 in the SCHEME DESCRIPTION section. This is a general diagram incorporating all of the available options. Connection need not be made to those terminals associated with options that will not be used.

Surge Ground Connections

WARNING

DLS TERMINALS AH13 AND AH14 MUST BE TIED TOGETHER, AND TERMINAL AH14 MUST BE TIED TO THE GROUND BUS, AS SHOWN IN THE ELEMENTARY DIAGRAM, FIGURE 1-5. THE CONNECTION TO THE GROUND BUS MUST BE MADE USING A NO.12 WIRE OR LARGER. THE LEADS USED IN MAKING BOTH OF THESE CONNECTIONS SHOULD BE AS SHORT AS POSSIBLE.

Installation Adjustments

There are two adjustments required that must be made after installation. These are the communications link phase delay compensation and the pilot tone level adjustment.

The phase delay compensation is almost always required. It may be unnecessary if a very short fiber-optic link is used. In this case all the phase compensation settings can be zero (0). Any link involving wire pairs will require compensation due to the delays in the DLS filters. Even with short wires between DLS units, the local delay will have to be set to 10°. With longer wire pairs, or a microwave link, longer delays will be needed.

Phase Delay Compensation

1. Two-Terminal Compensation

Two possible methods of making the local channel-delay adjustment are described. For both methods it is assumed that the trip outputs of the DLS relay at each end of the line have been **disabled**, and that the two-way relay/channel combination is connected and functional.

A. Load-Current Method

In this test, the load current on the line is used to simulate negative-sequence current. It is desirable that the secondary load current be greater than 0.2 x INPUT TAP ($I_{N\emptyset}$) x

NOMINAL CURRENT (1 or 5 amps). It is necessary that the ratio of line-charging current to through-load current be low enough so that the phase displacement between currents at the two ends of the line does not exceed 10°. Since the DLS will generally be applied on short lines, it is anticipated that in most instances the ratio of line-charging current to through-load current will be low enough to permit the load-current method to be used. If this condition is met, the procedure outlined below should be used. If the condition is not met, it will be necessary to use the alternate "Test Source" method.

At each terminal, prepare a left-hand test plug with connections as shown in Figure 3-4. These connections cause phase A current to flow in the phase B relay coil and vice versa, thereby making balanced load current appear as negative-sequence current to the relay. Do not insert the plug yet.

Put the ACM103/104 board on a card extender. Using a dual-trace oscilloscope at terminal A (local), connect the trace 1 vertical input to card pin 46 of the ACM103/104, connect the trace 2 vertical input to card pin 17 of the same board, and connect oscilloscope ground to board pin 30 or 60.

Now insert the left-hand test plug into the left test receptacle at each end of the line. Oscilloscope trace 1 will show a sine-wave output from the "local phase delay" and oscilloscope trace 2 will show a sine-wave output from the "remote phase delay". These two sine waves should be close to being 180° out of phase (compare the zero crossings). Note: Invert one channel of the oscilloscope for easier comparison

Put the AFM113/116 module on a card extender and adjust the LOCAL PHASE SHIFT setting such that trace 1 and trace 2 are as close to being in phase as possible within the resolution of the setting. Now repeat this procedure at terminal B (remote).

B. Test Source Method

If the line is not loaded, or if the ratio of charging current to load current is too high, an AC test source can be used at each terminal, provided the sources are in phase. Prepare a left-hand test plug as shown in Figure 3-5 table A for use at both terminals A (local), and prepare a left-hand test plug as shown in Figure 3-5 table B for use at terminal B (remote). Do not insert the plug yet. These connections simulate a through-current condition. The AC source for the test connections of Figure 3-5 will usually be station service AC, and on heavily-loaded long lines it may be found that the test sources are displaced by too great an angle (greater than 10°) for this method to be applicable. If at least one of the conductors of the protected line is equipped with line-side potential devices or transformers, it is possible that substantially-in-phase test sources can be obtained at the two ends by supplying the test circuit of Figure 3-5 from the potential device or transformer, and operating the line with the breaker open at one terminal. This in-phase source (REF) is used to phase lock a 3ϕ current source at each end of the line.

Having obtained AC test sources that are in phase within 10° of each other, proceed to adjust the LOCAL PHASE SHIFT as described above under Load-Current Method.

2. Three-Terminal Compensation

Use the technique described in B above where the three-terminal line has two open terminals and is driven at the third terminal. Potential transformers (PTs) or the equivalent are required at each terminal on the phase used to provide the reference. The output of the PTs must be converted to currents to be input into the phase-A current terminals of the DLSs. Phasing must be observed so that the currents at the three terminals are in phase. **Trips must be disabled** during this operation. The connections to make this adjustment are shown in Figure 3-6. In this figure the right hand breaker is closed, so the line is energized. There is a PT connected to the same conductor at every terminal. The 69 volt secondary voltage from each PT goes through a 70K ohm resistor to a high-current amplifier. This is set up to give an output current proportional to the input voltage. The amplifier gain is set to give a 5 ampere RMS signal into the same current inputs on all three DLSs. The design of the DLS is such that each DLS will send a link signal proportional to the negative-sequence component of this AC input. The negative-sequence signal seen in the local signal and those received via the links will be in phase except for the channel delays.

To set the phase compensation at a terminal, put the ACM10(-) board on an extender. Set the phase shift links on the AFM11(-) modules (both of them) to zero. Use an oscilloscope that can display 3 traces. Connect the oscilloscope inputs to card extender pins 46, 17, and 16. Set the oscilloscope to display all three inputs with a sweep speed of about 5 milliseconds per division. Adjust the oscilloscope triggering so the input sine waves are displayed. Compare the phases. The phase that lags the most should be one of the remote terminals (extender pins 16 or 17). No phase delay will be added to this channel. Add local phase delay on the right-hand AFM11(-) (Position G) until the oscilloscope signal from extender pin 46 (LOCOP) matches the phase of the sine wave that lags the most. Next add phase delay on the remote signal that lags the least. If this comes from extender card pin 16, use the remote phase adjustment on the left-hand AFM11(-) module (Position L). If it comes from extender card pin 17, use the remote phase jumpers on the right hand AFM11(-) module (Position G). This process must be repeated at each terminal. (As an alternative, it is possible to use the single phase (See Figure 3-5) to lock in the three-phase generator at each site.)

Pilot-Tone Level Adjustment

This adjustment is applicable only to audio channel relays with pilot tone . The adjustment may be needed to compensate for the differing attenuation in the channel at 400, 1800, and 3000 Hz. The 400 Hz pilot tone serves as an amplitude reference for the 1800 Hz or the 3000 Hz, depending on which is present. These frequencies must neither be more than twice, nor less than half, the voltage of the 400 Hz. Otherwise the pilot-tone circuit will disable the relay.

To make this adjustment, the DLS relays must be installed and communicating via the audio links. **The trip outputs should be disabled**, since there will be trips during this test. Voice communications between the ends of the line are required (at each DLS site). Put the AMM10(-) modules at each end on extenders. Measure the 400 Hz level at TP6 and the 1800 Hz level at TP7 at one of the DLSs. Record the values. Ask the other end of the line to send a steady DTT. Measure its level at TP7. Record this value and compare it with the 400 Hz and 1800 Hz levels. The 400 Hz level should be between those of the 1800 Hz and the 3000 Hz (DTT) levels. If necessary adjust the 400 Hz (Pilot Tone) transmit level at the transmitting DLS, using R144 (labeled PILOT1) on the AMM10(-) module. With the revised setting it is important that the highest signal (normally the 1800 Hz) be no more than 1.5 times the voltage of the 400 Hz pilot signal at the receiving AMM10(-) test points. Similarly the lowest signal (normally the 3000 Hz DTT signal) must be no less than 0.7 times the 400 Hz amplitude. The maximum permissible ratios are two to one, and this would give marginal operation. If the required ratios can not be obtained, then the communication channel bandwidth is too narrow or is offset in frequency. This process must be repeated for the receiving DLS at the other end of the line.

For three-terminal lines there are two links to each DLS. Both have to be adjusted as described. The test points for the added terminal are TP4 for the 400 Hz signal and TP5 for the 1800 Hz and 3000 Hz signals. The 2nd pilot-tone level adjustment for three terminals is R172 (PILOT2). At a particular DLS the labeling of the communications lines from the remote terminals is arbitrary. The installation drawings must be used to determine which remote terminal's transmit-line-pilot level is controlled by the PILOT1 trimmer and which by the PILOT2 trimmer.

Checking Optical Fiber Links

Depending on the test equipment available, it may be possible to verify that the fiber-optic links are operating as designed. Refer to the section on periodic testing.

FFM1(--) MODULE AUDIO LINE ATTENUATOR SETTINGS (AUDIO LINK MODELS ONLY)

Before placing the DLS3 on line, the attenuator links on the receiving audio- signal filter must be set.

On a Power Line Carrier System, Standard transmit (TX) signal level is -16 dBm and receive (RX) signal level is +7 dBm. The DLS3 relays were designed for RX levels of 10 dBm to -26 dBm and TX levels of 7 dBm (including Exalt) to -36 dBm. To obtain the highest system security and dependability, the RX signal should be within 0 dBm to -10 dBm. Higher or lower values will slow down the relay's operating time.

The TX channel should be set to provide the optimum signal needed for your channel equipment. Excessive signal levels will overload the channel, and weak signals will produce excessive channel noise, all of which can degrade the performance of the DLS3 relay. TX levels higher than 8 dBm cannot be obtained from the DLS3, due to amplifier clipping. Therefore, the TX signal should be -3 dBm maximum to allow for a 10 dB Exalt, or a 0 dBm maximum to allow for a 6 dB Exalt. Exalt should not be used with the Pilot Tone option.

The DLS3 relays with 600 ohm audio-channel systems have been provided with a set of signal-level adjustment links for the RX and TX channels. These links are on the FFM1(--) module. A second TX level adjustment is provided on the IOM152 module, which has been factory set to provide a TX signal level of 0 dBm on the channel output terminals of the DLS. Channel signal levels for RX and TX should be measured at the connection terminal boards on the back of the DLS. A receive and a transmit passive analog filter is used in the FFM1(--) module, and each has a -2.5 dB insertion loss. Measurement other than on the terminal block will reflect this loss. All tests must be run with 600 ohm terminations.

To adjust the RX and TX channel levels, place the FFM1(--) module on an extender card, allowing access to the links. Turn on both local and remote DLS3 relays and ascertain that the channels are working. To set the RX channel, connect a volt meter or dBm meter to terminal points AA7 and AA8. Also use AG7 and AG8 in three-terminal systems. Read the input signal level in dBm. Calculate the number of dBs the signal must be reduced, and set this value with the receiver-attenuator links. These links have values of -1, -2, -4, -8, and -16 dBs, and when placed to the "IN" position produce attenuation values amounting to the sum of those values placed "IN". To set the TX channel, connect the volt meter or dBm meter to terminal points AA5 and AA6. Also use AG5 and AG6 in three-terminal systems. Then repeat the preceding procedure using the transmit attenuator links.

Stub Bus Protection Level Settings (FFM111 only)

After all the previous level settings have been performed, it will be necessary to set the stub bus protection levels. The DLS3 relays must be installed and communicating via audio links. Voice communication at each terminal is required. Disable all trip outputs. Place the local FFM111(s) on an extender card. Close contact converter CC4 (Stub Bus Protection) by connecting AA1 to +Battery and AA2 to -Battery. This will connect the Stub Bus oscillators to the Local and Remote terminal. Place a dB or Voltmeter on the remote terminal receiver input. Measure this input on the rear Terminal Board of the remote DLS3, between pins AA7 and AA8, and also, in three-terminal systems, between pins AG7 and AG8. Connect a jumper from TP9 to TP5 on the local FFM111 module(s). Adjust R30 until a signal of -6 dBm (400 Hz) is obtained at the remote terminal. Remove the jumper from TP9 and TP5 at the local terminal. Next, adjust R29 until a signal of -3 dBm (modulated 1800 Hz) is obtained at the remote terminal. Place the FFM111 Board back in the case and open contact converter CC4.

CAUTION
Do not remove or replace a module with system power on. Use the switch on the power supply (PSM module) to turn off all logic supplies.

CAUTION
Some of the output contacts of the DLS3 are not disconnected by removing the connection plugs from the test block. This could result in disruption of external protection schemes when testing the DLS3 functions.

Dielectric Tests

Consult the factory for recommendations.

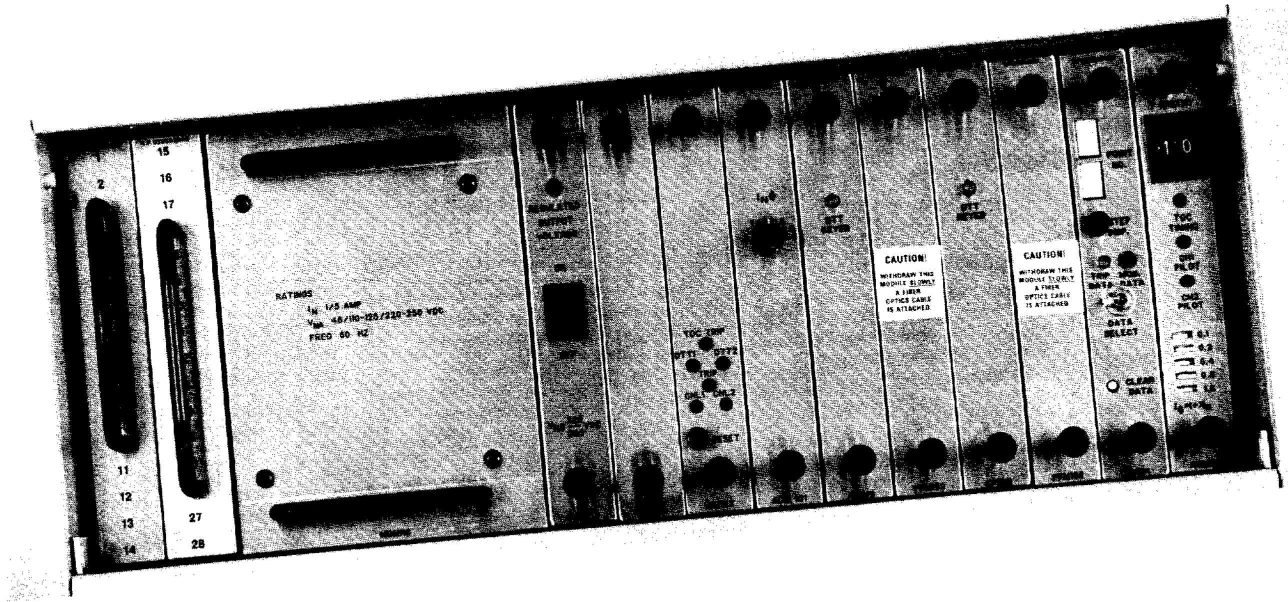


Figure 3-1 (8043792) DLS Relaying System, Front View

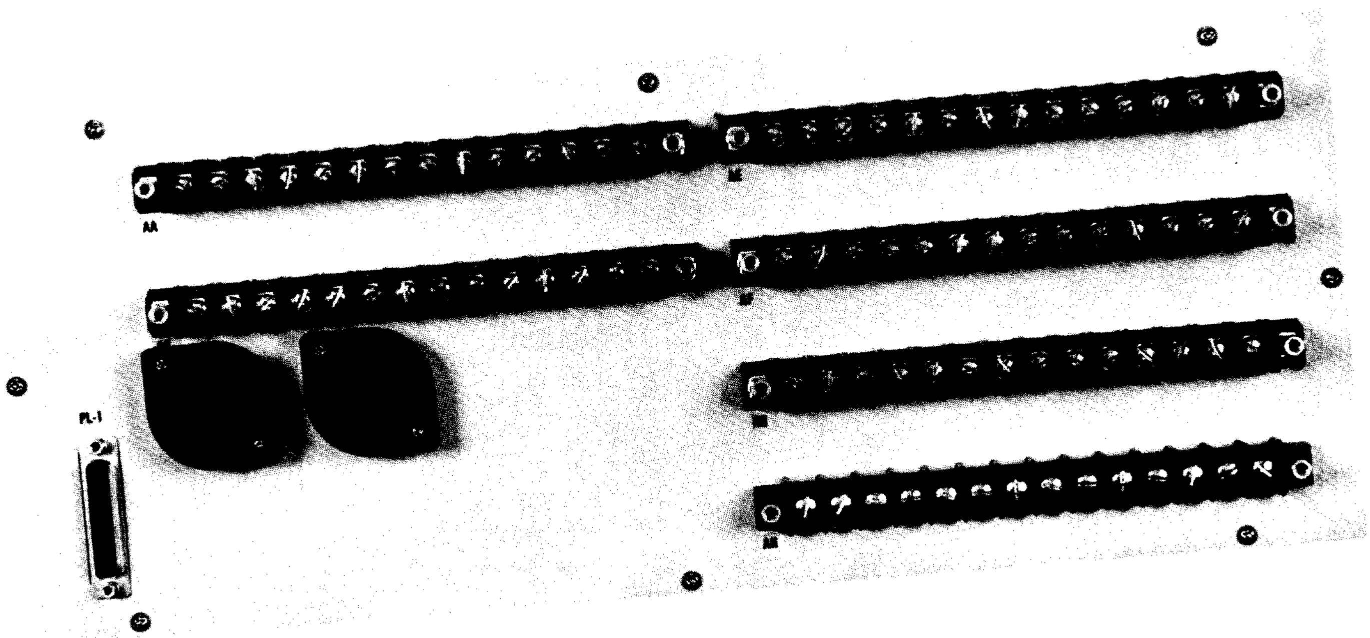


Figure 3-2 (8043793) DLS Relaying System, Rear View

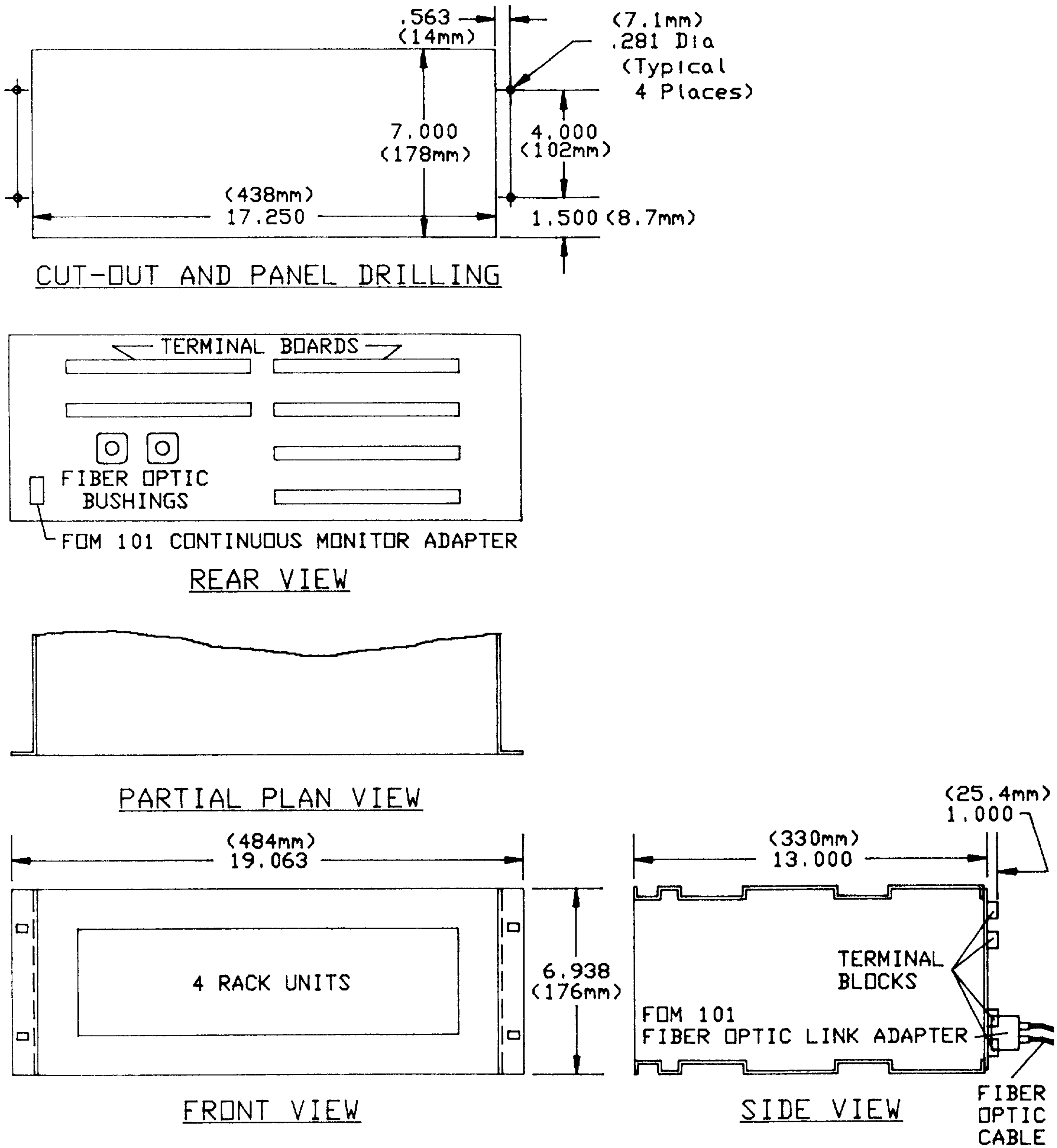
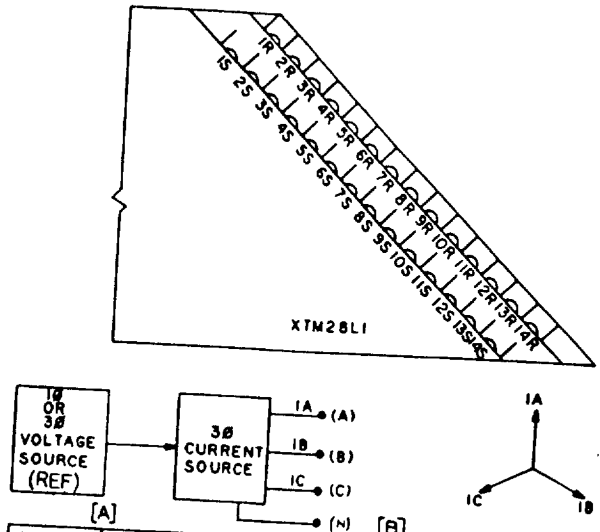


Figure 3-3 (0286A2801[1]) Enclosure Outline and
Mounting Dimensions, DLS3 System



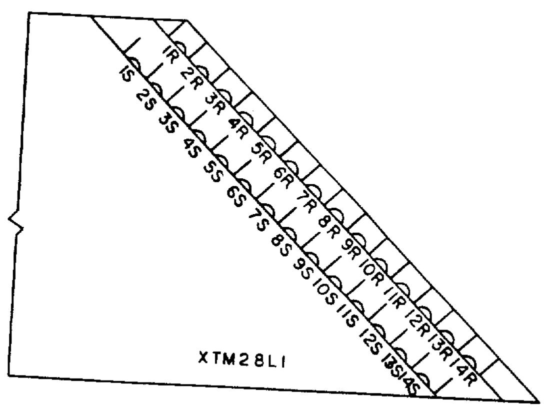
[A]

FROM	TO
A	9R
B	7R
C	11R
7S	8S
9S	10S
11S	12S
1S	1R
8R	10R
10R	12R
14S	14R
N	12R

[B]

FROM	TO
A	10R
B	8R
C	12R
7S	8S
9S	10S
11S	12S
1S	1R
7R	9R
9R	11R
14S	14R
N	12R

Figure 3-4 (0285A9941[2]) XTM Connections for Test Source Method



FROM	TO
7S	9R
8S	10R
9S	7R
10S	8R
11S	11R
12S	12R
1S	1R
14S	14R

Figure 3-5 (0285A9942) XTM Connections for Load Current Method

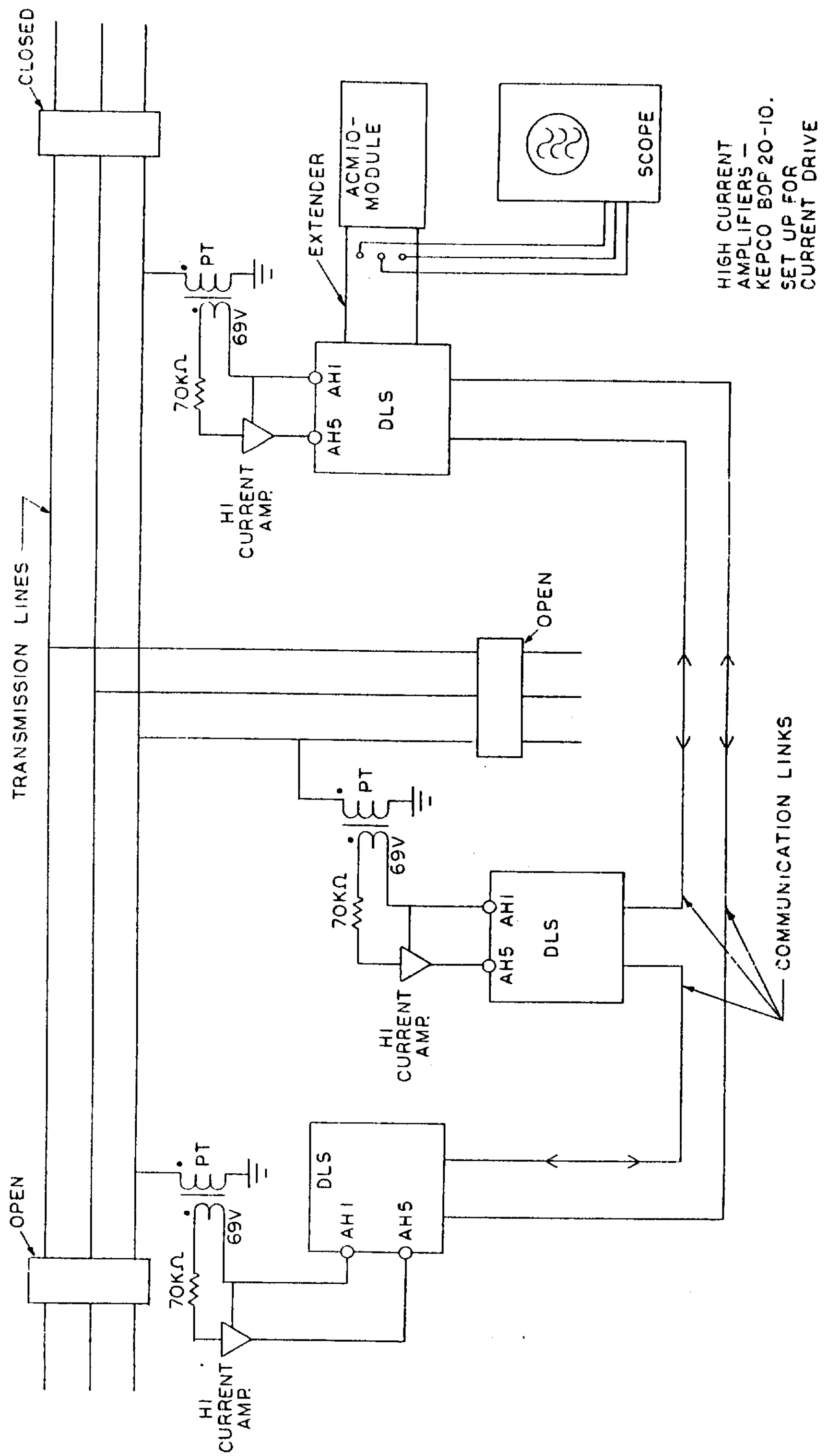


Figure 3-6 (0184B8939) Three-Terminal Phase Compensation Connections

MODULES

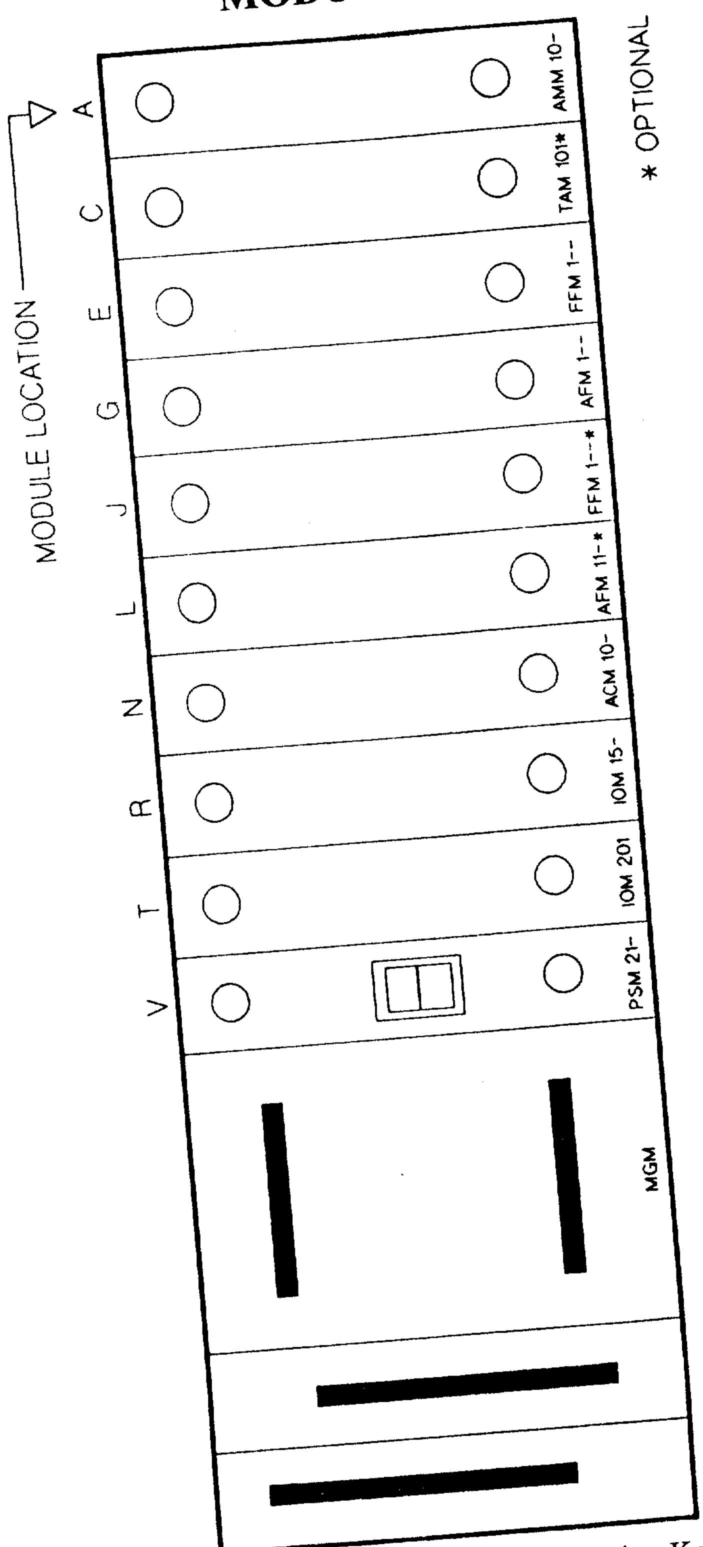


Figure 4-1 (0285A9699 [1]) Module Location Key, DLS Relay

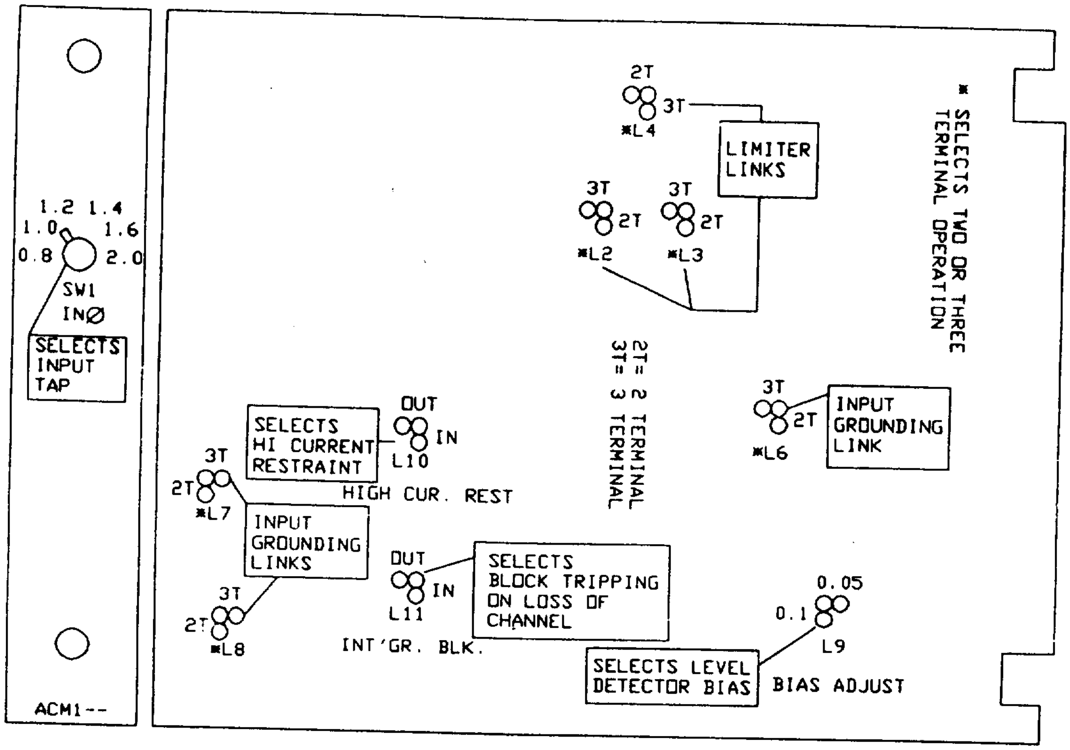


Figure 4-2 (0286A2836 [2]) ACM1(--) Module

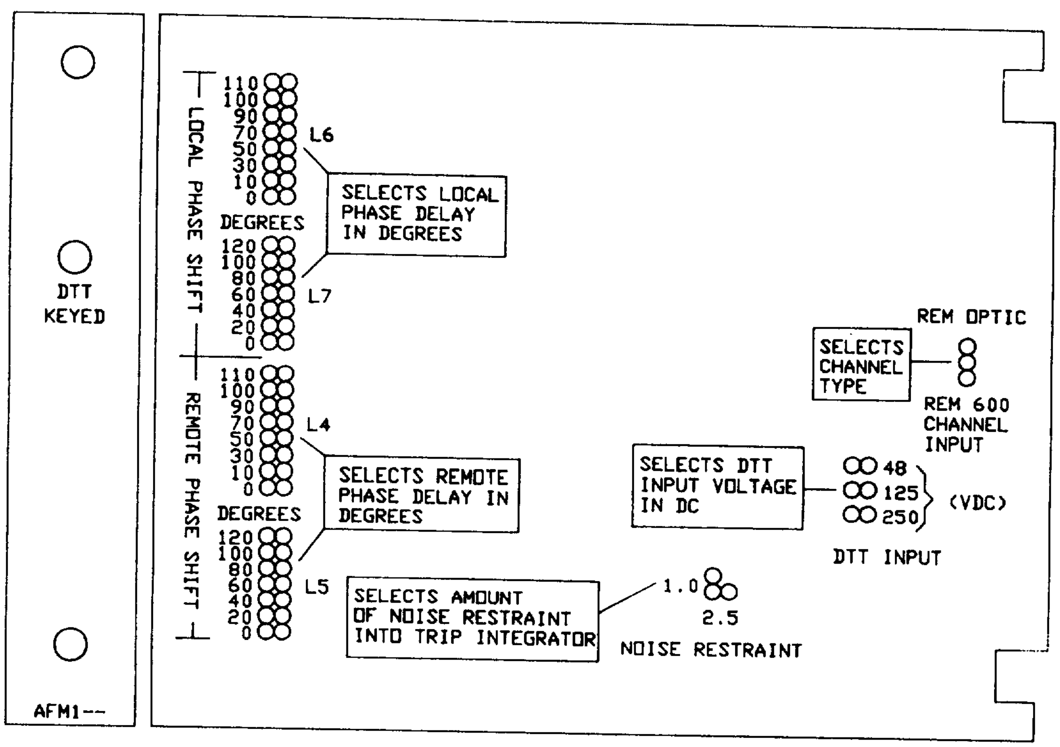


Figure 4-3 (0286A2837) AFM11(-) Module

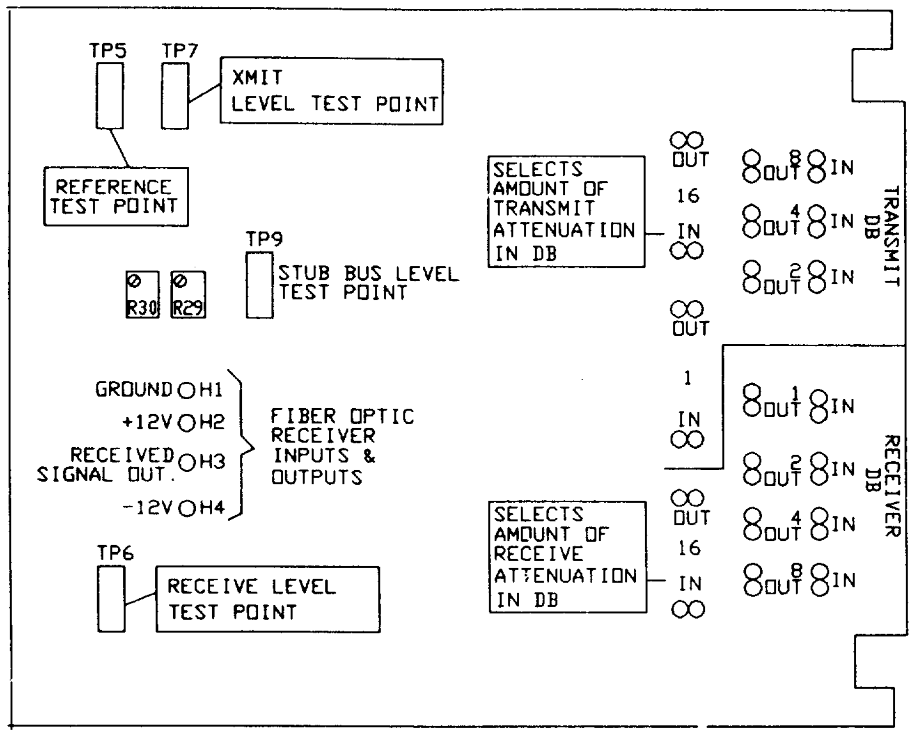


Figure 4-6 (0286A2924) FFM11(-) Module

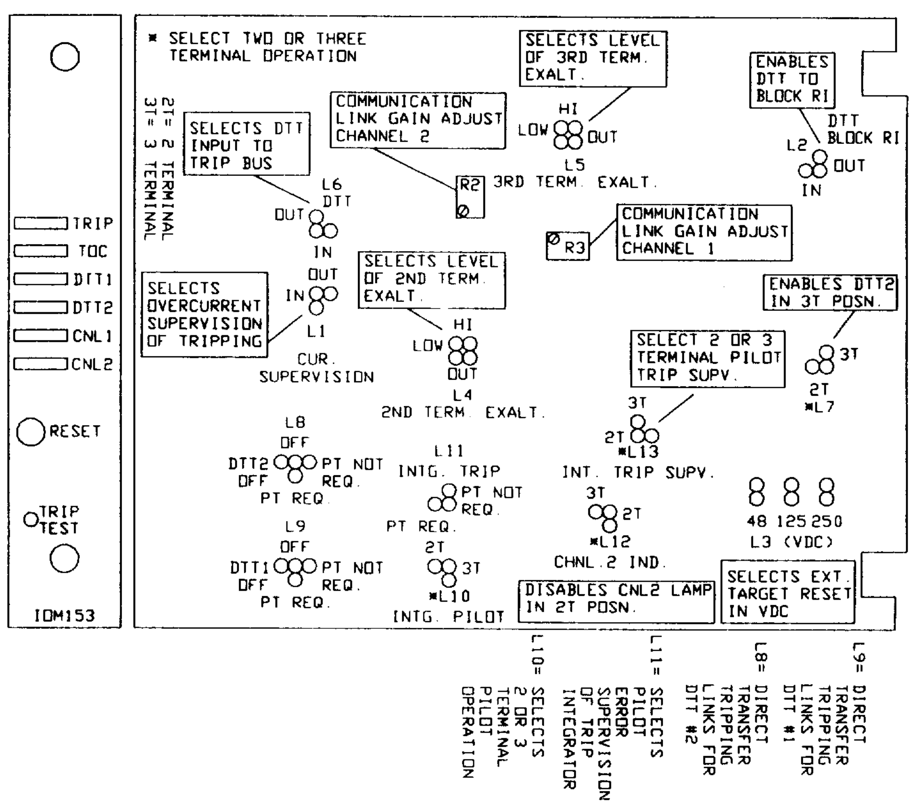


Figure 4-7 (0285A5424) IOM153 Module

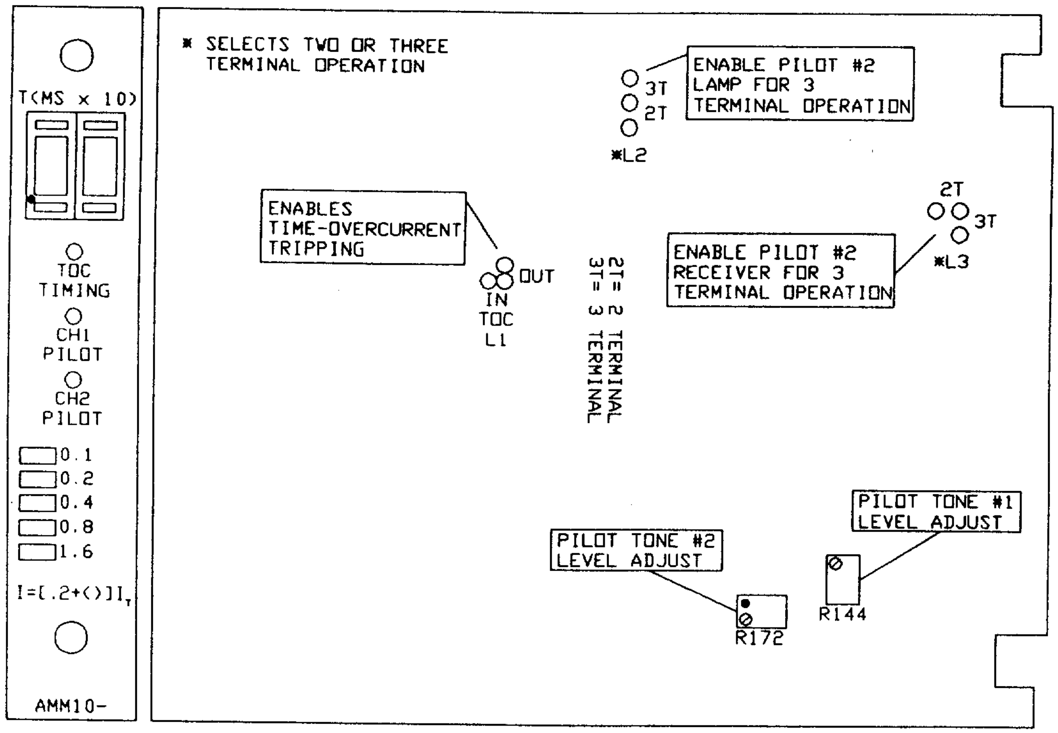


Figure 4-4 (0286A2838 [3]) AMM1(--) Module

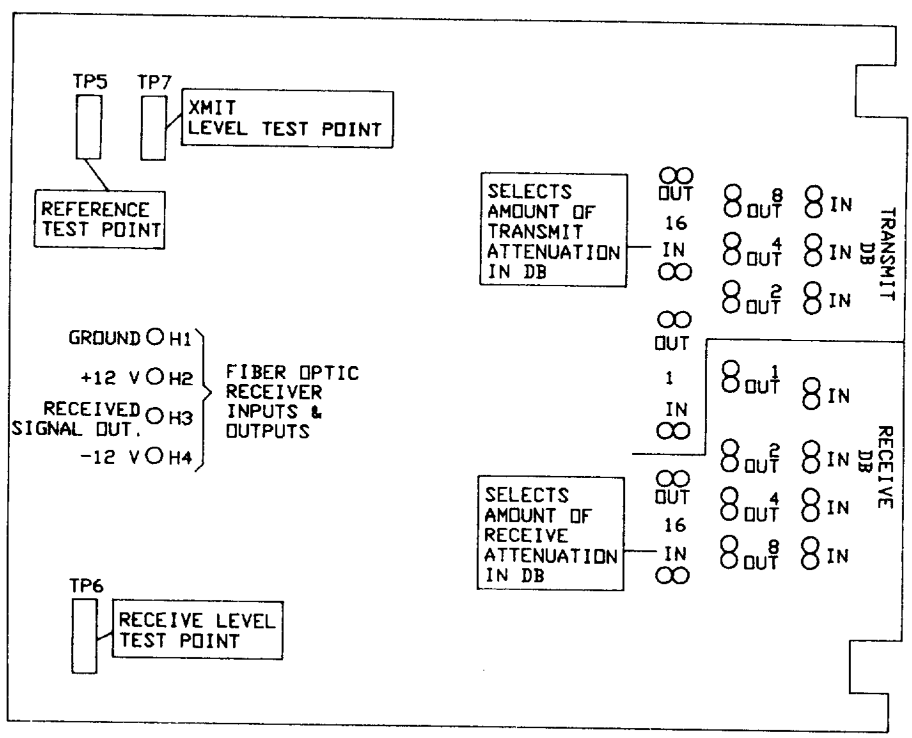


Figure 4-5 (0286A2839) FFM10(-) Module

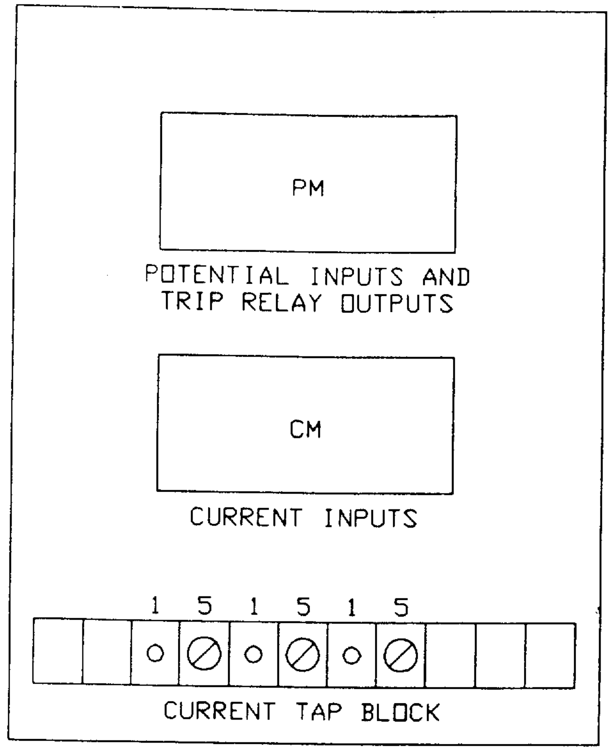


Figure 4-8 (0286A2873) MGM (---) Module Current Links

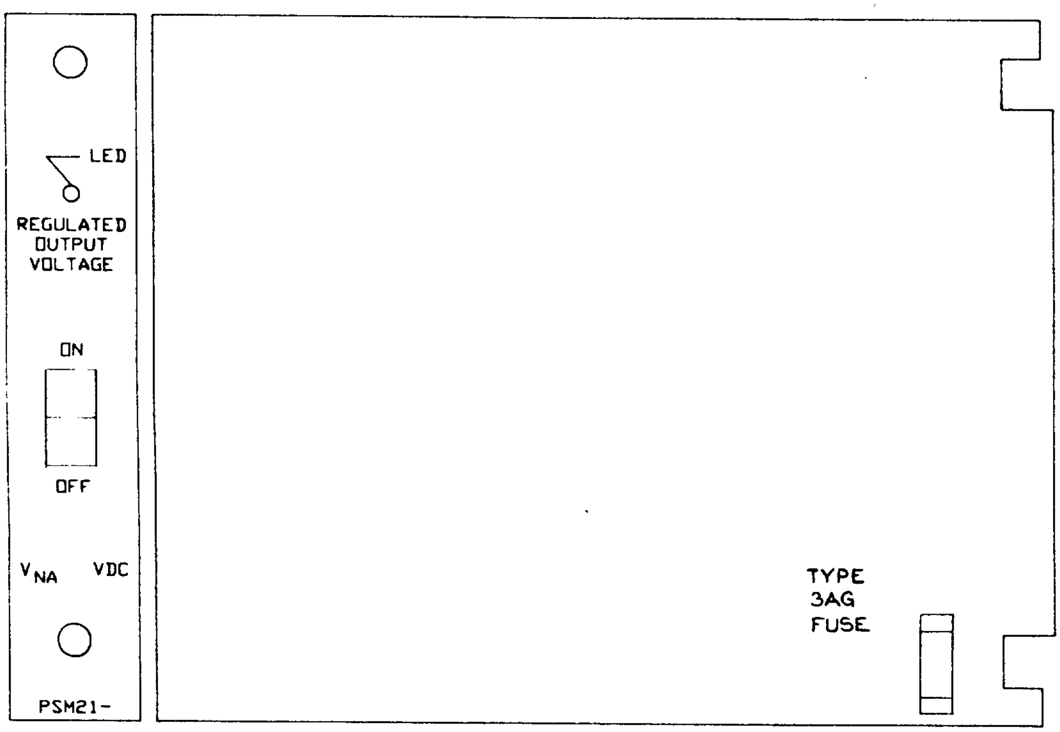


Figure 4-9 (0286A2547 [1]) Front Panel and Internal Fuse, PSM21(-) Module

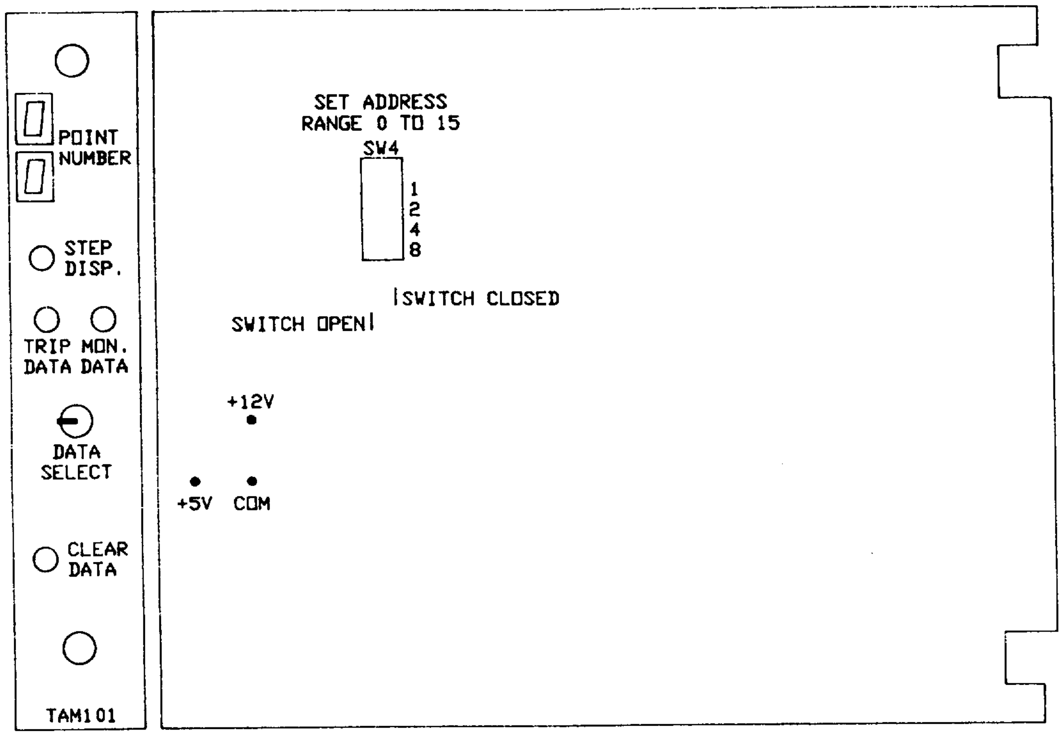


Figure 4-10 (0285A9831[2]) Front Panel & Internal Switches, TAM101

ACCEPTANCE TESTS

DESCRIPTION:

The DLS3 can use either telephone lines (or microwave) or fiber-optic links. The DLS3 includes channel monitoring. The monitor checks that the signal level is adequate for proper operation. The link is also monitored for an adequate signal-to-noise ratio. With an audio link, an optional check for frequency translation errors is made, using a pilot tone transmitted over the link. When an audio link is used, it is possible to exalt the transmitted signal. The DLS is intended for use with dedicated communications lines. It contains provision to compensate for fixed transmission delays.

Tests

> **CAUTION**
> **Do not apply voltage until instructed to.**

Note: If your equipment does not contain a TAM101, ignore all references to that module.

1. Test Setup

Figure 5-1 shows the setup required to test the DLS3 system units.

The three-phase current source must be capable of supplying up to 15 amperes. To carry out all the tests it must be capable of ramping all three currents up smoothly and simultaneously.

2. Relay Settings

Set the internal links and front panel switches per tables 5-1 and 5-2 for two-terminal relays. Use tables 5-3 and 5-4 for three-terminal relays.

> **WARNING**
> **BEFORE APPLYING POWER, MAKE SURE THE JUMPERS ON ALL MODULES ARE SET CORRECTLY, AS SHOWN IN TABLE 5-1 AND 5-2 OR 5-3 AND 5-4.**

If the DLS3 is equipped with the Continuous Monitor option, the TAM101 module should show 0,0 on the numeric displays. The Trip and Mon Data LEDs on the TAM101 module may or may not be lit.

TWO-TERMINAL DLS SYSTEM DLS3

Internal Drawing: 0153D7705
(See Figure 7-1 in the SERVICING section of this book.)

5

Set the internal links and front panel switches per Tables 5-1 and 5-2.

1. Power Supply Alarm

With the unit power supply off, the test circuit lamp 'PSA NO" should be lit. Turn on the unit power supply and the test circuit lamp "PSA NC" should light. This will apply to all future tests.

2. Continuous Monitor Alarm

Whenever the "MON DATA" lamp on the TAM101 module is lit, the "CON MON" lamp in the test circuit will be lit. This will apply to all future tests.

TABLE 5-1 TWO-TERMINAL INTERNAL LINK SETTINGS

Module Name	Location	Link Name	Setting Name	Setting
ACM10(-)	N	Link 2	2T/3T	2T
"	"	Link 3	2T/3T	2T
"	"	Link 4	2T/3T	2T
"	"	Link 6	2T/3T	2T
"	"	Link 7	2T/3T	2T
"	"	Link 8	2T/3T	2T
"	"	Link 9	BIAS ADJUST	0.05N
"	"	Link 10	HI CUR REST	OUT
"	"	Link 11	INT'GR BLK	IN
AFM11(-)	G	Link Odd degrees	LOCAL PHASE SHIFT	0
"	"	Link Even Degrees	LOCAL PHASE SHIFT	0
"	"	Link Odd Degrees	REMOTE PHASE SHIFT	0
"	"	Link Even Degrees	REMOTE PHASE SHIFT	0
"	"	Link	NOISE RESTRAINT	1.0
"	"	Link	DTTINPUT	Battery DC
"	"	Link	REMOPTIC/REM 600	Channel Type
AMM10(-)	A	Link L1 (Optional)	TOC	IN
"	"	Link L2 (Optional)	2T/3T	2T
"	"	Link L3 (Optional)	2T/3T	2T
FFM1(--)	E	Link (Audio Channel)	TRANSMIT DB	All OUT
"	"	Link (Audio Channel)	RECEIVE DB	All OUT
"	"	Links (2) Optional	48/125/250	Battery DC
IOM 153	R	Link L1	CURRSUPRV	OUT
"	"	Link L2	DTT BLOCK RI	IN
"	"	Link L3	48/125/250	Battery DC
"	"	Link L4	2ND TERM EXALT	OUT
"	"	Link L5	3ND TERM EXALT	OUT
"	"	Link L6	DTT	OUT
"	"	Link L7	2T/3T	2T
"	"	Link L8	DTT2	DTT2 OFF
"	"	Link L9	DTT1	PTNOTREQ
"	"	Link L10	INTG PILOT SUPV 2/3	2T
"	"	Link L11	INTG TRP	PTNOTREQ
"	"	Link L12	CNL2 IND	2T
"	"	Link L13	INT TRIP SUPV 2/3I	2T
MGM1(--)	MGM TAPS (3)		1/5 AMPS	5

TABLE 5-2 FRONT PANEL SETTINGS

Module Name	Location	Switch Name	Setting
ACM10(-)	N	INϕ	1.0
AMM10(-)	A	I (Optional)	1.0
AMM10(-)	A	t (Optional)	0.50

3. DTT Tests

Turn power on and press the "CLEAR DATA" switch on the TAM101 module. Close Switch CC1. The "DTT KEYED" lamp on the AFM11(-) module and the "DTT1" lamp on the IOM153 module should light. The test circuit lamps "DTT TRIP" and "DTT1" will light. After a few seconds the "MON DATA" lamp on the TAM101 should light, the test circuit lamp "CON MON" will light. Turn off switch CC1. Move the "TRIP DATA/MON DATA" switch on the TAM101 module to the "MON-DATA" position. Press "STEP DISP" and points 7, 9, and 18 should be seen. Press the "CLEAR DATA" switch.

4. Current Differential Trip Tests

Positive Sequence

Set the three-phase current source to 0.8 ampere rms positive sequence. Turn on the unit power and press the "CLEAR DATA" switch on the TAM101 module. Move the "TRIP DATA/MON DATA" switch to the "TRIP DATA" position. Simultaneously apply the three-phase current. The relay should not trip.

Note: Do not ramp the current. The delta circuit in the DLS3 would adapt to the change and this test would be invalid.

Turn off the three-phase current source and set it to 1.7 amperes rms positive sequence. Once again apply three-phase

current and the relay will trip. The test circuit lamps "TRIP", "BFI", and "RI" will light. The "DIFF TRIP" light will pulse. Remove the three-phase current. The "TRIP" lamp on the I0M153 module, as well as the "TRIP DATA" lamp on the TAM101 module, will light. Press the "STEP DISP" switch on the TAM101 module. E1 will contain data points 6, 47, and 48.

Negative Sequence

Set the three-phase current source to 0.15 ampere rms negative sequence. Press the "CLEAR DATA" switch on the TAM101 module. Apply the three-phase current and the relay will not trip. Turn off the three-phase current source. Set the source to 0.35 ampere rms and re-apply the current. The relay will trip. Turn off the three-phase current source. The indicators and trip data points should be the same as in the positive-sequence tests.

5. TOC Tests (Optional)

Turn off the unit power. Open the channel by opening switch SW1 in the test circuit or by disconnecting the fiber-optic transmitter from the receiver. Turn the module power on. Press the "CLEAR DATA" switch on the TAM 101 module. Set the three-phase current source to 4.0 amperes rms negative sequence. Apply the current and the relay will not trip. Turn off the three-phase current source. Set the three-phase current source to 5.5 amperes rms negative sequence. Apply the current and the relay will trip in 0.5 second. The test circuit lamps "TRIP", "BFI", "CHANNEL" and "TOC" will light. Remove the current. The "TOC TRIP" and "TRIP" lamps on the IOM153 module, as well as the "TRIP DATA" on the TAM101 module, will light. The "MON DATA" lamp on the TAM101 will also be lit, due to the loss of channel. Press the "STEP DISP" switch on the TAM101 module. E1 will contain data points 2, 3, 5, 11, 47, and 48.

5

6. Fault Detector Test

With the channel still open, set one phase of the three-phase current source to 0 amperes rms. Turn on this phase only and increase the current until the "EXALT" lamp in the test circuit lights. This should occur for a current between 0.7 and 0.9 ampere rms.

7. Local Loop Test (Optional)

With the channel still open, press the "CLEAR DATA" switch on the TAM101 module. The "CNL1" on the IOM153 module, as well as the "CH1 PILOT" (if applicable) on the AMM101 module, should be off. After about 10 seconds the "MON DATA" lamp on the TAM101 module will light due to loss of channel. Close switch CC3 in the test circuit. The Channel and pilot lamps will light. The "LOCAL LOOP TEST" lamps on the FFM11(-) modules will light. Open switch CC3.

8. Stub Bus Test (Optional)

With the channel still open as above, close switch CC4 in the test circuit. The channel and pilot lamps will light, along with the "STUB BUS" lamps on the FFM11(-) modules.

9. Error Detection (Optional)

With the channel still open, close switches CC3 and CC4 in the test circuit. The channel and pilot lamps will remain off and the "STUB BUS" and "LOCAL LOOP TEST" lamps on the FFM11(-) module will flash.

THREE-TERMINAL DLS SYSTEM DLS3

Internal Drawing: 0153D7705
(See Figure 7-2 in the SERVICING section of this book.)

Set the internal links and front panel switches per Tables 5-3 and 5-4.

1. Power Supply Alarm

With the unit power supply off, the test circuit lamp 'PSA NO" should be lit. Turn on the unit power supply and the test circuit lamp "PSA NC" should light. This will apply to all future tests.

2. Continuous Monitor Alarm

Whenever the "MON DATA" lamp on the TAM101 module is lit, the "CON MON" lamp in the test circuit will be lit. This will apply to all future tests.

3. DTT Tests

Turn power on and press the "CLEAR DATA" switch on the TAM101 module. Close Switch CC1. The "DTT KEYED" lamps on the AFM11(-) modules, and the "DTT1" and "DTT2" lamps on the IOM153 module, should light. The test circuit lamps "DTT TRIP", "DTT1" and "DTT2" will light. After a few seconds the "MON DATA" lamp on the TAM101 should light. The test circuit lamp "CON MON" will light. Turn off switch CC1. Move the "TRIP DATA/MON DATA" switch on the TAM101 module to the "MON-DATA position. Press "STEP DISP" and points 7, 8, 9, 10, and 18 should be seen. Press the "CLEAR DATA" switch.

4. Current Differential Trip Tests

Positive Sequence

Set the three-phase current source to 0.8 ampere rms positive sequence. Turn on the unit power and press the "CLEAR DATA" switch on the TAM101 module. Move the "TRIP DATA/MON DATA" switch to the "TRIP DATA" position. Simultaneously apply the three-phase current. The relay should not trip.

Note: Do not ramp the current. The delta circuit in the DLS3 would adapt to the change and this test would be invalid.

Turn off the three-phase current source and set it to 1.7 amperes rms positive sequence. Once again apply the three-phase current and the relay will trip. The test circuit lamps "TRIP", "BFI", and "RI" will light. The "DIFF TRIP" will pulse. Remove the three-phase current. The "TRIP" lamp on the IOM153 module, as well as the "TRIP DATA" lamp on the TAM101 module, will light. Press the "STEP DISP" switch on the TAM101 module. E1 will contain data points 6, 47, and 48.

Negative Sequence

Set the three-phase current source to 0.15 ampere rms negative sequence. Press the "CLEAR DATA" switch on the TAM101 module. Apply the three-phase current and the relay will not trip. Turn off the three-

TABLE 5-3 THREE-TERMINAL INTERNAL LINK SETTINGS

Module Name	Location	Link Name	Setting Name	Setting
ACM10(-)	N	Link 2	2T/3T	3T
"	"	Link 3	2T/3T	3T
"	"	Link 4	2T/3T	3T
"	"	Link 6	2T/3T	3T
"	"	Link 7	2T/3T	3T
"	"	Link 8	2T/3T	3T
"	"	Link 9	BIAS ADJUST	0.05N
"	"	Link 10	HI CUR REST	OUT
"	"	Link 11	INT'GR BLK	IN
AFM11(-)	G	Link Odd degrees	LOCAL PHASE SHIFT	0
"	"	Link Even Degrees	LOCAL PHASE SHIFT	0
"	"	Link Odd Degrees	REMOTE PHASE SHIFT	0
"	"	Link Even Degrees	REMOTE PHASE SHIFT	0
"	"	Link	NOISE RESTRAINT	1.0
"	"	Link	DTTINPUT	Battery DC
"	"	Link	REMOPTIC/REM 600	Channel Type
AMM10(-)	A	Link Ll (Optional)	TOC	IN
"	"	Link L2 (Optional)	2T/3T	3T
"	"	Link L3 (Optional)	2T/3T	3T
FFM1(--)	E	Link (Audio Channel)	TRANSMIT DB	All OUT
"	"	Link (Audio Channel)	RECEIVE DB	All OUT
"	"	Links (2) Optional	48/125/250	Battery DC
IOM 153	R	Link Ll	CURRSUPRV	OUT
"	"	Link L2	DTT BLOCK RI	IN
"	"	Link L3	48/125/250	Battery DC
"	"	Link L4	2ND TERM EXALT	OUT
"	"	Link L5	3ND TERM EXALT	OUT
"	"	Link L6	DTT	OUT
"	"	Link L7	2T/3T	3T
"	"	Link L8	DTT2	PT NOT REQ
"	"	Link L9	DTT1	PT NOT REQ
"	"	Link L10	INTG PILOT SUPV 2/3	3T
"	"	Link Ll1	INTG TRP	PT NOT REQ
"	"	Link L12	CNL2 IND	3T
"	"	Link L13	INT TRIP SUPV 2/3I	3T
MGM1(--)	MGM TAPS (3)		1/5 AMPS	5

TABLE 5-4 FRONT PANEL SETTINGS

Module Name	Location	Switch Name	Setting
ACM10(-)	N	INϕ	1.0
AMM10(-)	A	I (Optional)	1.0
AMM10(-)	A	t (Optional)	0.50

phase current source. Set the source to 0.35 ampere rms and re-apply the current. The relay will trip. Turn off the three-phase current source. The indicators and trip data points should be the same as in the positive-sequence tests.

5. TOC Trip Tests (Optional)

Turn off the unit power. Open the channels by opening switches SW1 and SW2 in the test circuit or by disconnecting the fiber-optic transmitters from the receivers. Turn the module power on.

Press the "CLEAR DATA" switch on the TAM101 module. Set the three-phase current source to 4.0 amperes rms negative sequence. Apply the current and the relay will not trip. Turn off the three-phase current source. Set the three-phase current source to 5.5 amperes rms negative sequence. Apply the current and the relay will trip in 0.5 second. The test circuit lamps "TRIP", "BFI", "CHANNEL" and "TOC" will light. Remove the current. The "TOC TRIP" and "TRIP" lamps on the IOM153 module, as well as the "TRIP DATA" on the TAM101 module, will light. The "MON DATA" lamp on the TAM101 will also be lit, due to the loss of channel. Press the "STEP DISP" switch on the TAM101 module. E1 will contain data points 1, 2, 3, 4, 5, 11, 47, and 48.

6. Fault Detector Test

With the channels still open, set one phase of the three-phase current source to 0 amperes rms. Turn on this phase only and increase the current until the "EXALT" lamp in the test circuit lights. This should occur for a current between 0.7 and 0.9 ampere rms.

7. Local Loop Test (Optional)

With the channels still open, press the "CLEAR DATA" switch on the TAM101 module. The "CNL1" and "CNL2" on the IOM153 module, as well as the "CH1 PILOT" and "CH2 PILOT" (if applicable) on the AMM101 module, should be off. After about 10 seconds the "MON DATA" lamp on the TAM101 module will light due to loss of channel. Close switch CC3 in the test circuit. The Channel and pilot lamps will light. The "LOCAL LOOP TEST" lamps on the FFM11(-) modules will light. Open switch CC3.

8. Stub Bus test (Optional)

With the channels still open as above, close switch CC4 in the test circuit. The channel and pilot lamps will light, along with the "STUB BUS" lamps on the FFM11(-) modules.

9. Error Detection (Optional)

With the channels still open, close switches CC3 and CC4 in the test circuit. The channel and pilot lamps will remain off and the "STUB BUS" and "LOCAL LOOP TEST" lamps on the FFM11(-) modules will flash.

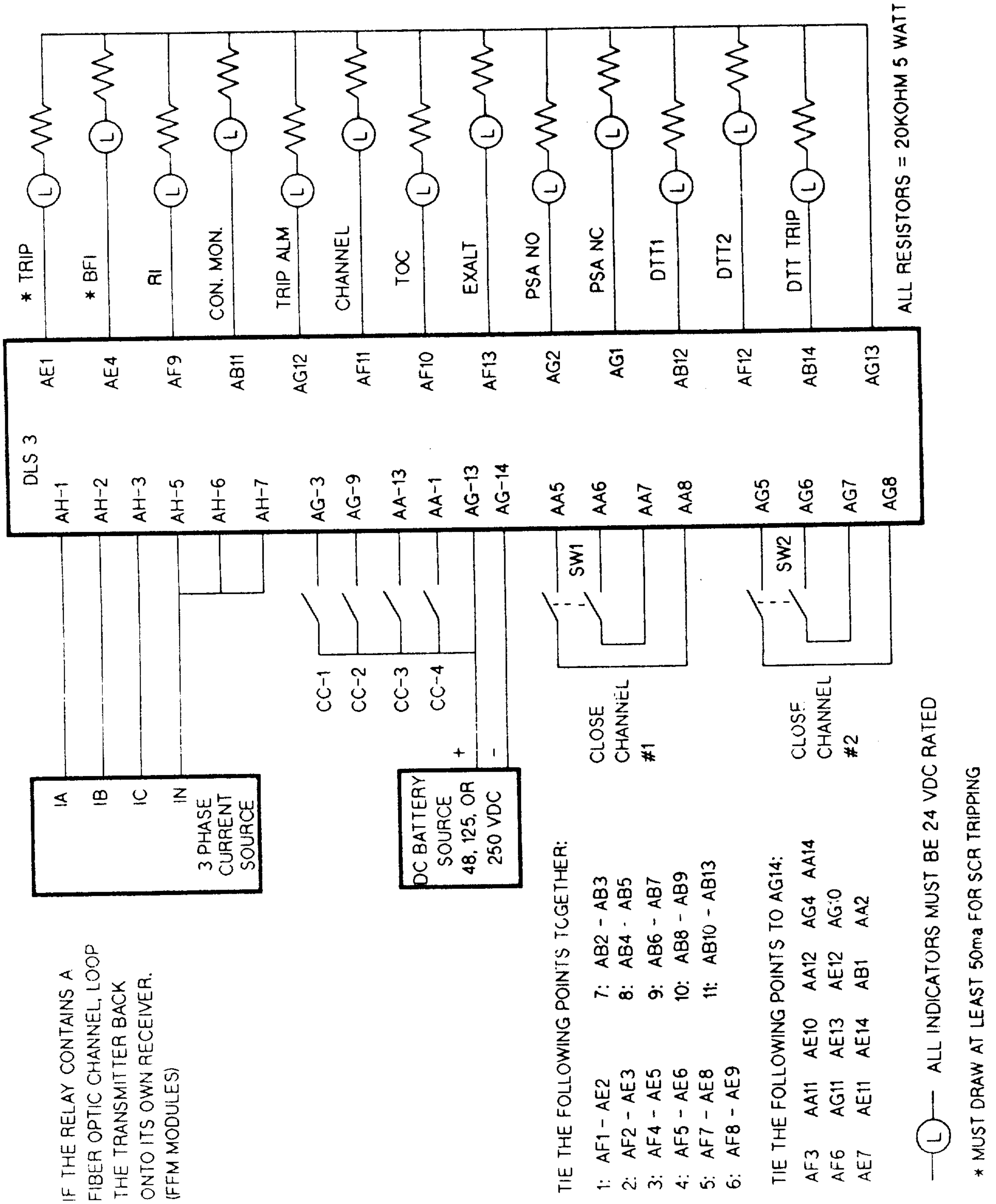


Figure 5-1 (0286A2964 [1])DLS3 Unit Test Setup

PERIODIC TESTING

The frequency with which the DLS relay is tested after installation is left to the user's discretion. The following tests are suggested.

> **CAUTION**
> **Disable trip outputs from the DLSs at all terminals on the line during these tests.**

1. The optical power from 1300 nm fiber-optic (FO) transmitters should be measured every 5 years, since it decreases with time. It is preferable to do this at the fiber-optic patch panel if one is provided at the station. If not, it may be possible to use the fiber-optic cable connector on the FO cable leaving the rear of the DLS (unless removed during installation). If only splices are used, it will be necessary to cut the cable and resplice it after the test.

Some optical power meters will not read correctly on the pulsed optical power emitted by the DLS transmitter. In any event, the duty factor of the optical transmitter is 50%. If it reads correctly, the optical power meter will read one half (3 dB below) the optical power in the specifications.

The loss budget allows a 3 dB drop in output due to time, and 3 dB for high temperature at the transmitter.

> **CAUTION!**
> **Avoid looking at the invisible IR (infra red) radiation from the cable. Turn off the DLS while making fiber-optic connections, and turn it back on when the connections are complete.**

2. If the optical power meter is sensitive enough, it can be used to measure the optical power going to the receiver. As an alternative the AFM1(--) module can be put on an extender. The received signal at extender pin 11 should have at least a 1 volt peak-to-peak signal. This is true for both 820 and 1300 nm links.

3. An alternative test is to put a calibrated optical attenuator in the link and add attenuation until the link drops out (CNL1 or CNL2 indicator goes off at the receiver end). The added attenuation is the signal margin. This test is most easily run with the attenuator at the receiver end since no one is needed at the other end.

The same test can be run without the actual link by running the output of the DLS transmitter back into its own receiver through a calibrated attenuator. Increase the attenuation until the CNL1 (or CNL2 on three terminal systems) indicator goes off.

The attenuation should exceed the loss budget given in the specifications.

4. Systems employing audio links are most easily tested by measuring the transmit and receive levels at the rear terminals of the units. Verify that these levels have not shifted appreciably from their original values. Make sure the signals are properly terminated for these tests by having the DLS connected to the audio lines.

5. A rather simple test can be used to test the current-differential tripping function. This requires applying a single-phase current to the unit. This current is switched (not ramped) off and on as the current level is increased, until a trip occurs. The current at this point can be compared with that previously required. The operate signal in this case is a mix of positive-sequence and negative-sequence components, so it will usually detect any changes in the relay. The test setup for this test is shown in Figure 6-1. It is possible to calculate the trip level but it is more easily determined experimentally. It depends on the tap setting, the phase driven, whether the high current restraint is in or out, whether the unit is a three-terminal or two-terminal unit, whether the communications link is closed on itself, etc.. When the operate level is determined experimentally, the connections and settings for the test must be recorded so that the test

can be repeated precisely. Otherwise subsequent tests will be meaningless. With the test circuit shown, a trip will light both the TRIP and the BFI test-set indicators. The trip and BFI outputs are broken but one RI contact is still connected. Check that this RI contact cannot give an undesired breaker closure.

Note that the communications link (both links for a three-terminal unit) must be operational. With 820 nm fiber-optic units this can be achieved by putting the FFM1(--) board(s) on extenders and running the transmitter output to the receiver on the same board. A similar technique can be used with 1300 nm units if the fiber-optic connectors at the rear of the unit have not been removed. They can be coupled with a mating connector. If the connectors have been removed, it may be possible to connect the transmitter to its receiver at an optical patch panel, if one is provided.

With spliced fiber-optic systems, or with audio lines, it is simpler to have the communications links to the other terminals operating. In this case, there must be **no current flow** in the line, or current must be **disconnected** from the DLSs at the other terminals. If the remote DLSs send any signal, it will alter the trip level of the DLS where the tests are being run. The operate level will be higher than if the links are closed on themselves.

6. The direct-transfer trip can be tested with the same circuit, if a local DTT input can be generated. It should give a DTT KEYED indication on the front panel of the AFM1(--) module. If the communications link for the DTT being tested is closed back on itself, then DTT and trip indicators will latch "on" on the front of the IOM153 module. The test-set TRIP and BFI indicators will come on.

7. The optional TOC protection can also be tested. Increase the test current until the TOC timing light comes "on" on the AMM1(--) module. After the TOC delay, the TOC TRIP light on the IOM153 module will come on.

8. If the optional Continuous Monitor (TAM101) is used, its operation can be verified by noting that the preceding tests give a trip data indication on each trip. Check that the stored data matches the trip types. Clear the TAM101 data between trips to avoid confusion.

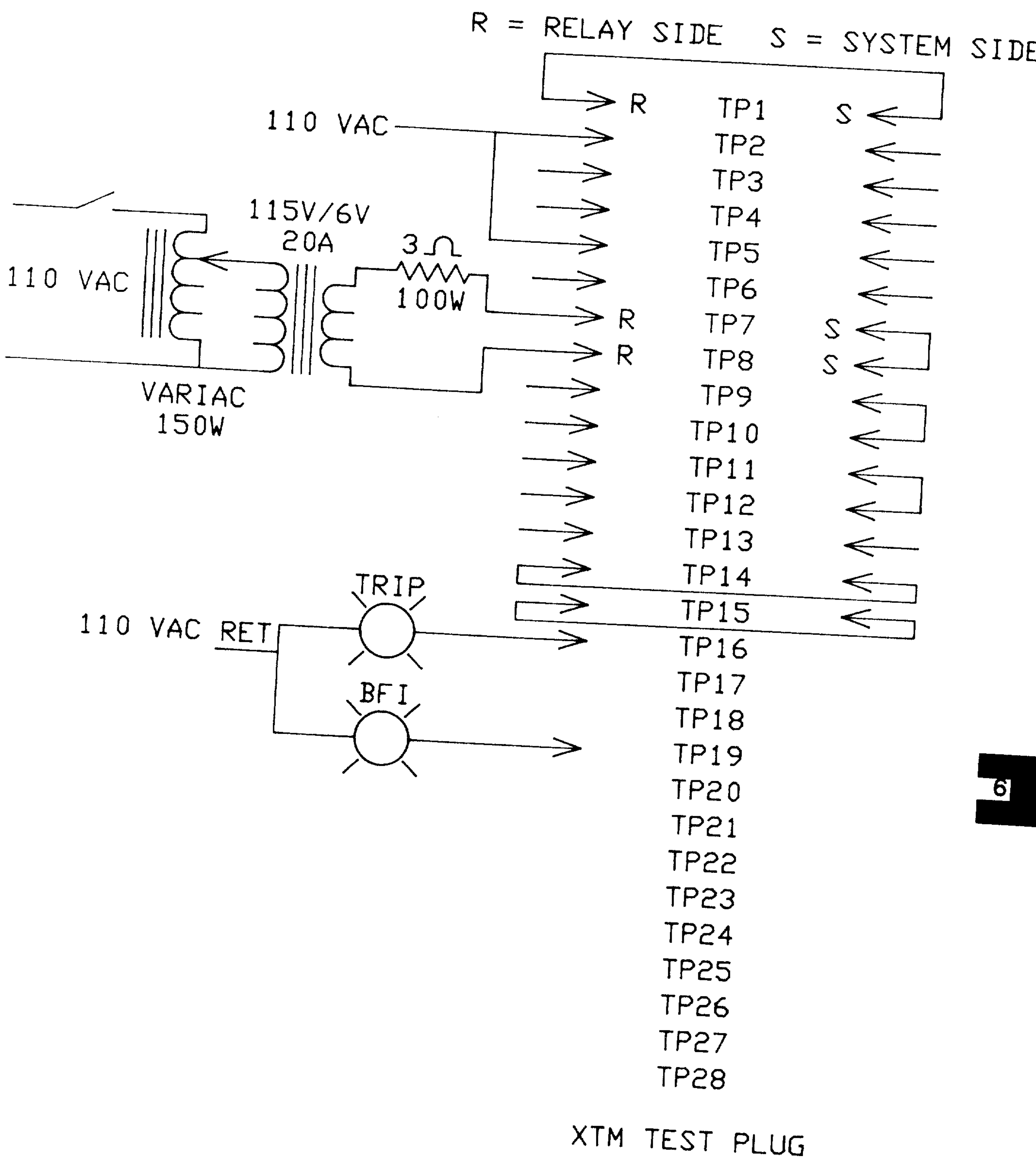


Figure 6-1 (0286A2749[1]) Test Diagram for Periodic Test of Trip Circuit

6

SERVICING

SPARES

There are two basic approaches that may be followed in servicing the DLS. 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. ACM103);

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. 0215B5865 G001 or G1);

3. The revision number (this is also found on the component side of the printed-circuit board, e.g. REV.1).

WITHOUT THE CONTINUOUS MONITOR MODULE

If the DLS3 is not equipped with a Continuous Monitor, or if the problem is not indicated by the Continuous Monitor, proceed as follows. First determine that the problem is in the DLS3 itself. Is the power supply (PSM21(-)) LED on? If not, the DLS may not be getting D.C.. If this is a possibility, check that there is D.C. at terminals AG13 and AG14 on the rear. If not, the trouble is not in the DLS. If voltage is present at the rear, then make sure the modules in the rack are properly seated in their connectors. Make sure the connection plugs in the test block (extreme left) are properly seated. If no problem is found, replace the power supply module.

If the power supply LED is on, see if the CNL1 (and CNL2 on three-terminal systems) LEDs on the IOM153 module are on. If not, check the communications links. If the links are O.K., try replacing the AFM1(--) or the FFM1(--) modules. If the problem persists, try replacing the remaining modules.

If the CNL1 and CNL2 indicators are on, then check the PILOT1 and PILOT2 indicators on the AMM1(--) module, if the DLS has the pilot tone option. If PILOT1 is off (or PILOT2 on a 3 terminal system), replace the AMM1(--) module. If the audio link characteristics have changed, this could cause the problem. In this case it may be necessary to readjust the pilot tone level, as described under **Installation** in the **HARDWARE DESCRIPTION** Section.

As a last resort, change all the modules to see if this cures the problem. Normally this will work. Problems with the modular relay cases are rare. If the problem persists, rerun the acceptance tests and the installation adjustments.

This may uncover an external problem, or may provide helpful information if you have to call the factory.

WITH THE CONTINUOUS MONITOR MODULE

If there is no indication of a problem as described above, and the DLS has a Continuous Monitor, see if the Continuous Monitor front panel controls and displays operate properly. If not, there may be a power supply problem that has disabled the Continuous Monitor through the DC supervision circuit on the AMM1(--) module. Replace the power supply or the AMM1(--) module and see if this cures the problem.

When the DLS 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 5-10 seconds, the Continuous Monitor will give a Monitor Alarm contact closure. The front panel MON DATA indicator on the TAM 101 module, Figure 9-6 in the CONTINUOUS MONITOR 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 7-1 to find the mnemonic of the DLS signal connected to this input. Table 7-1 also gives the module where the signal originates. Refer to the overall system diagram, Figure 7-1 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 DLS. 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.

If there is no earlier logic point, then the AC inputs to the DLS that drive the abnormal logic point should be checked. Refer to the Measuring Functions Block Diagram, Figure 7-1 in this section, and locate the abnormal signal levels on this diagram.

The techniques just described locate failures that resulted in <u>monitor alarms</u> from the continuous monitor. If a failure is suspected of causing a false <u>trip</u>, 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 LCD 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 DLS. 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 DLS. 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.

TABLE 7-1
CONTINUOUS MONITOR POINT NUMBER ASSIGNMENTS

Monitor Point	Signal	Source	Input Pin
1	CHMON2	TAM101	12
2	CHMON1	TAM101	42
3	PILTON1	AMM10(-)	13
4	PILTON2	AMM10(-)	43
5	TOC TRIP	IOM153	14
6	INT TRIP	IOM153	44
7	DTT1 (UNSUP)	10M153	15
8	DTT2 (UNSUP)	IOM153	45
9	DTT1	IOM153	37
10	DTT2	IOM153	7
11	INTGRBLK	IOM153	36
12	NXCHNOS1	†AFM11(-)	22
13	NXCHNOS2	#AFM11(-)	22
14	NO CONNECTION		
15	NOT USED		
16	CHECK SUM ERROR INTERNAL		
17	NO CONNECTION		
18	DTT TRIP	IOM153	12
19	NOT USED		
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			
32			
33			
34			
35			
36			
37			
38			
39			
40			
41			
42			
43			
44	NOT USED		
45	LOC TRANSF TRIP	AFM11(-)	
46	NOT USED		
47	FAULT DET.	IOM201	23
48	TRIP BUS	IOM153	53

† Slot G
# Slot L

POWER SUPPLY MODULE

Check the following items if the LED found on the front panel of the PSM21(-) module (Figure 4-8) fails to light when the Power Supply is turned on:

Correct DC supply is applied to the DLS.

Connection plugs, located on the left side of the MGM module (see Figure 4-1), are properly inserted into the test receptacle.

Condition of the fuse located on the PSM21(-) module, (Figure 4-8).

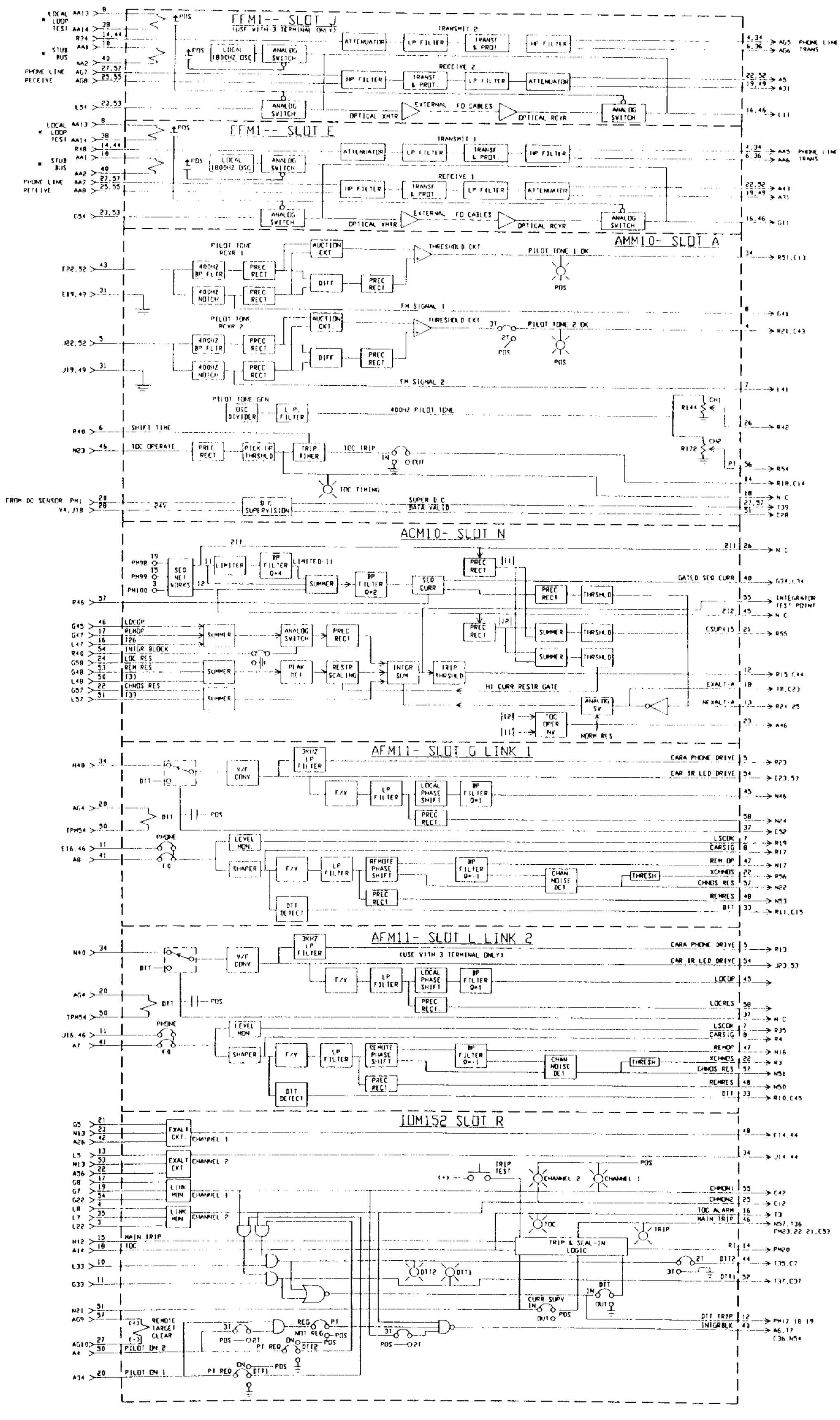
Correct voltages from the Power Supply Module.

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.



* FFM111, FFM112 AND FFM113 ONLY.

Figure 7-1 (0153D7885 Sh. 1[1]) Overall Block/Internal Diagram for Three-Terminal DLS

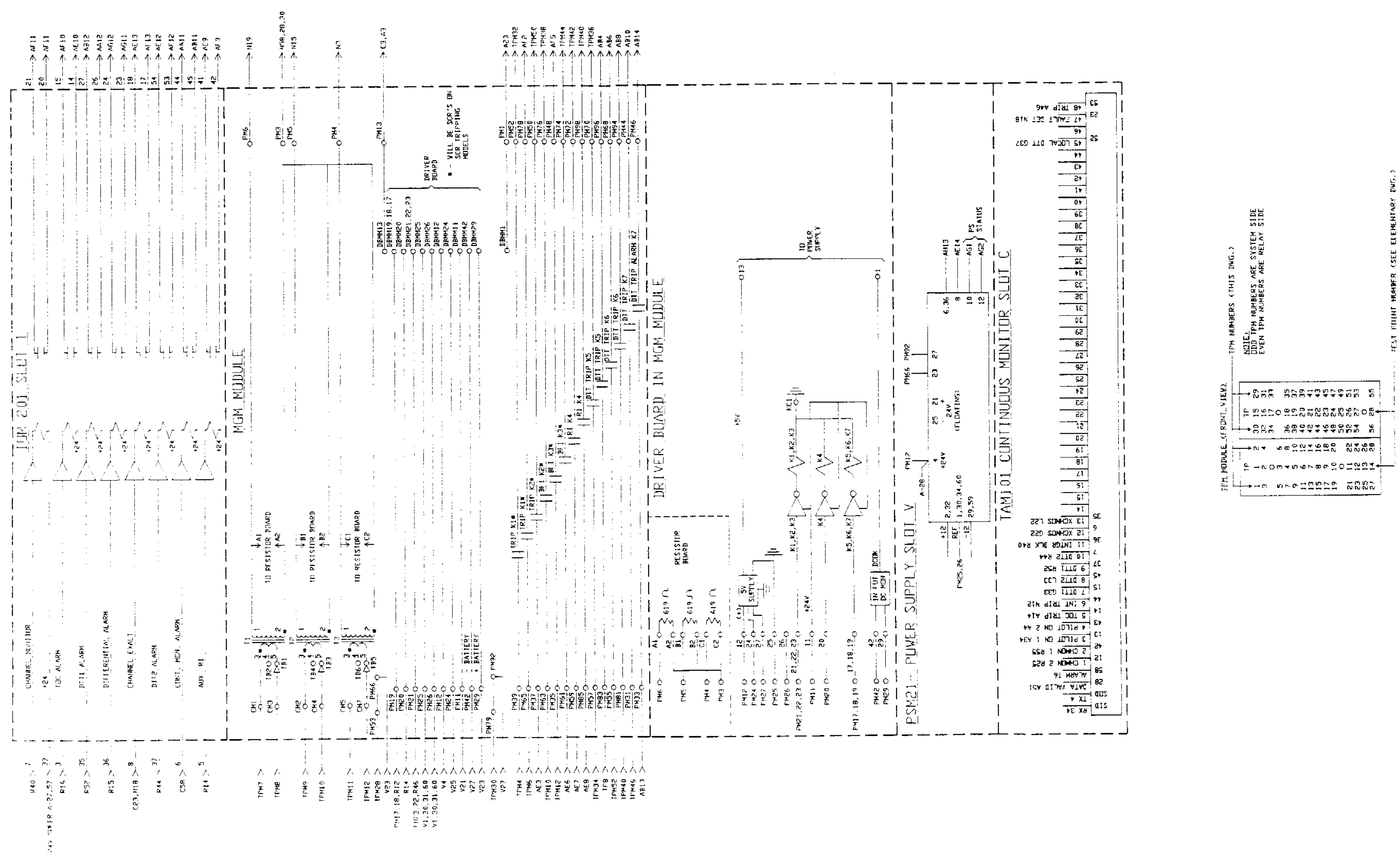


Figure 7-2 (0153D7885 Sh. 2)
Overall Block/Internal Diagram for Three-Terminal DLS

SPECIFICATIONS

RATINGS

Rated Frequency	50 or 60 hertz (Different models)
Rated Current	I_N = 1 or 5 amperes (Internal selection)
DC Control Voltage	48 VDC, Operating Range 34 - 60 VDC 110/125, Operating Range 88 - 150 VDC 220/250, Operating Range 176 - 300 VDC (Different models)
Maximum Permissible Currents	
Continuous	2 x I_N
Three Seconds	50 x I_N
One Second	100 x I_N
Ambient Temperature Range	
Storage	30°C to +75°C
Operation	20°C to +65°C +45°C Maximum recommended with 1300 nm fiber-optic link
Humidity	95% without condensing
Insulation Test Voltage	2 kV 50/60 Hz, one (1) minute
Impulse Voltage Withstand	5 kV peak, 1.2/50 milliseconds, 0.5 joule
Interference Test Withstand	1 MHz, 2.5 kV peak decay time of 3 to 6 cycles to 1/2 value

BURDENS

Current Circuits	0.03 ohm ∠5°, I_N = 5 amps 0.14 ohm ∠30°, I_N = 1 amp	
DC Battery (for contact converters)	1.4 milliamperes each	
DC Battery (for Power Supply and Audio Relays)	<u>Normal</u>	<u>Tripped</u>
ALL VOLTAGE RATINGS	19 watts	26 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

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	Break 60 VA inductive at 125/250 VDC
Thyristor Outputs	Same as trip contacts except no interrupting rating
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

CURRENT SENSITIVITY

	Refer to APPLICATION Section
TOC (Optional) Operate Level	0.2-2 PU (I_N times tap) setting range corresponds to: 1.4-3.2 PU of I_1 0.2-2 PU of I_2
Time Settings	0.0-990 milliseconds in 10-millisecond steps

COMMUNICATIONS CHANNELS

Fiber-Optic Link Wavelength	820 or 1300 nm	
Transmitter Power 820 nm	-11.2 dBm † -19.1 dBm †	140/100 micron fiber 50/125 micron fiber
1300 nm	-21 dBm (minimum at 25°C) into 9/125 micron cable	
Loss Budget 820 nm (multi mode)	38 dB typical † 35 dB worst case †	100/140 micron fiber
	30 dB typical † 25 dB worst case †	50/125 micron fiber
1300 nm (single mode)	27 dB at high temperature after LED aging (worst case)	

† Measured with HP cables

ADVICE: Avoid placing equipment with 1300 nm links in high ambient temperatures . High temperatures increase receiver noise and decrease optical transmitter output. Both degrade the received signal-to-noise ratio. High temperatures also accelerate optical transmitter aging (decreasing output).

Optical Receiver Dynamic Range	Will operate from minimum required power to full transmitter output
Channel Delay Compensation	0-230° in 10° steps

600 Ohm Audio Link Frequency Range	400 to 3000 Hz
Exalt Keying (output boost) (not recommended with pilot tone)	0, 6, or 10 dB
Audio Output	
Level	-36 to 0 dBm
Impedance	600 ohms ± 10%, balanced
Audio input	
Level	-32 to +1 dBm
Impedance	600 ohms ± 10%, balanced

Note: An optional pilot tone capability is available with audio channels. Powers specified above are peak (normal signal plus pilot tone). To stay within peak rating, normal signal must be one-half (1/2) voltage. Pilot tone voltage is equal to this.

PHYSICAL PARAMETERS, STANDARD RACK MOUNTED

Height	6 15/16 inches, 176 millimeters
Width	19 1/16 inches, 484 millimeters
Depth	16 inches, 406 millimeters including terminal blocks. Add 5.5 inches (140 mm.) with FOM101 data-link option on Continuous Monitor (MMI)
Weight	
2-terminal	25.5 lbs., 11.6 Kg.
3-terminal	26.5 lbs., 12 Kg.

CONTINUOUS MONITOR MODULE

BASIC OPERATION

The continuous monitor function works on the principle of recognizing a change in state of one or more of the up to 40 monitored points (reference Table 7-I 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 (Microprocessor Monitoring Interface, or MMI) is not included. The fault detector responds to negative- and zero-sequence current levels 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 9-1. 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 9-1 is not a fixed value, but rather a statistically variable 5 seconds minimum and 10 seconds

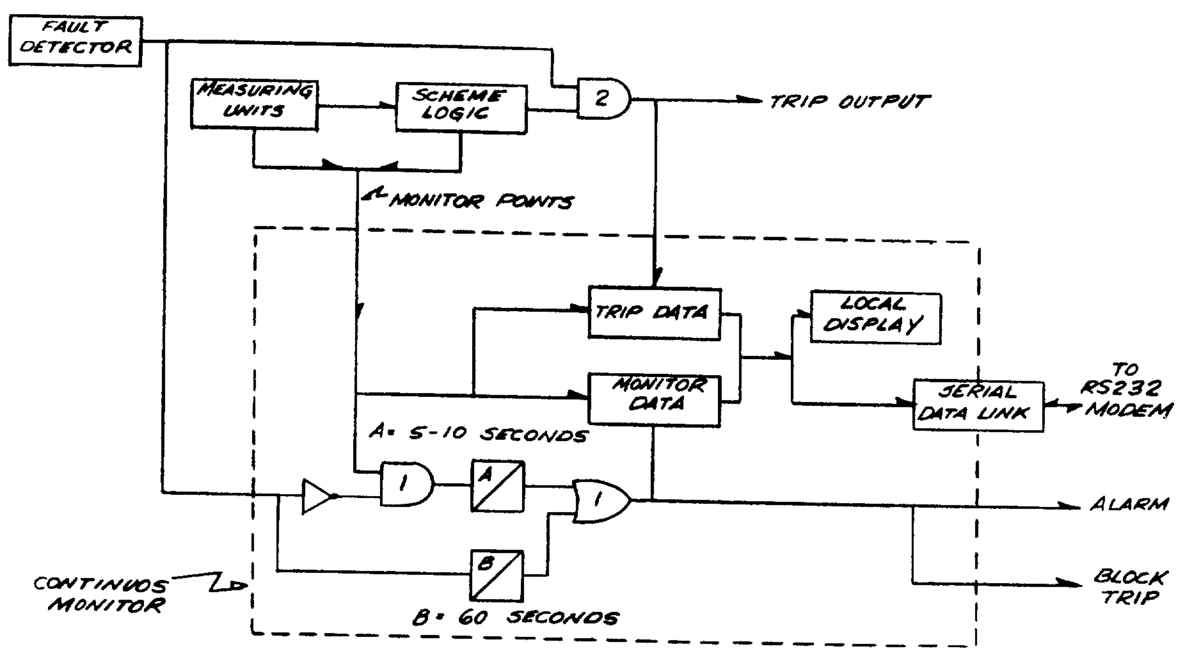

Figure 9-1 (0285A9897) Simplified Functional Diagram Depicting Continuous Monitor Operation

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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. 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 9-1 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 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 a Continuous Monitor failure when the trip input is accidentally held high. The Continuous Monitor module will not respond properly until the continuous high has been removed.

ACCESS OF STORED DATA

Figure 9-2 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.

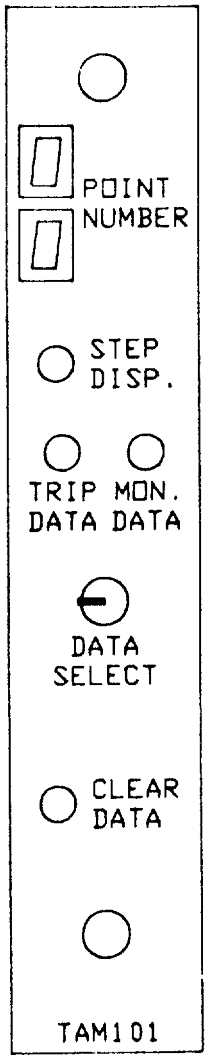

Figure 9-2 (0285A9898) Continuous Monitor Module Front Panel

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. button should be pushed to bring the display to 0/0. The next push of the STEP DISP. button 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 first trip event, assuming five trip events are stored in memory. When starting from 0/0, the first push of the STEP DISP. button will cause E/1 to appear on the LED numeric display. Successive operations of the STEP DISP. button 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

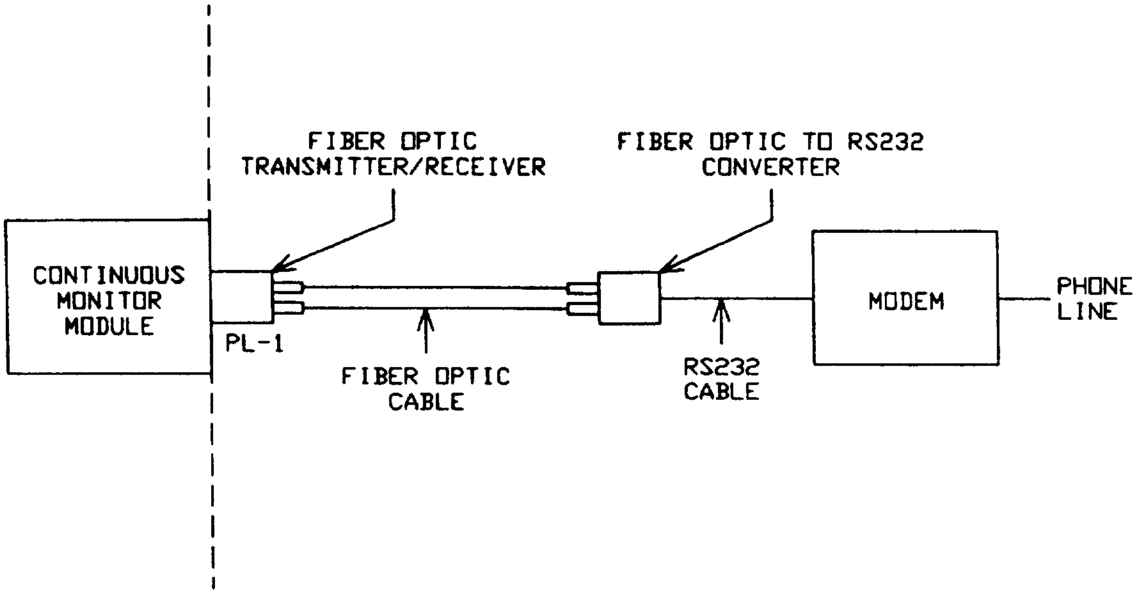

Figure 9-3 (0285A9899[3]) Serial Data Link Connection

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, a small, optional, 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 audio lines, as shown in Figure 9-3. 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 9-3 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 a 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. QUIT will not clear the memory, whereas CLEAR will.

If there are multiple Continuous Monitor modules, then QUIT should be used as the final command, since it will return all the units on the communication line to the normal state. If the memory is to be cleared in such cases, CLEAR should be used to each module, then QUIT to return all modules to their normal (monitoring) 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. button. 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. button 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 automatic reversion will prevent all but the first five minutes of data from being lost. 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. button 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 trip data, then leave the serial-data-access mode and return to the monitor 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 9-6. 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 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 (FOM101) 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 9-4 and 9-5 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 read "C5". The monitor alarm will operate and monitor bit 16 will be set. If this occurs, the Continuous Monitor module should be replaced.

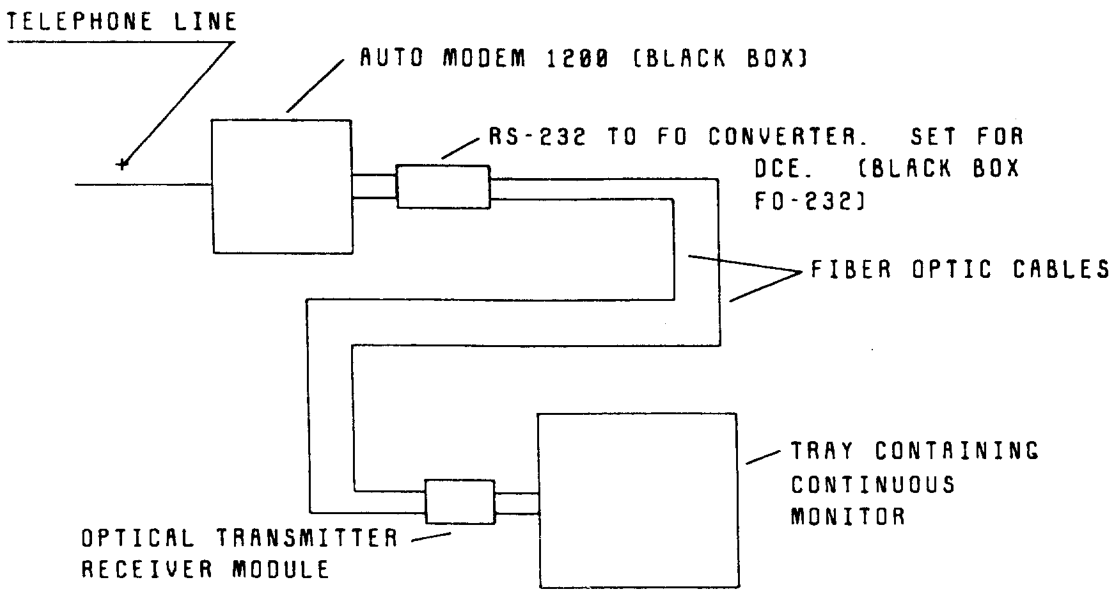

Figure 9-4 (0285A9836[1]) Continuous Monitor Phone Connection

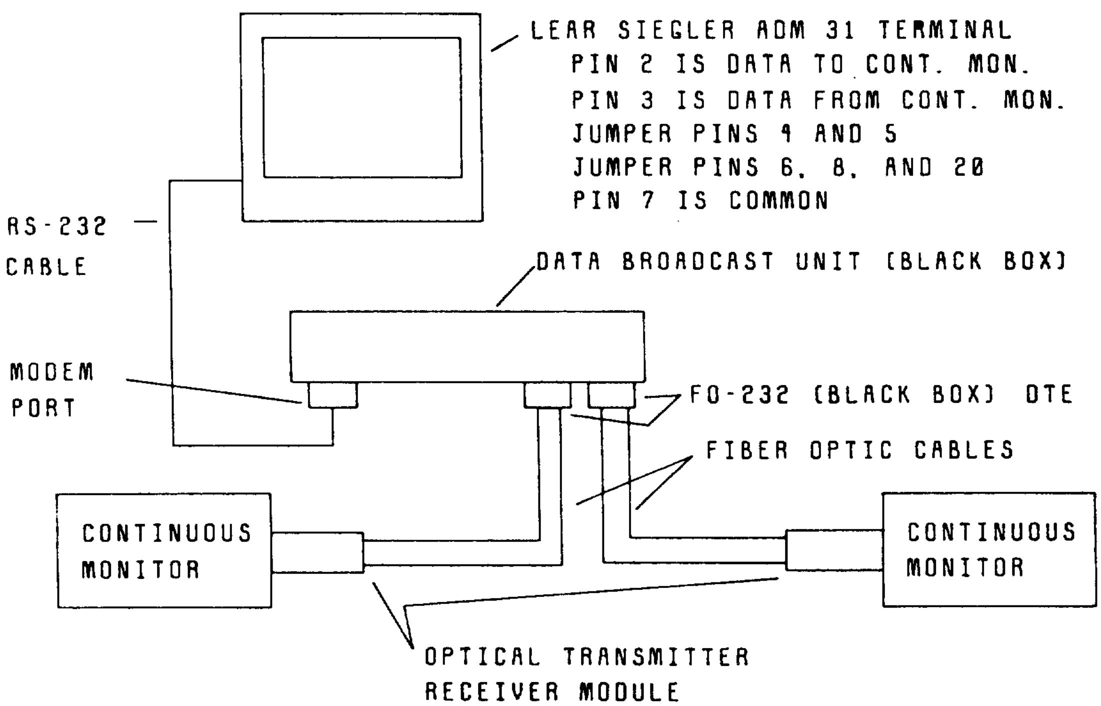

Figure 9-5 (0285A9837[1]) Connection for Multiple Continuous Monitors

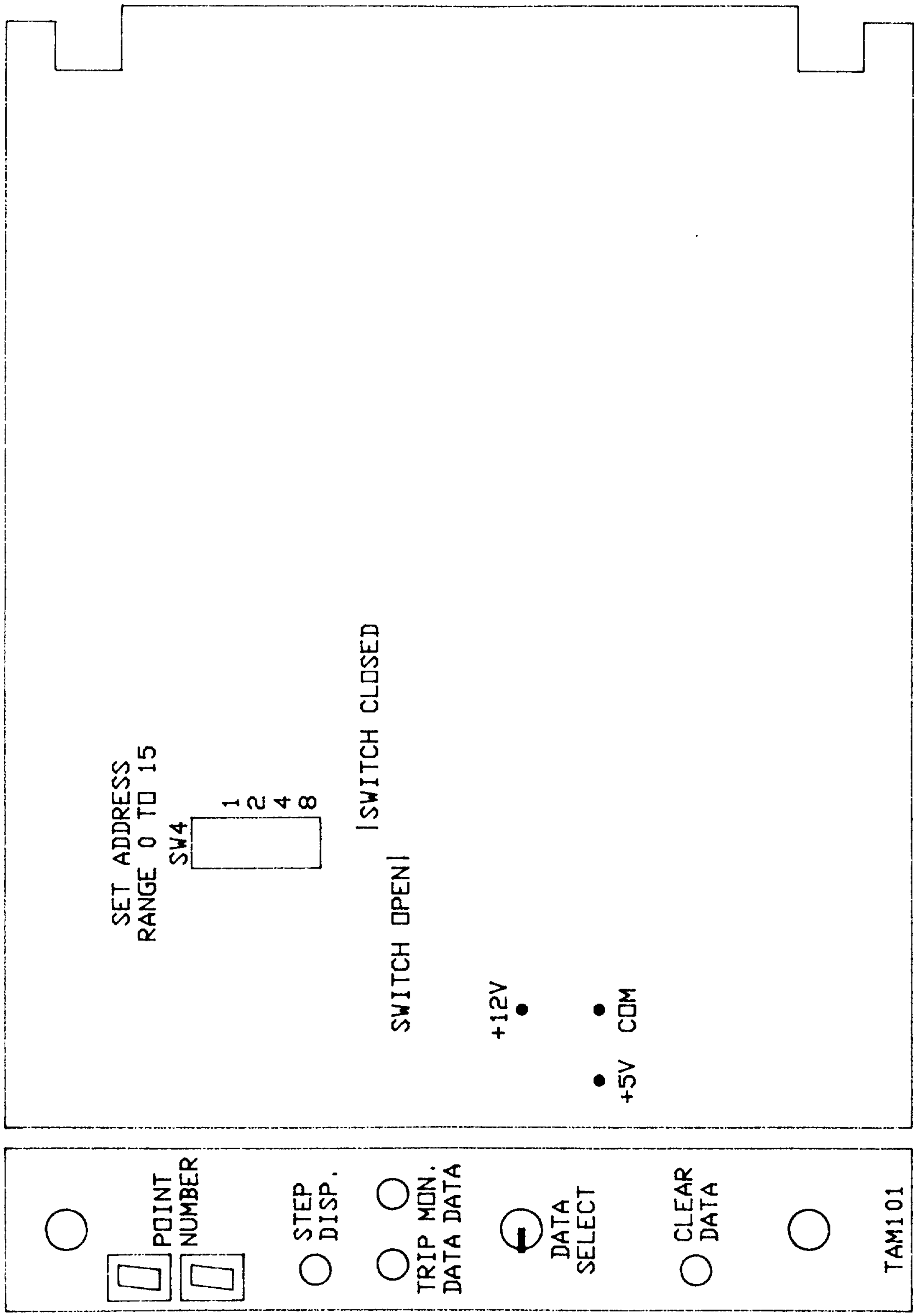

Figure 9-6 (0285A9831[3]) Front Panel & Internal Switches, TAM101

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