

DIGITAL FIBER-OPTIC TRANSMISSION SYSTEM  
FOX-2 T-HUB  
THEORY OF OPERATION

1. GENERAL

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- 1.02 Whenever this section is reissued the reason(s) for reissue will be listed in this paragraph.
- 1.03 This section represents a functional description of the FOX-2 T-HUB DS-2 Fiber-Optic Transmission System.
- 1.04 If corrections are required in the attached document, use Form-3973 as described in Section 000-010-015.
- 1.05 If equipment design and/or manufacturing problems should occur, refer to Section SW 010-522-906 for procedures on filing an Engineering complaint.

2. ORDERING PROCEDURE

- 2.01 For information concerning equipment and parts availability contact Telco Systems, Order Administration Department, In Norwood, Massachusetts, at:

1-800-44-SALES  
1-617-551-0300

- 2.02 To order additional copies of this practice, use TELC 365-407-862SW as the section number.

3. REPAIR/RETURN

- 3.01 For defective modules and assemblies contact the Repair and Return Department at the following number:

8:00 a.m. - 5:00 p.m. (617) 551-0300 - Ext. 2778

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Attachment: Telco Systems Fiber Optics Corporation  
Digital Fiber-Optic Transmission System  
FOX-2 T-HUB  
Theory of Operation

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 FOX-2 T-HUB  
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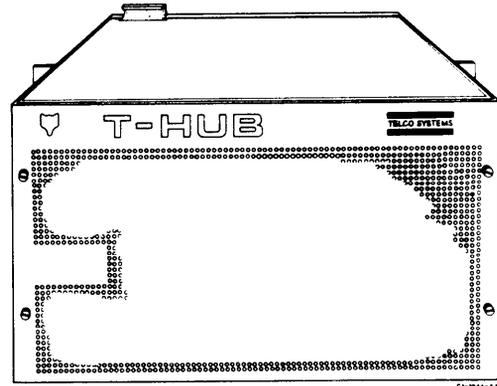


Figure 2-1. FOX-2 T-HUB

1. SCOPE

1.01 This section presents a functional description of the FOX-2 T-HUB DS-2 Fiber-Optic Transmission System (see Figure 2-1). Detailed descriptions of the operation of individual circuit cards have also been included as a series of subsections at the end of this practice. These circuit card descriptions highlight the interrelationship of FOX-2 T-HUB hardware components and subsystems to a block diagram level. This section also contains operational descriptions of related accessories, such as the ACX025 Fuse and Alarm Panel.

1.02 Whenever this section is reissued, the reason for reissue will be listed in this paragraph.

2. FUNCTIONAL DESCRIPTION

A. Operational Description

2.01 The FOX-2 T-HUB is a rack mountable unit. The unit is capable of distributing up to 28 T1 or 14 T1C

channels (or combinations thereof, up to an equivalent of 28 T1s) from a central office location, via individual DS-2 single-mode optical spans, to up to seven FOX-2/FOX-2R units equipped at remote office locations. The FOX-2 T-HUB unit, with the front panel removed to show the circuit card layout, is illustrated in Figure 2-2. Comprised of two interconnected 828A multiplexer units, the FOX-2 T-HUB can be conveniently reconfigured into a pair of independent MX-3 multiplexers to address changing network requirements.

2.02 Each shelf unit is responsible for T1/T1C or optical DS-2 transmission interface. T1 and T1C Low-Speed Interface cards, mounted on the upper shelf unit, provide T1/T1C bipolar line interface and time division multiplex all channels to the DS-2 (6.312 Mb/s) level. The lower shelf unit contains individual LTU (Line Terminating Unit) circuit cards which optically code each DS-2 channel for

optical span transmission to remote FOX-2/FOX-2R sites.

2.03 All high-speed and optical span transmission circuitry can be 1:1 protected by optional redundant circuit cards. Internal to each Low-Speed Interface card, redundant M12 MULDEM (DS-1 to DS-2 Multiplexer/Demultiplexer) circuitry ensures uninterrupted operation of critical components.

2.04 Individual MPU (Microprocessor Unit) cards monitor the operation of all circuit cards which comprise each shelf unit. In the presence of an equipment fault, each MPU illuminates fault and status LEDs on the suspected faulty card; initiates automatic switching to protection circuitry; and reports all pertinent information to remote alarm reporting systems, such as a TELTRAC (Telco Systems Telecommunications Remote Alarm and Control) master terminal.

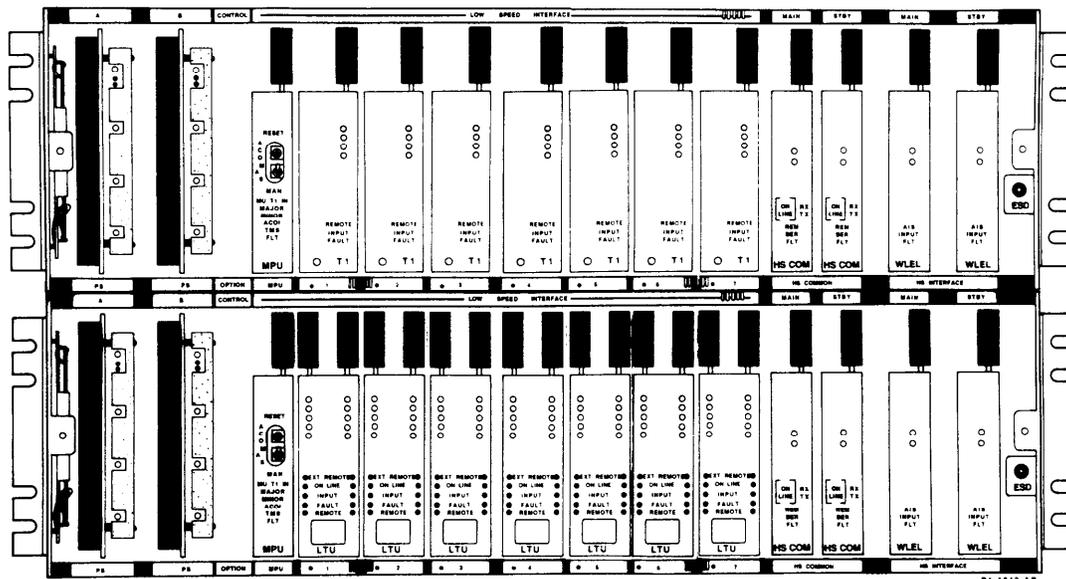


Figure 2-2. FOX-2 T-HUB Unit Layout (Cover Removed)

## B. Mechanical Description

2.05 The FOX-2 T-HUB, measuring approximately 12-inches high (seven standard rack mount spaces) and weighing approximately 44 lbs fully loaded, can be mounted into a standard 23-inch wide equipment rack. A ribbon cable and power terminal harness allow multiple FOX-2 T-HUB or 828A/828AF unit(s) to be interconnected to a common Fuse and Alarm Panel for centralized primary power protection and consolidation of MAJOR, MINOR, BAY, and FUSE remote alarm reporting (ACX025).

2.06 To facilitate fiber management and to promote improved heat dissipation, a combination fiber trough and air baffle unit is required for all applications. This fiber trough/air baffle accessory mounts directly below each FOX-2 T-HUB. It is approximately 1.5 standard rack spaces high, allowing up to four FOX-2 T-HUB units to be mounted in a standard 7-foot equipment rack along with a Fuse and Alarm Panel.

## C. Equipment Interfaces

2.07 Figure 2-3 is a pictorial representation of the power, alarm, T1/T1C electrical, and DS-2 optical interfaces of the FOX-2 T-HUB unit.

2.08 Each low-speed interface can accommodate either four T1 or two T1C channels. T1/T1C electrical interface is accomplished via rear-mounted wire-wrap pins on the upper shelf unit. In the lower shelf unit, an LTU card associated with each Low-Speed Interface card multiplexes and optically codes each DS-2 data stream as a 12.624 Mb/s data channel for transmission. Each DS-2 optical span interconnects with fiber-optic termination equipment, using optical pig-tails or patch cords interconnected to FC-type transmit and receive optical connectors mounted on each LTU card.

2.09 Terminal block TB-1 on each FOX-2 T-HUB shelf unit provides independent isolated -48 Vdc primary power feeds to PS-A and PS-B (Power Supplies) on each shelf unit. Terminals TB-2 and TB-3 provide interconnection points for chassis and earth grounds for each shelf unit.

2.10 External alarm interface is accomplished via a rear-mounted 60-pin ribbon connector, which cables the MAJOR, MINOR, BAY, and REMOTE fault signals to the Fuse and Alarm Panel for visual indicator display on the panel, and simultaneous relay contact closure for remote alarm hardware notification. On the ACX025 Fuse and Alarm Panel, both audible and visual, major and minor, relay contact closures are available. The audible closures, typically interconnected to audible office signaling devices, can be silenced using the ACO (Alarm Cutoff) switch on each Control MPU. ACO control of the visual contacts is selective by customer optioning.

2.11 TELTRAC interface is accomplished through connectors on the Fuse and Alarm Panel. This serial telemetry channel can be directly connected from the Fuse and Alarm Panel to a local TELTRAC master terminal station within proximity of the FOX-2 T-HUB unit. If the TELTRAC master terminal is not locally resident, this interface can be coupled to the service channel or vendor-defined DS-3 X-bit of other Telco Systems transmission equipment.

2.12 When utilizing the RAC-II (Remote Alarm II) card, external alarm inputs from remote FOX-2/FOX-2R units can initiate corresponding relay contact closure for remote alarm reporting or control functions. A 34-pin ribbon connector jack J7 located on the rear of the upper shelf unit is used to access these control relay contact closures.

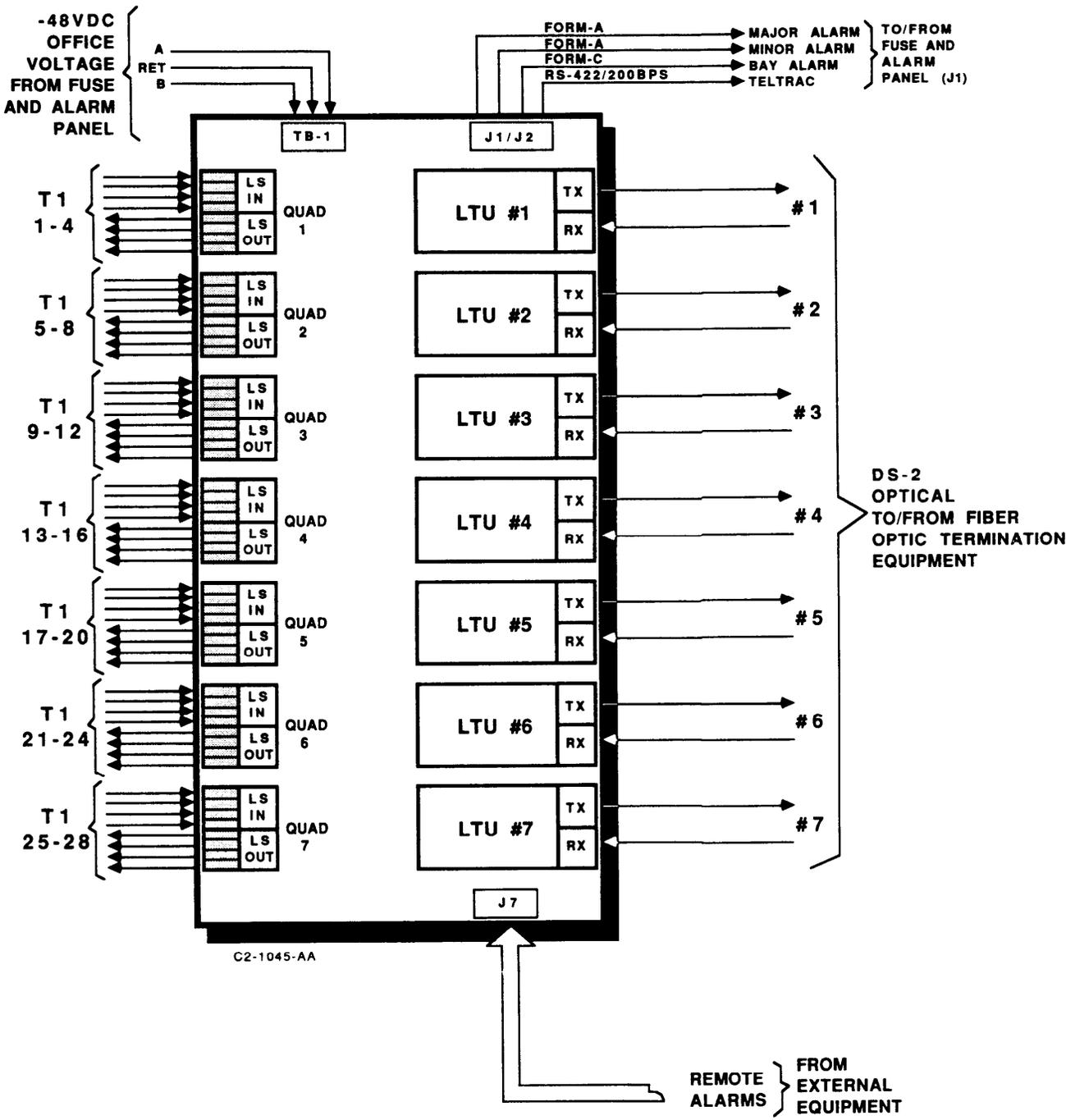


Figure 2-3. FOX-2 T-HUB Equipment Interfaces

## D. Block Diagram

2.13 A block diagram of the FOX-2 T-HUB is shown in Figure 2-4. Signal flow for each block is discussed as it relates to system operation.

2.14 The FOX-2 T-HUB accepts up to 28 DS-1 or 14 DS-1C channels (or combinations thereof, up to an equivalent of 28 DS-1 channels). T1/T1C input circuitry (CCA161G2 only) converts the bipolar AMI (Alternate Mark Inversion) or B8ZS (Bipolar with Eight-Zero Substitution) line coding of each incoming channel into unipolar data and timing streams for processing. The M1C MULDEM circuit within the T1C Low-Speed Interface card demultiplexes each T1C data channel into its two T1 component channels prior to DS-2 multiplexing.

2.15 Since the timing rate of individual T1 channels can vary, timing synchronization is required prior to time-division multiplexing. Bit-stuffing technology within the SWEL (Switching and Elastic Store) circuit is employed to raise the received timing of each incoming or derived T1 data channel to the master clock rate determined by the HS COM (High-Speed Common) card.

2.16 Within the M12 MULDEM circuit, each group of four T1 channels is bit-interleaved into a single 6.312 Mb/s DS-2 data channel. This aggregate channel also contains an embedded overhead data channel which is introduced into the DS-2 channel to facilitate far-end demultiplexing. When received by receive circuitry of the far-end Low-Speed Interface card, this overhead channel will be extracted and utilized for frame synchronization and stuffing bit deletion by the demultiplexing circuits of the far-end FOX-2/FOX-2R unit(s).

2.17 Up to seven Low-Speed Interface cards perform identical multi-

plexing functions on their respective T1 channel groups to collectively generate seven DS-2 channels. These channels are coupled to the HS COM and WLEL (Wire-Line Entrance Link) cards for DS-3 multiplexing and B3ZS line coding, respectively. These high-speed interface cards are required to interconnect the upper and lower shelf units together, using a single pair of coaxial cables. If future network requirements call for the FOX-2 T-HUB to be reconfigured as two independent MX-3 multiplexers, these cards will fulfill the requirements of DS-3 bit interleaving and B3ZS line coding to transmit and receive an industry-standard DS-3 (44.736 Mb/s) data stream, via coaxial cable to/from other transmission equipment.

2.18 WLEL and HS COM cards in the lower shelf unit accept the DS-3 composite channel of the upper shelf unit, and B3ZS line decodes and demultiplexes the channel into its seven constituent DS-2 channels. Each DS-2 channel is applied to its associated LTU card which converts the DS-2 electrical data and timing streams into an equivalent intensity-modulated single-mode optical carrier, via a single-mode LED transmitter.

2.19 To provide the required data transition activity to ensure proper far-end clock recovery, each DS-2 channel is encoded as a 12.624 Mb/s data stream, using 3B6B line coding prior to optical transmission. Within this data channel, an embedded overhead channel allows remote TELTRAC information and alarm status to be received from remote FOX-2/FOX-2R units.

2.20 FC-type optical connectors, mounted on the LTU card, provide the interface to fiber-optic termination equipment used for optical span access. Optical pigtailed or patch cords are utilized to interconnect the FOX-2 T-HUB with fiber-optic termination equipment.

2.21 In the receive direction, incoming DS-2 optical transmission from far-end FOX-2/FOX-2R units is applied to a photodiode detector within each LTU card. The LTU converts each optically-coded DS-2 channel into its electrical equivalent and extracts clock timing. HS COM and WLEL cards in the lower shelf unit couple a composite DS-3 data channel to the upper shelf unit via internal coaxial cable connection. The WLEL and HS COM card of the upper shelf unit demultiplex the internal DS-3 channel back into its seven DS-2 component data and timing channels for processing by the T1 or T1C Low-Speed Interface cards.

2.22 Within the Low-Speed Interface card, M12 MULDEM circuitry demultiplexes the DS-2 channel into four T1 data channels. SWEL circuits delete stuffing bits inserted by the far-end LS INTER T1/T1C (T1/T1C Low-Speed Interface) cards for line synchronization and retime the resulting data streams to minimize inherent phase jitter. Within the T1C Low-Speed Interface card, an M1C MULDEM circuit multiplexes T1 channel pairs into T1C data channels. Bipolar line coding output stages with the T1 and T1C Low-Speed Interface cards (CCA161G2 only) provide AMI or B8ZS bipolar line coding for transmission via metallic facilities.

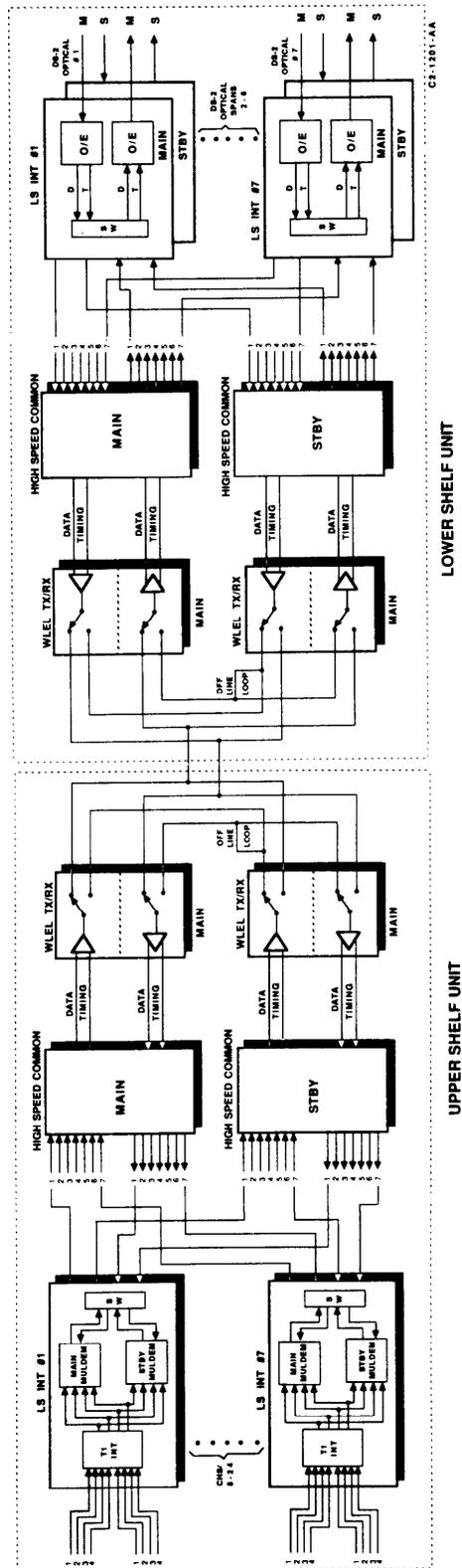


Figure 2-4. FOX-2 T-HUB Block Diagram

## E. Equipment Protection

2.23 The basic FOX-2 T-HUB is designed to operate either unprotected, or with integrated 1:1 protection by the addition of redundant cards.

2.24 All FOX-2 T-HUB configurations are equipped with redundant load-sharing power supplies. Each power supply can be fed from an independent primary power source for primary power protection. In the event of power supply failure, output switching diodes within the failed supply block the dc return to ground of secondary voltages from the operational power supply.

2.25 Internal transmission equipment protection and DS-2 optical span protection from the FOX-2 T-HUB to remote FOX-2/FOX-2R units is illustrated in Figure 2-5. The following unit-level operational description pertains to this illustration.

2.26 T1 and T1C Low-Speed Interface cards contain internal M12 MULDEM circuitry protection. DS-1 data from input SWEL circuitry is applied simultaneously to both M12 MULDEMs. DS-2 switching circuitry within the MULDEMs routes DS-2 data to the HS COM card stages. A bridge slot adjacent to each Low-Speed Interface card allows a defective card to be replaced and tested with minimal

service interruption, utilizing the Maintenance Interface card.

2.27 When both the FOX-2 T-HUB and remote FOX-2/FOX-2R units are equipped with optional STBY LTUs, each DS-2 optical extension span can likewise be 1:1 protected. To accomplish this protection, DS-2 data traffic from the on-line M12 MULDEM circuits of the corresponding Low-Speed Interface card is applied redundantly to both the MAIN and STBY LTU cards to generate identical DS-2 optical channels. At the far-end of the DS-2 optical extension span, FOX-2/FOX-2R MAIN and STBY LTU cards process these optical channels into identical DS-2 data and timing streams. Switching circuits within the FOX-2/FOX-2R Low-Speed Interface card automatically route either main or standby DS-2 data to the on-line M12 MULDEM circuitry under MPU control. The off-line LTU routes its data to the off-line M12 MULDEM circuit to provide continuous off-line performance monitoring.

2.28 The high-speed interface between the upper and lower FOX-2 T-HUB shelf units can be 1:1 protected with the addition of STBY HS COM and WLEL cards. High-speed protection switching between MAIN and STBY cards is accomplished by the coordinated DS-2 routing within all Low-Speed Interface cards in conjunction with DS-3 routing performed by the WLEL cards.

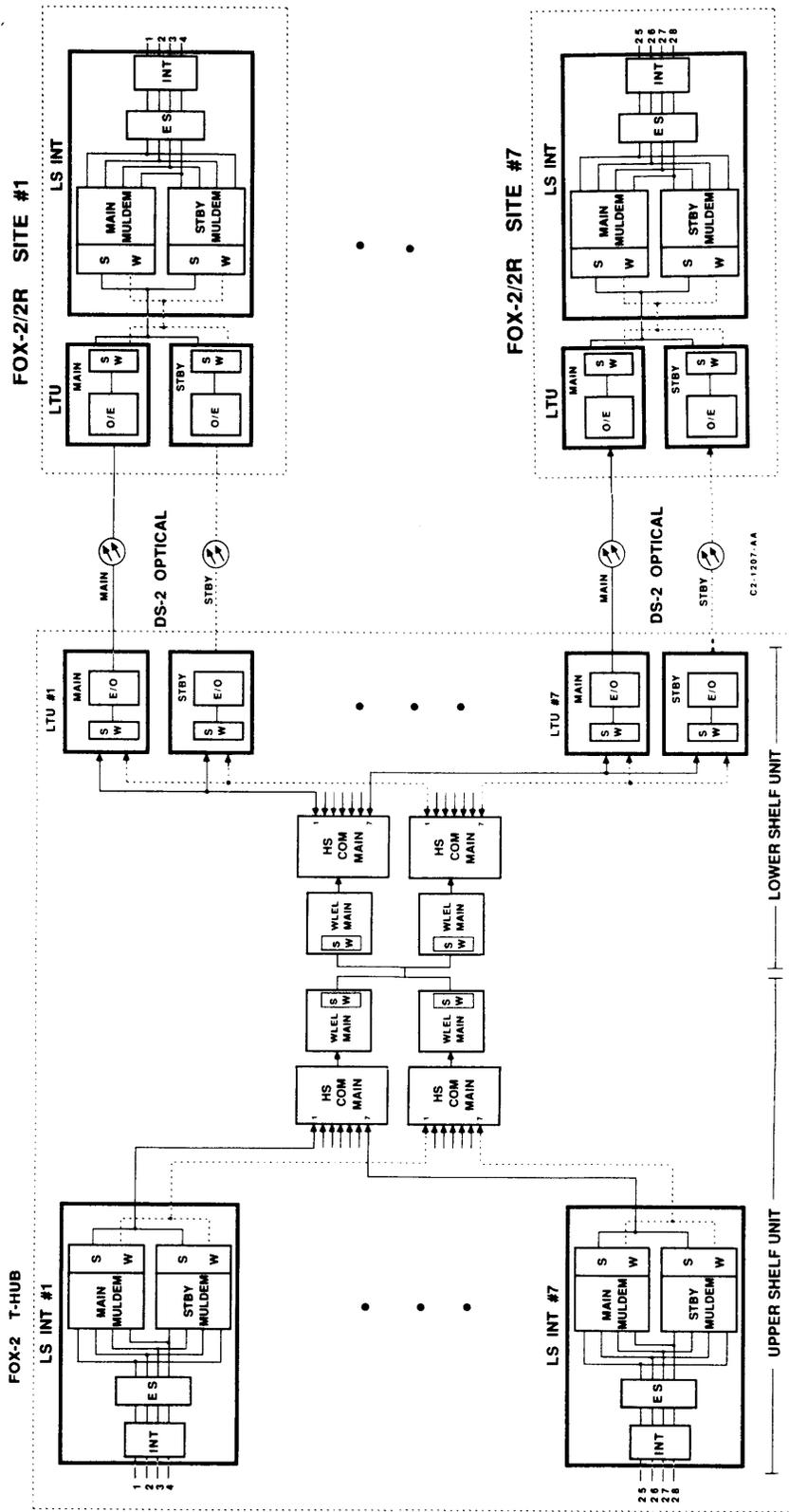


Figure 2-5. FOX-2 T-HUB Protection Switching

2.29 Fault monitoring and automatic protection switching are the responsibility of the Control MPUs, which monitor various alarm points within their respective shelf units and perform the following functions:

- o Illuminate appropriate fault and status indicators within the equipment, except for the Power Supply which controls its own indicators.
- o Utilize lockout software to localize a fault condition and prevent sympathetic illumination of fault LEDs on down-line cards.
- o Initiate and control automatic switching of low-speed and high-speed circuit cards from faulty circuitry to redundant circuitry.
- o The upper shelf unit MPU monitors the performance of incoming

T1 and/or T1C channels and calculates the T1/T1C BPV (Bipolar Violation) rate for each low-speed input. In the presence of an excessive BPV error rate, the MPU will illuminate an INPUT LED on the associated Low-Speed Interface card.

- o Provide MAJOR, MINOR, and BAY fault external alarm hardware notification via relay contact closure. This provision allows equipment external to the FOX-2 T-HUB bay to monitor equipment alarm status and provide visual and audible fault indications.
- o Optionally, communicate with the TELTRAC system, which performs comprehensive fault alarm reporting and analysis of an entire telecommunications network from a central master terminal location.

3. FUSE AND ALARM PANEL DESCRIPTIONS

3.01 The ACX025 Fuse and Alarm Panel provides fused power distribution, alarm, and TELTRAC interface for up to twelve rack-mounted Telco Systems products, including the FOX-2 T-HUB. A BAY FLT lamp indicator is provided which illuminates when any fault in the BAY exists.

3.02 A Relay card, used within the ACX025 Fuse and Alarm Panel, contains relays, lamp indicators, and protective fuses. If any of these components fail, the card can be easily replaced without disconnecting power. See Figure 2-6 and TABLE A for the ACX025 Fuse and Alarm Panel (Relay Card) indicators and their functions.

3.03 There are two protection fuses on the Relay card. One fuse

protects the Fuse and Alarm Panel from the power source; the other provides FUSE lamp and relay protection.

3.04 A jumper on the Relay card allows VISUAL alarm contacts to be ACO-controlled in the same manner as the AUDIBLE contacts, or to be operated independent of ACO control.

3.05 A front-accessible, limited feature, Fuse and Alarm Panel (ACX043), illustrated in Figure 2-7, provides fused power distribution, alarm, and TELTRAC interface for up to six protected power feeds to supply other rack-mounted Telco Systems products. A BAY FLT lamp indicator is provided which illuminates when any fault in the BAY exists. Refer to TABLE B for ACX043 Fuse and Alarm Panel indicators and their functions.

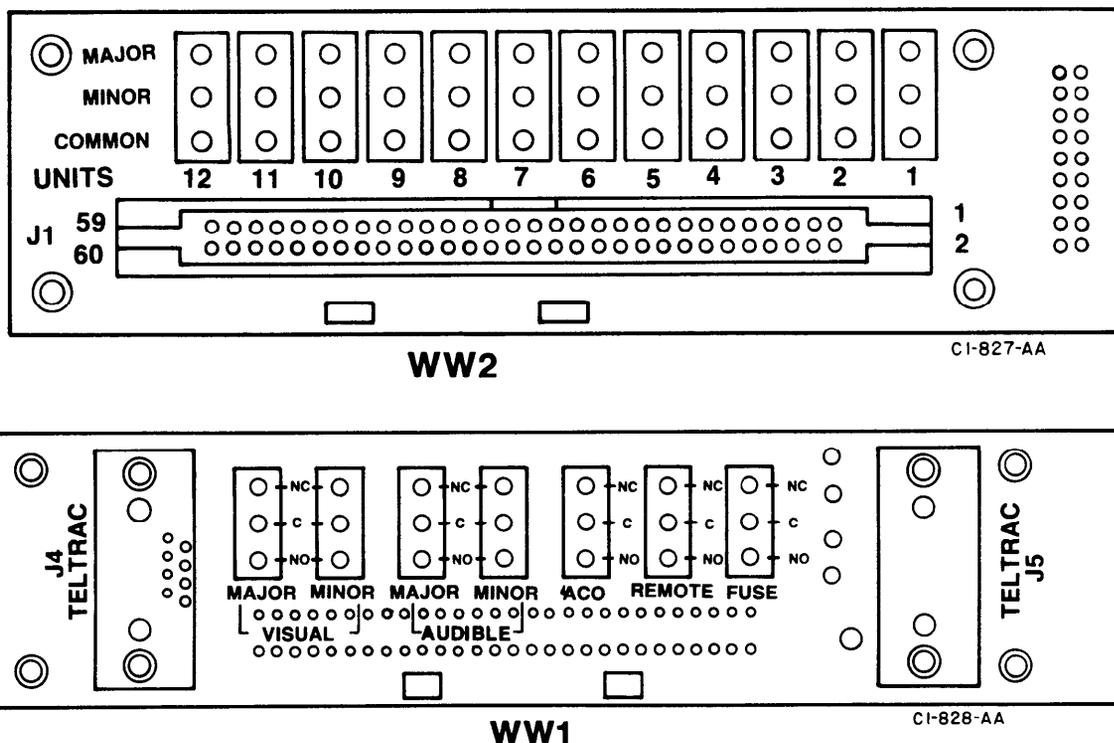
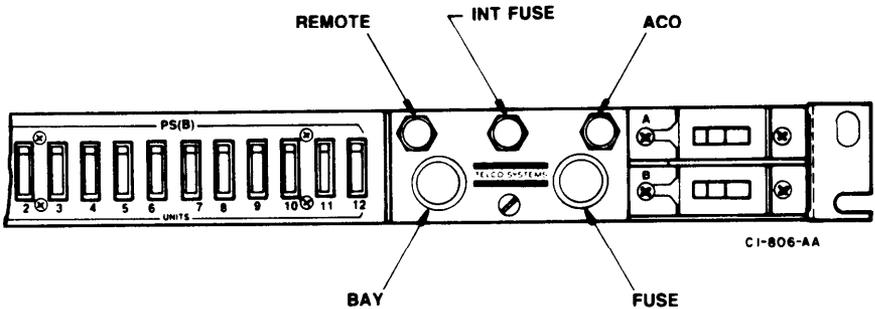


Figure 2-6. ACX025 Fuse and Alarm Panel

TABLE A. ACX025 Fuse and Alarm Panel (Relay Card)

INDICATOR	DESCRIPTION OF MONITORED POINT
	 <p>The diagram shows a horizontal panel with 12 units labeled 2 through 12. To the left of the units is a section labeled PS(B). In the center is a section labeled TELCO SYSTEMS. To the right of the units are two sections labeled A and B, and a section labeled ACO. Labels with arrows point to specific indicators: REMOTE (top left), INT FUSE (top center), ACO (top right), BAY (bottom left), and FUSE (bottom center). The panel is identified as CI-806-AA.</p>
FUSE (red)	Monitors the status of all the UNIT fuses at the front of the Fuse and Alarm Panel.
BAY (red)	Monitors all MAJOR and MINOR fault indications in all FOX-2 T-HUB units connected to the Fuse and Alarm Panel.
REMOTE (yellow)	<p>For other 828A or 828AF units mounted within the same equipment bay, this indicator illuminates in conjunction with BAY FLT lamp, by action of a RAC-II card, when REMOTE BAY FLT option has been enabled on the Control MPU in the 828A or 828AF unit containing the RAC-II card and a BAY alarm is reported from the far-end.</p> <p>However, the REMOTE alarm indicator has no practical FOX-2 T-HUB application and should be ignored for FOX-2 T-HUB units.</p>
INT FUSE (red) (Internal Fuse)	Monitors the condition of the relay protection fuses. The FUSE lamp will also illuminate in conjunction with the illumination of the INT FUSE lamp.
ACO (yellow) (Alarm Cutoff)	Illuminates whenever the ACO switch on either Control MPU is activated, or will momentarily illuminate when either Control MPU card is reset.

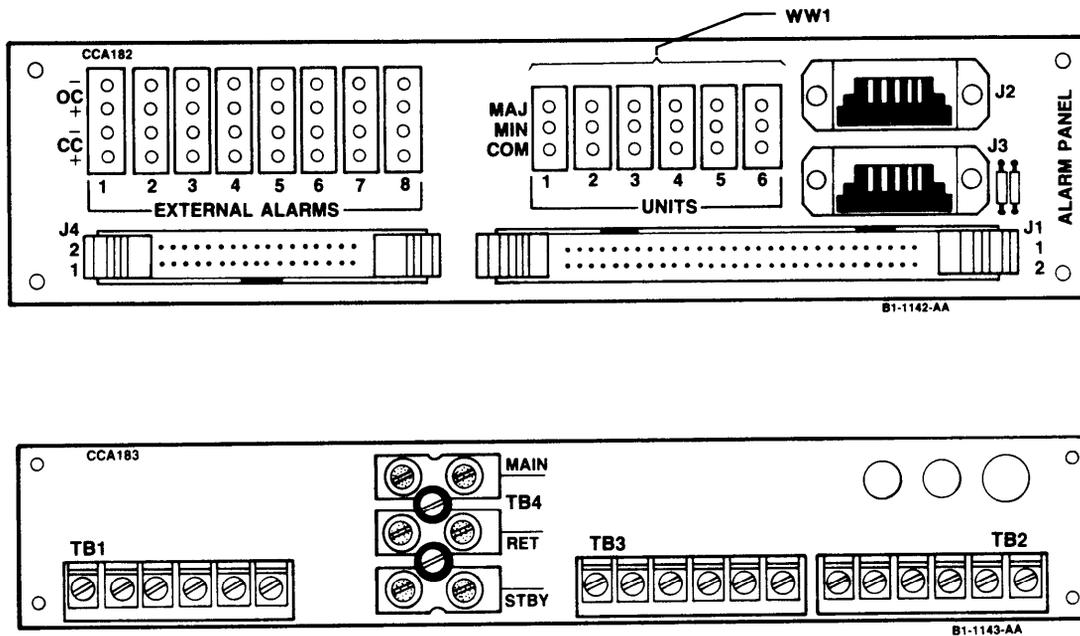


Figure 2-7. ACX043 Fuse and Alarm Panel

TABLE B. ACX043 Fuse and Alarm Panel Indicators

ALARM INDICATOR	DESCRIPTION OF MONITORED POINT
<p>FUSE (red)</p> <p>BAY (red)</p>	<p>Monitors the status of all the Unit fuses at the front of the Fuse and Alarm Panel.</p> <p>Monitors all MAJOR and MINOR fault indications in the units connected to the Fuse and Alarm Panel.</p> <p>This indicator can also illuminate in response to far-end alarm if Remote Bay Enable is active.</p>

## 4. SPECIAL TEST EQUIPMENT

## A. Maintenance Interface Card

4.01 The Maintenance Interface card (see Figure 2-8) is used to replace faulted T1 and T1C Low-Speed cards, and permits testing of the Low-Speed Interface card before restoring the card in service. The CHANNEL SELECT switch is used to check the traffic on each of the DS-1 or DS-1C channels on the Low-Speed Interface card under test without interrupting traffic. The Maintenance Interface card is also used to replace a faulty Control MPU card. A block diagram of the Maintenance Interface card is shown in Figure 2-9.

4.02 When the NORMAL/TEST switch is set to the NORMAL position, the receive circuits of the on-line MULDEM circuit of the Low-Speed Interface

card under test are bridged to on-line traffic. In the TEST mode, the TX and RX circuits of the on-line M12 MULDEM circuits of the off-line Low-Speed Interface card are looped at the DS-2 level. Front-mounted DS-1 test jacks, used in conjunction with the CHANNEL SELECT switch, allow individual DS-1 channels to be tested via external DS-1/-1C test equipment. Once tested, data traffic is automatically transferred to the Low-Speed Interface card under test when the failed card is removed. If a new card is installed in the original slot, traffic automatically transfers back to the new card.

4.03 The LEDs on the front of the Maintenance Interface card and their functions are listed in TABLE C. The switches on the front of the Maintenance Interface card and their functions are listed in TABLE D.

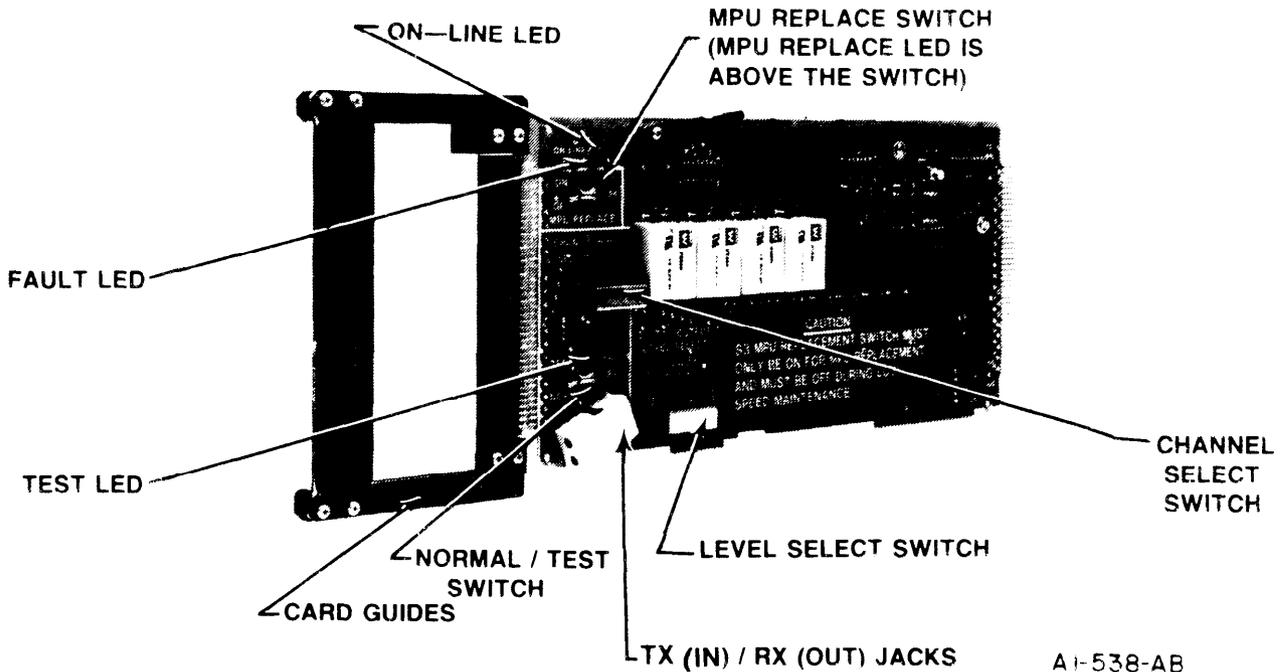
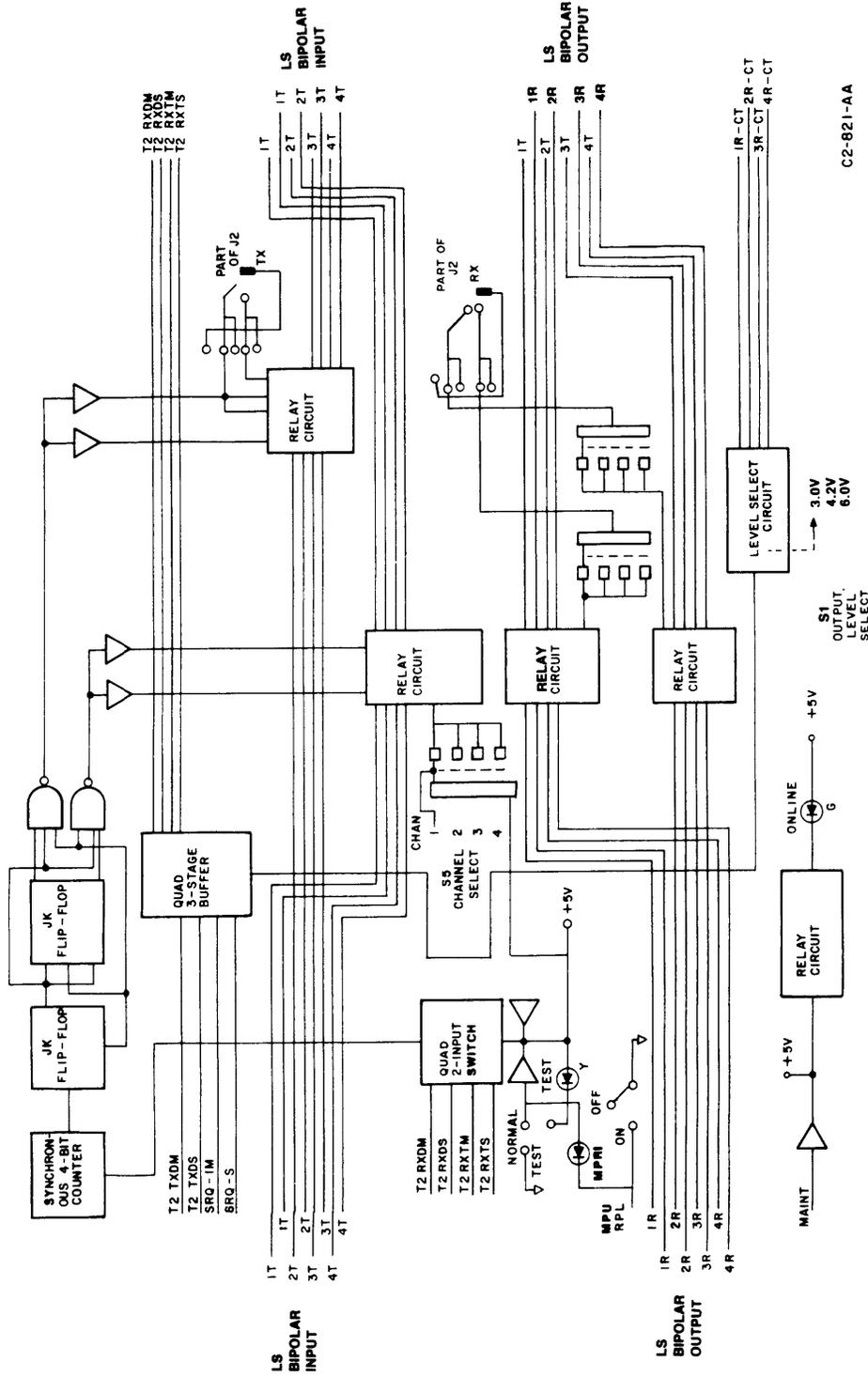


Figure 2-8. Maintenance Interface Card



C2-821-AA

Figure 2-9. Maintenance Interface Card Block Diagram

TABLE C. Maintenance Interface Card Indicators

LED INDICATOR	DESCRIPTION OF MONITORED POINT
ON LINE (green)	Illuminates when the Low-Speed Interface card plugged into the Maintenance Interface card is carrying on-line traffic.
FAULT (red)	Illuminates when the Maintenance Interface card has a failure.
MPU REPLACE (red)	Illuminates when the Maintenance Interface card is in the MPU REPLACE mode.
TEST (yellow)	Illuminates when the Maintenance Interface card is in the TEST mode.

TABLE D. Maintenance Interface Card Switches

SWITCH	DESCRIPTION OF MONITORED POINT
MPU REPLACE	Set to ON when replacing either Control MPU card; otherwise, set to OFF.
CHANNEL SELECT	Four-position slide switch that routes channels 1 through 4 on the Low-Speed card under test to the front-mounted test jacks. The channel 1 position connects low-speed channel 1 to the test jacks (T1 and T1C). The channel 2 position connects low-speed channel 2 to the test jacks (T1 and T1C). The channel 3 position connects low-speed channel 3 to the test jacks (T1 only). The channel 4 position connects low-speed channel 4 to the test jacks (T1 only).
TEST/NORM	Configures the test operation of the Maintenance Interface card to allow the Low-Speed Interface card under test to frame up on incoming bridged data (NORMAL), or to be loop-backed on itself at the DS-2 rate (TEST).
T1/T1C OUTPUT LEVEL SELECT	Selects the proper voltage level for the Low-Speed Interface output signal. From left to right: Position 1 is 3.0 Vdc, 0 to 100 feet; Position 2 is 4.2 Vdc, 101 to 350 feet; Position 3 is 6.0 Vdc, 351 to 655 feet; and Position 4 is not used.

## B. Manual Control Interface Card

4.04 The MCI (Manual Control Interface) card (see Figure 2-10) is an I/O (Input/Output) board allowing immediate and direct access to the Control MPU card. This access is used to initiate test functions and provide detailed operational status through interrogation of the local FOX-2 T-HUB terminal. A block diagram of the Manual Control Interface card is shown in Figure 2-11.

4.05 All DS-1, DS-1C, or DS-2 lines can be bidirectionally looped either individually (see Figure 2-12) at the DS-1 level or as a group at the DS-2 level. DS-2 loopbacks initiated at the local terminal (see Figure 2-13) loop the channel bidirectionally toward the FOX-2/FOX-2R span and toward the equipment, thereby enabling technicians at the local terminal site and far-end FOX-2/FOX-2R site(s) to perform simultaneous BER (Bit Error Rate) testing of a DS-2 optical span under test.

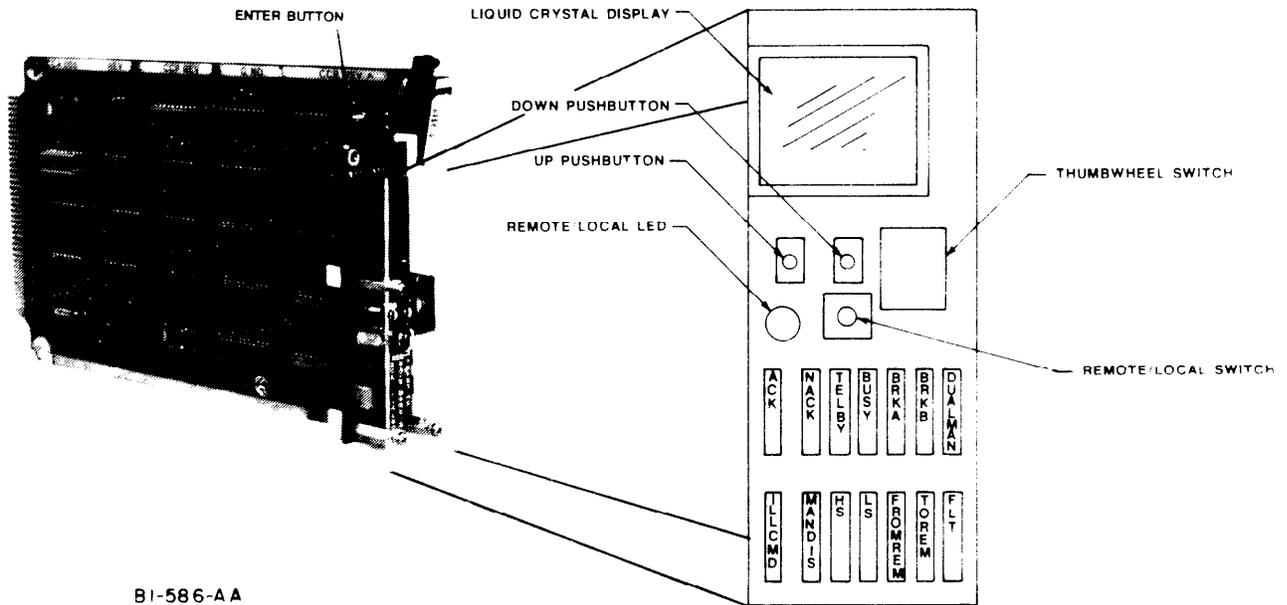


Figure 2-10. Manual Control Interface Card

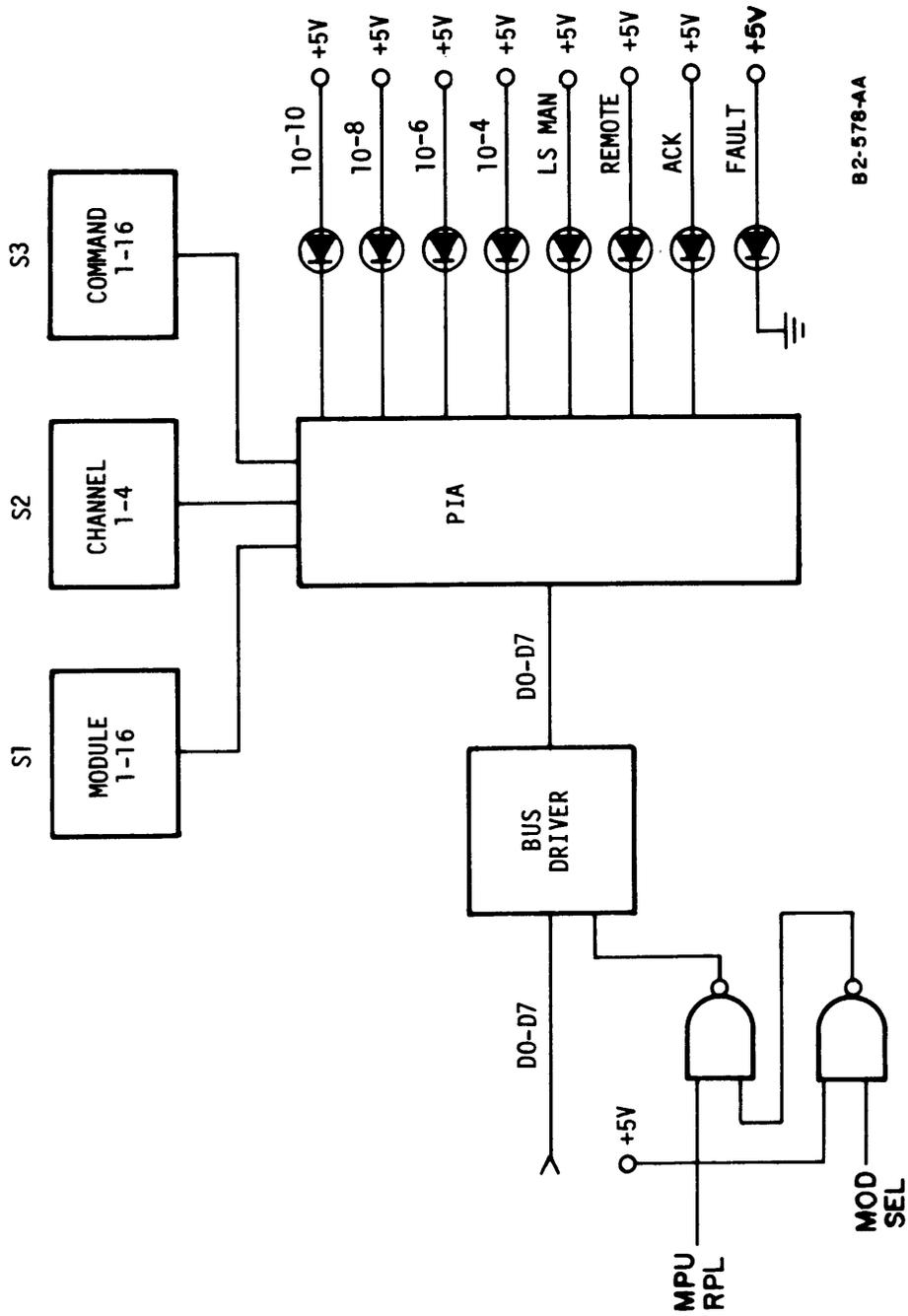


Figure 2-11. Manual Control Interface Card Block Diagram

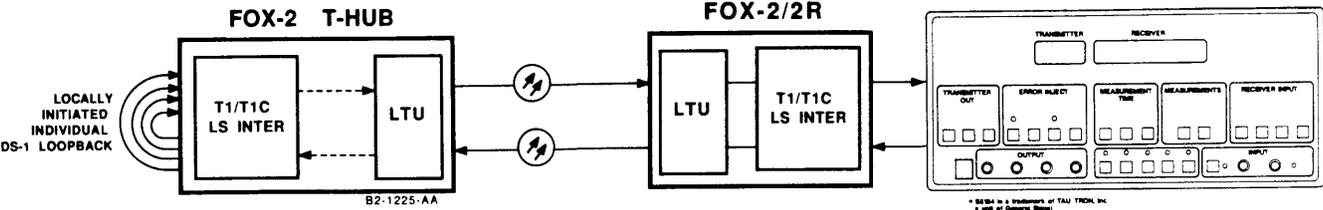


Figure 2-12. FOX-2 T-HUB DS-1/1C Channel Loopback Testing

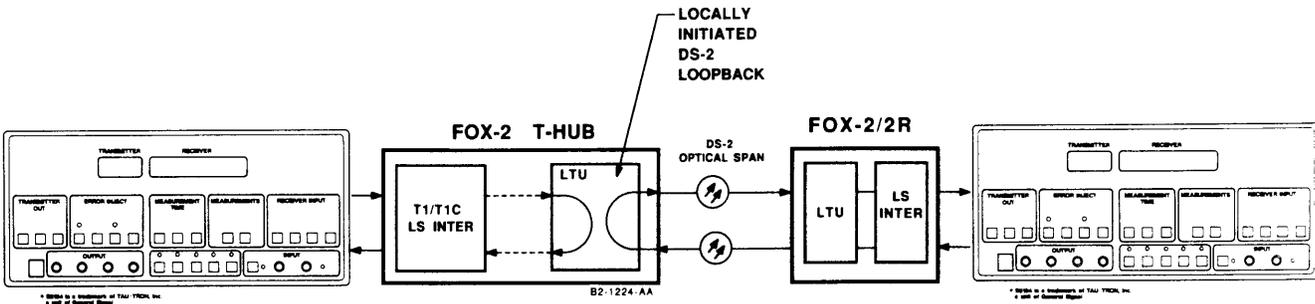


Figure 2-13. FOX-2 T-HUB DS-2 Channel Testing

5. DETAILED CIRCUIT CARD DESCRIPTIONS

5.01 Subsections to the Theory of  
Operation Section which detail  
the operation of individual circuit  
cards to the block diagram level are  
not included in this manual.