FOX-2R DS-2 FIBER OPTIC EXTENSION UNIT
THEORY OF OPERATION

1. GENERAL

1.01 This section is a cover sheet for the Telco Systems Fiber Optics Corporation FOX-2R DS-2 Fiber Optic Extension Unit Theory of Operation. This section is reproduced with permission of Telco Systems Fiber Optics Corporation and is the equivalent of Telco practice 831-100-002, Issue 1.

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-2R DS-2 Fiber Optic Extension Unit.

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 365-407-858SW 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

Attachment: Telco Systems Fiber Optics Corporation
FOX-2R DS-2 Fiber Optic Extension Unit
Theory of Operation

FOX-2R DS-2 FIBER OPTIC EXTENSION UNIT
THEORY OF OPERATION

CONTENTS PAGE

1. GENERAL

A. Scope

1.01 This section presents a functional description of the FOX-2R DS-2 Fiber Optic Extension Unit (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 section. These circuit descriptions highlight the interrelationship of FOX-2R hardware components and subsystems.

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

B. References

1.03 For additional information regarding unit operation, features, functions, options, or mechanical/electrical design, please consult the following sections of this manual for details:

831-100-001 General Description
831-100-008 Drawings

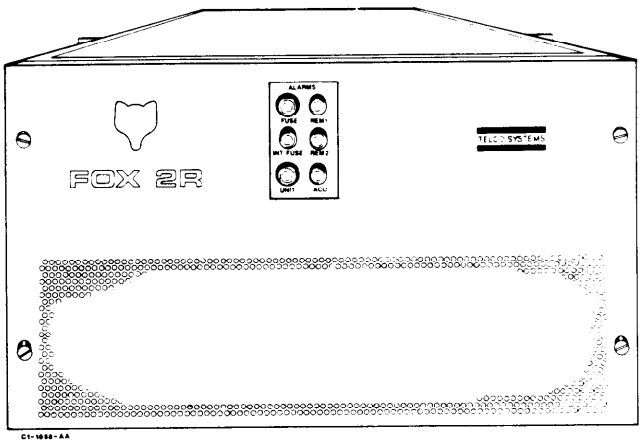


Figure 2-1. FOX-2R Equipment Cage

2. FUNCTIONAL DESCRIPTION

A. Operational Description

2.01 The FOX-2R is a dual 1:1 protected DS-2 fiber optic extension unit which can be employed as a point-to-point DS-2 optical transmission system or a DS-2 optical extension from an 828M/F or 828A/AF MX-3 type multiplexer, depending on the system application.

2.02 Each of the FOX-2R units, designated FOX-2R I and II, within the equipment cage contains the circuitry required to multiplex up to four T1 (1.544 Mb/s) or two T1C (3.152 Mb/s) channels into a DS-2 single-mode optical data channel. This composite optical data channel can therefore represent the combined transmission capacity of up to 96 voice or data channels (64 Kb/s PCM) along with embedded overhead supervisory information. To ensure sufficient data transitions to extract receive clock timing regardless of data stream content, the DS-2 data stream is 3B6B encoded into a 12.624 Mb/s data stream (2 x 6.312 Mb/s) which also accommodates an overhead channel for MPU-to-MPU communications. A fully loaded FOX-2R can handle a total of eight T1 or four T1C signals for a total of 192 (64 kb/s PCM) voice channels via two protected optical transmission spans. Figure 2-2 illustrates the FOX-2R with front cover removed to expose the circuit cards.

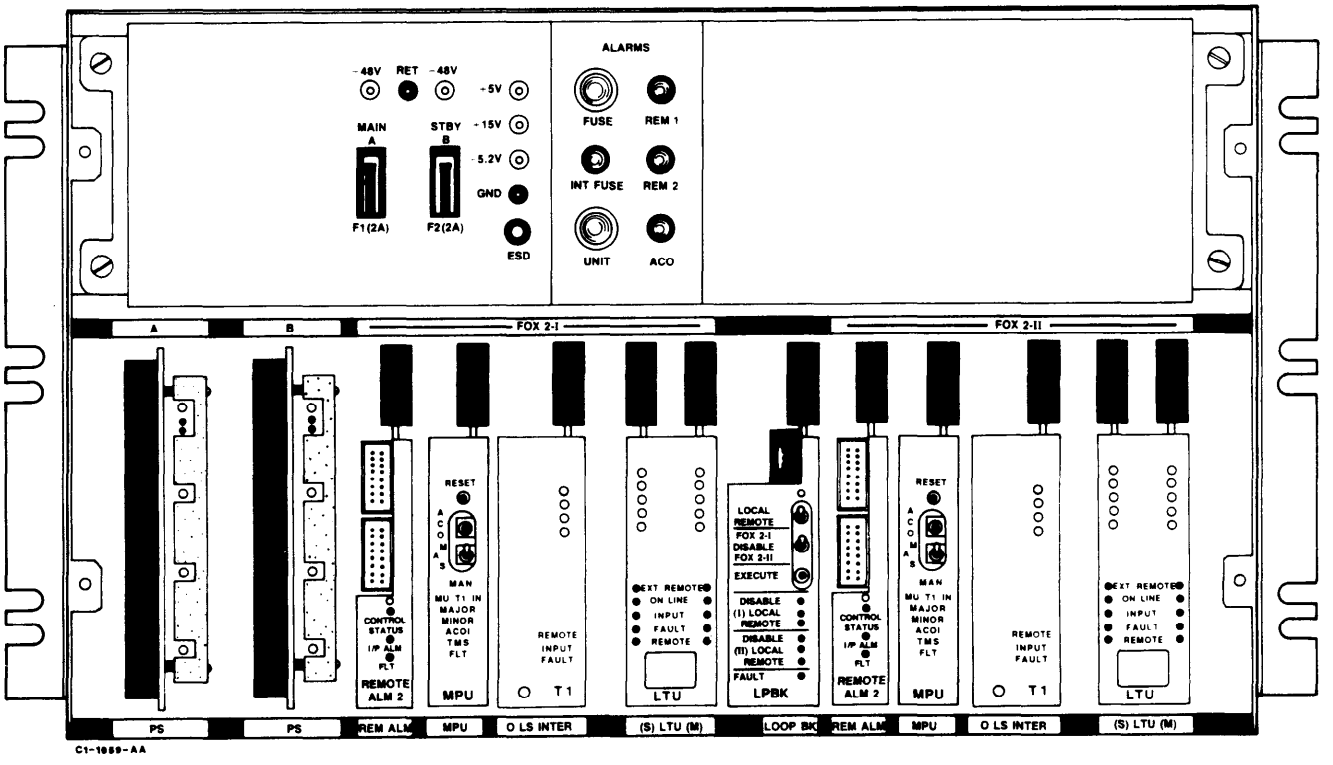


Figure 2-2. FOX-2R Fiber Optic Extension Unit (Cover Removed)

B. Mechanical Detail

Equipment Description Overview

2.03 The FOX-2R is a rack-mounted dual FOX-2 unit. The FOX-2R is approximately 19-inches wide, 12-inches deep, and 10.4-inches high and weighs about 40 lbs (fully loaded). See Drawings Section (831-100-008) for assembly prints of the rack-mount FOX-2R. The equipment cage contains two independent DS-2 optical units and incorporates an integrated Fuse and Alarm Panel Assembly to eliminate the need of an external panel for primary power fuse protection, regulation, and filtering.

2.04 The 19-inch rack mechanics of the FOX-2R equipment cage allows the unit to be mounted into 19-inch equipment racks or 23-inch racks using mounting adapter ears. Since the FOX-2R can be installed in bay configurations with 828A/AF multiplexers, a ribbon cable interface interconnects the FOX-2R Major and Minor alarms to a common alarm interface on the 828A Fuse and Alarm Panel (ACX025G1).

C. Equipment Interfaces

2.05 Figure 2-3 is a pictorial representation of the T1/T1C optical DS-2, electrical, and alarm interfaces of the FOX-2R.

2.06 Up to eight T1 channels (1.544 Mb/s each) or four T1C channels (3.152 Mb/s each) can be interconnected to the FOX-2R via separate 15-pin D-subconnectors (Unit-I: J2-J5 and Unit-II: J10-J13) on the interface panel. Wire wrap channel access terminals on the rear of the motherboard support T1/T1C pre-emphasis/build-out networks used to maintain proper waveform envelope at the DSX-1/1C cross-connect facility.

2.07 FC-type transmit and receive optical connectors on each Line Transmission Unit (LTU) card provide single-mode optical interface to fiber optic entrance cable via fiber optic terminations such as an external splice tray and/or optical patch panel.

2.08 Terminal block TB1 on the FOX-2R motherboard is used for independent primary power (-48 Vdc) interface from the power source to PS-A and PS-B power supplies of the FOX-2R. A fuse and alarm panel integrated into the cage design provides independent fused primary protection, voltage regulation, and filtering.

2.09 External alarm interface is accomplished via jack J6 which remotes Major and Minor, Audible and Visual, Fuse, and Remote alarms to external office alarm notification hardware. The Remote Alarm II card (RAC-II) accepts alarm lines from external equipment. Upon receipt of an external alarm, RAC-II activates local unit and major or minor alarms, and initiates N/O or N/C contact closure of the corresponding relay in the far-end Remote Alarm II card. Jacks J1 (Unit-I) and J9 (Unit-II) are used to couple external alarm/control information from/to external equipment. Remote, Fuse, and Major/Minor Visual alarm interfaces are also provided via rear-mounted wire-wrap blocks.

2.10 In DS-2 optical extension applications from an 828A/AF multiplexer, all FOX-2R fault and status information can be transmitted to a TELTRAC master terminal station via the optical span overhead channel. TELTRAC can be used to provide detailed fault/status interrogation and remote control of the FOX-2R unit from a central network location.

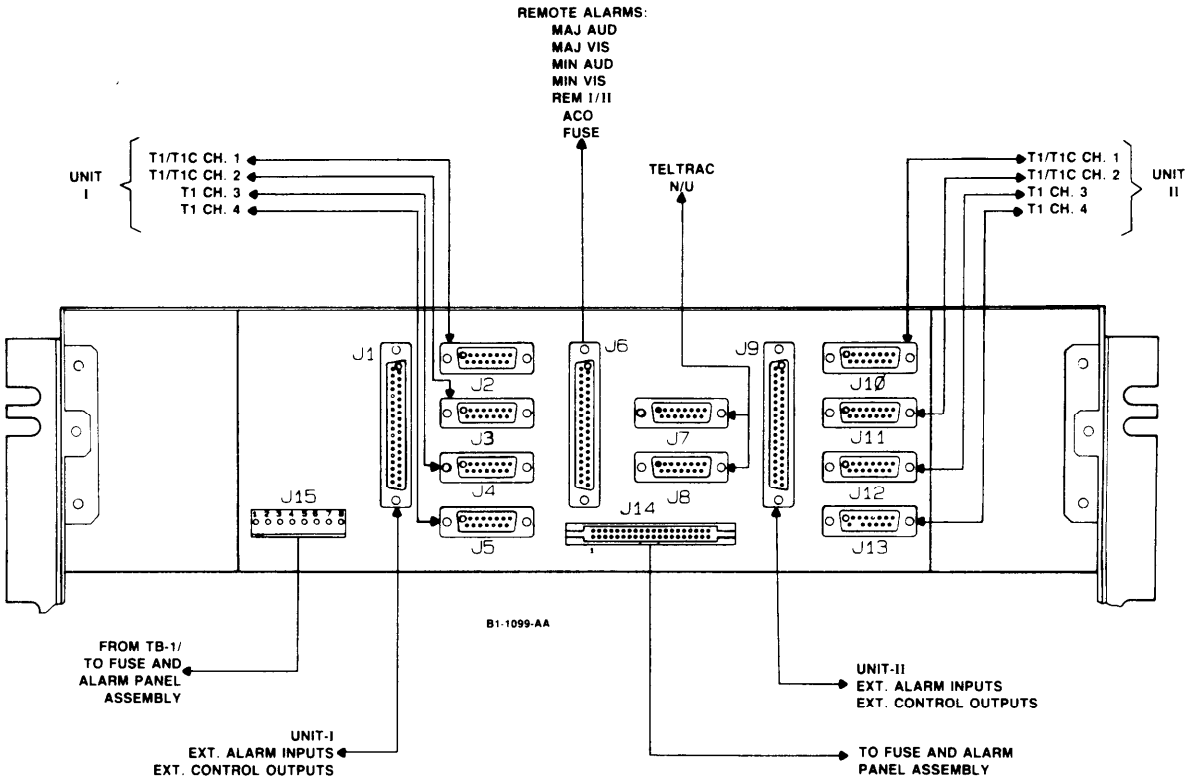


Figure 2-3. FOX-2R Equipment Interfaces

D. Equipment Protection

2.11 The basic FOX-2R is designed as an unprotected DS-2 optical extension. With the addition of a STBY LTU, the DS-2 optical interface and fibers can be 1:1 protected. To accomplish this protection, on-line DS-2 data from the Low-Speed Interface card is redundantly applied to both the MAIN and STBY LTU cards. At the receiving end of the system, identical information is derived from the receive circuits of each LTU. Switching DS-2 circuits within the Low-Speed Interface card are controlled by the MPU. When no equipment faults are present, this switching circuit routes the DS-2 electrical output of the MAIN LTU to the on-line muldem of the Low-Speed Interface card. In the event of a failure, DS-2 data is routed from the STBY LTU instead.

2.12 Internal main and standby M12 muldem circuitry within the T1 and T1C Low-Speed Interface card provide 1:1 transmit and receive low-speed equipment protection. Muldem circuit failures initiate automatic switching by the MPU to redundant muldem circuitry. A bridge slot adjacent to the Low-Speed Interface card allows the card to be replaced without service interruption using the Maintenance Interface card.

2.13 Main (PS-A) and standby (PS-B) power supplies provide protected power supply operation. Main and standby power supply isolation allows each supply to be fed from isolated primary power sources. If a power supply fails, steering diodes contained within each supply automatically route the secondary voltages from the redundant power supply to the circuit cards, while blocking the return path to ground through the failed supply.

3. UNIT BLOCK DIAGRAM

3.01 Consult Figure 2-4 for a detailed block diagram of the unit-level operation of the FOX-2R DS-2 Optical Extension Unit.

A. Transmit Signal Flow

3.02 Each FOX-2R unit accepts up to four T1 (1.544 Mb/s) or up to two T1C (3.152 Mb/s) channels from external T-carrier terminal equipment. The T1 electrical interface can be AMI (Alternate Mark Inversion) or B8ZS (Bipolar with Eight Zero Substitution) industry-standard line coded. Cable interface is accomplished via twisted pair metallic transmission facility interconnected to separate D-sub connectors.

3.03 Input circuitry within the T1 or T1C Low-Speed Interface card converts the bipolar line coding into unipolar data and timing streams. Normal data line activity provides edge transitions to allow clock recovery circuitry to extract transmit timing. SWEL circuitry within the Low-Speed Interface card synchronizes all incoming data channels to an internally generated master clock rate using bit stuff technology. Bit stuffing rate is dependent upon the timing difference between the incoming T1/T1C rate and the master clock timing of the on-line LTU. Overhead information inserted into the DS-2 masterframe identifies the time occurrence of inserted stuffing bits to aid far-end stuffing bit extraction.

3.04 Transmit muldem circuitry multiplexes four T1 channels into a single DS-2 (6.312 Mb/s) data channel. DS-2 overhead information is included in the channel to aid far-end frame synchronization and demultiplexing. Switching circuitry routes the composite DS-2 channel to either the MAIN or STBY LTU circuit cards on command from the MPU card.

3.05 The transmit circuits of each LTU circuit card convert the incoming DS-2 electrical data channel into an equivalent optical channel. A 3B6B encoder circuit converts the DS-2 channel into a 12.624 Mb/s data channel. This encoding guarantees the presence of data transitions to assist receive clock recovery regardless of data content. An available bit within the optical line coding is used to support an overhead channel to transmit remote fault and TELTRAC data.

3.06 Optical transmission from the LTU is accomplished by a modulation circuit which biases the optical output power of a single-mode infrared LED in correspondence to logical level transitions. An FC-type optical connector couples the transmit optical signal to optical termination equipment.

B. Receive Signal

3.07 Incoming intensity-modulated single-mode optical transmission from the far-end FOX-2R unit is converted into an equivalent electrical data channel by a photodetector within the receive circuitry of the LTU. The presence of regular data transitional edges guaranteed by 3B6B optical line coding is used to extract receive clock timing using phase-locked loop technology.

3.08 A 3B6B decoding circuit converts the 12.624 Mb/s data channel back into its DS-2 (6.312 Mb/s) equivalent and extracts the coded overhead bit used for MPU-to-MPU serial communications. The recovered DS-2 data channel is coupled to the Low-Speed Interface card for demultiplexing.

3.09 Transmit and receive switching circuitry, embedded within the LTU, loop DS-2 transmit into the receive for local loopback, or loops the DS-2 receive into the transmit for remote loopback testing. Loopback commands are coupled into the FOX-2R unit via the controls of the Loopback card, which are read and executed by the control MPU(s).

3.10 Input switching circuits within the Low-Speed Interface card couple the received DS-2 data channel from the on-line MAIN or STBY LTU into the on-line main or standby M12 muldem circuitry. The receive circuitry of each muldem locates and synchronizes on embedded DS-2 frame data and demultiplexes the composite DS-2 data channel into its DS-1 component channels.

3.11 Internal switching circuits within the Low-Speed Interface card route the input and output of either the MAIN or STBY muldem circuits to the SWEL line synchronization and AMI/B8ZS line-coding circuitry.

3.12 Receive SWEL circuits delete all stuffing bits identified by the muldem circuit and a phase locked-loop retimes the resulting T1 data channels to reestablish the original T1 transmit data rate. Within the T1C Low-Speed Interface card, an M1C muldem circuit multiplexes the four T1 channels into two T1C (3.152 Mb/s) channels.

3.13 Line coding circuitry codes the T1 or T1C data channels into bipolar line format compatible with metallic facility transmission. Passive pre-emphasis/build-out networks on each T1/T1C channel peaks the high frequency response of the output envelope to maintain an industry standard waveform template at the DSX cross-connect facility despite the low-pass filtering effects of the T1/T1C transmission cable.

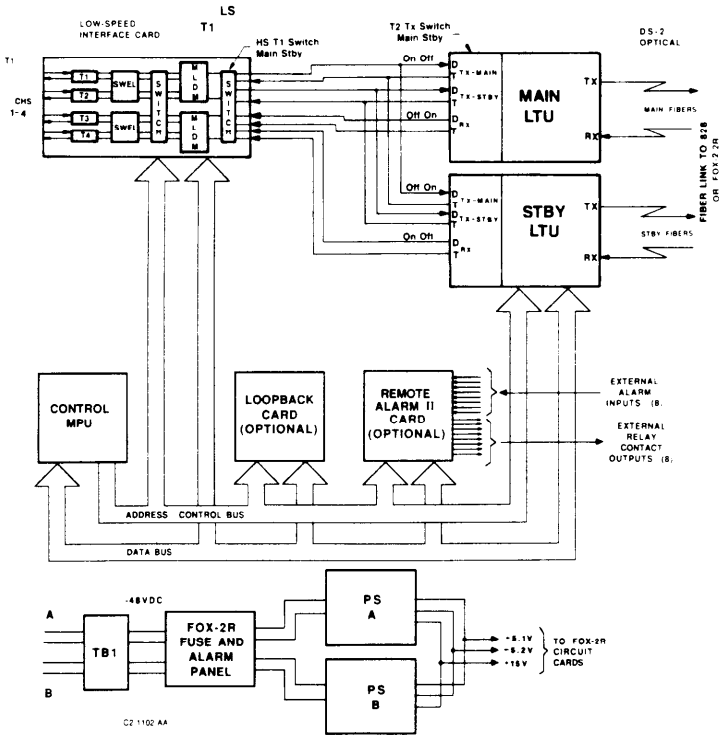


Figure 2-4. FOX-2R Unit Block Diagram

4. DETAILED CARD DESCRIPTIONS

4.01 Separate subsections are included in the last part of this section to describe the functions of individual circuit cards to the block diagram level. Below is a listing of the circuit cards described and their subsection numbers:

Power Supply Module

MPU Card

MAIN/STBY LTU Card

T1/T1C Low-Speed Interface Card

Loopback Card

FOX-2R DS-2 FIBER OPTIC EXTENSION UNIT
POWER SUPPLY MODULE THEORY OF OPERATION
PSX016-1

CONTENTS PAGE

1. SCOPE

1.01 This subsection presents a functional description of the Power Supply (PS A or PS B) card used in the FOX-2R. Figure 2A-1 illustrates the Power Supply module as viewed from the front and side perspectives.

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

2. FUNCTIONAL DESCRIPTION

A. General Description

2.01 The Power Supply module down-converts the incoming primary office voltage of -48 Vdc to +5.1, -5.2, and +15 Vdc secondary voltage potentials compatible with the operation of FOX-2R circuitry.

2.02 Power supply circuit protection is provided through the use of an internal Fuse and Alarm Panel Assembly which is integrated into the equipment cage design. This panel provides individually filtered, regulated, and fused primary power feeds from terminal block TB-1 to each power supply.

2.03 Power Supply A (PS A) and Power Supply B (PS B) are used in the FOX-2R system to provide redundant power supply protection. The secondary voltages of each power supply are connected in parallel to provide power supply protection. In the event of a failure, steering diodes within the failed power supply reverse bias to block the return electrical path to ground via the failed supply.

2.04 Each power supply is designed to withstand continuous shorts on all dc outputs without component damage. Power supply protection circuits prevent any adverse effects on equipment performance resulting from voltage transients or short duration over voltage conditions. If the primary power interface is wired with reverse polarity, the power supply will trip its protective fuse prior to circuit damage. Automatic power supply shutdown and restoral will occur in the presence of over-temperature conditions.

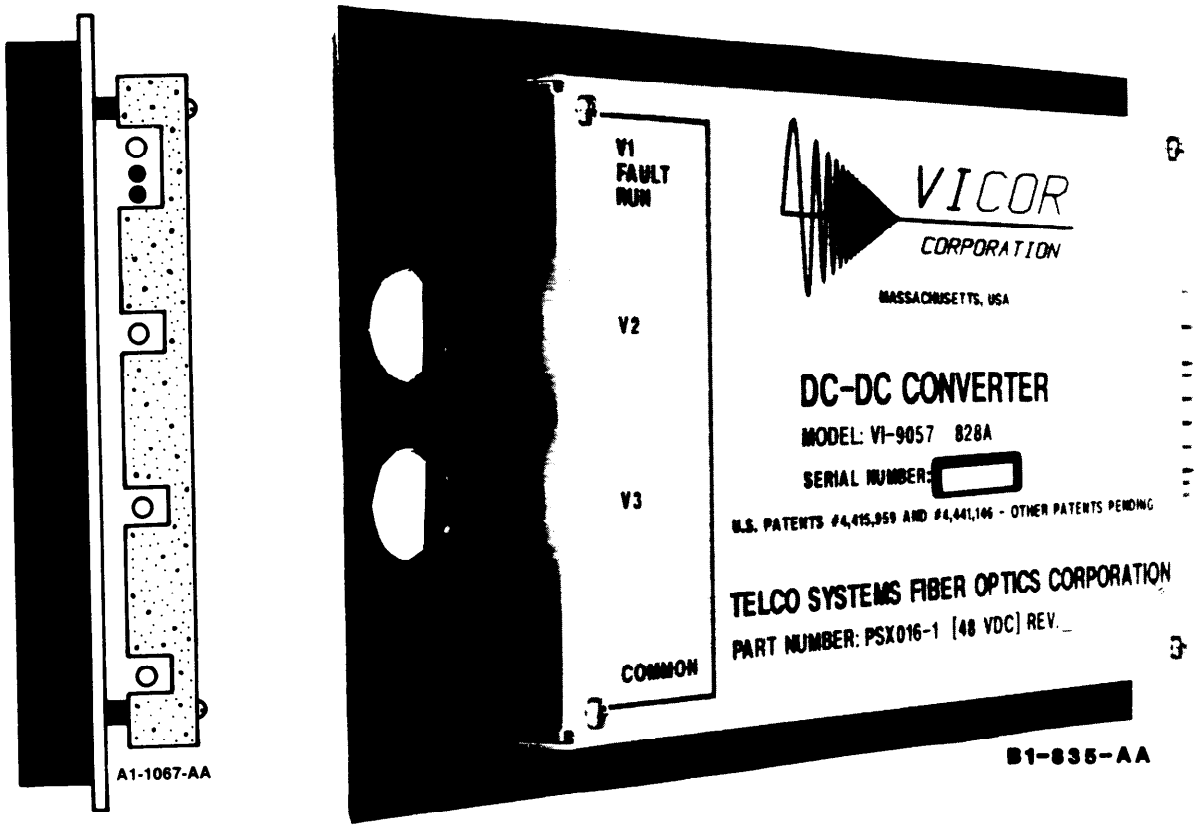


Figure 2A-1. Power Supply Module (PSX010-1)

B. Interfaces

2.05 Consult Figure 2A-2 for a pictorial representation of equipment interfaces to the Power Supply module. Primary office power is coupled to the FOX-2R via terminal block TB-1 located on the unit motherboard and distributed via the integrated Fuse and Alarm Panel Assembly to each power supply. TB-1 provides individual power feeds for the PS A and PS B power supplies sharing a common (-48 Vdc) return line.

2.06 Primary power input to the power supply must be in the range of -42 to -56 Vdc as measured at TB-1 of the FOX-2R motherboard. Voltage tolerance for each secondary voltage is ± 0.2 Vdc. All secondary voltages are accessible for measurement via the following front-mounted test points on each power supply:

Test Point	Voltage
V1	-5.20 Vdc
V2	+5.10 Vdc
V3	+15.00 Vdc
COMMON	Ground

C. Options

2.07 All secondary output voltage levels and alarm thresholds have been preset at the factory under full-load conditions. Field adjustment of these functions is not required or recommended. Power supplies with voltage outputs which are not within specifications should be returned to Telco Systems for readjustment or replacement. No other options are contained on the Power Supply module.

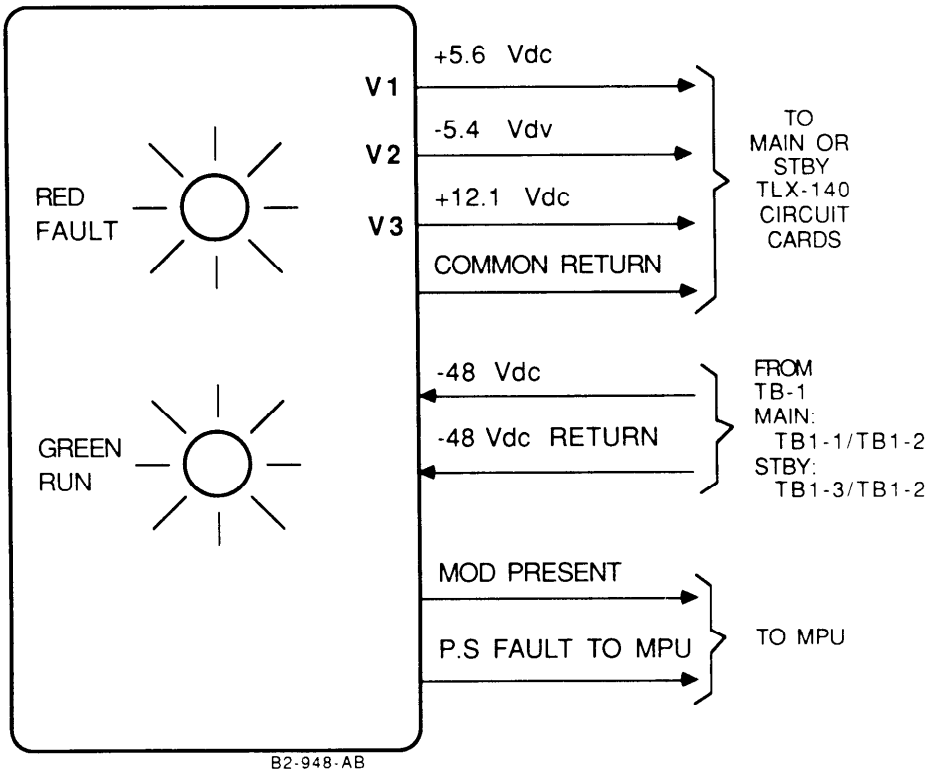


Figure 2A-2. Power Supply Module Interfaces

D. Alarms

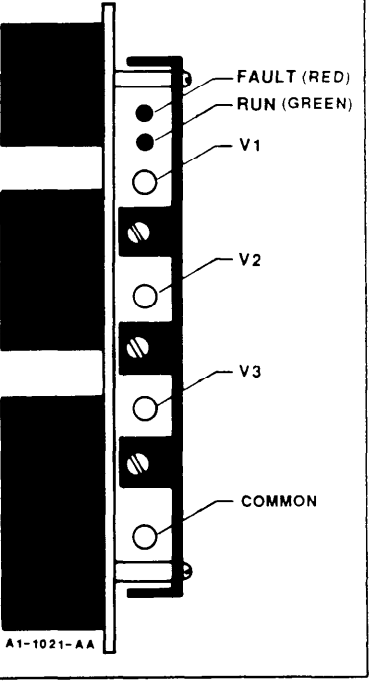
2.08 Fault detection circuitry contained in each Power Supply module monitors and compares all secondary voltages with an internal stable reference voltage. If the output level of all voltages is within 5% of its preset value, the green RUN LED remains illuminated to indicate normal power supply operation.

2.09 If any secondary voltage should deviate by more than 5% of its preset rated value, the FAULT LED on the front of the supply illuminates and the RUN LED extinguishes to identify the failed power supply module. Both the RUN and FAULT LEDs on the front of the Power Supply module are directly hardware driven from fault monitoring circuits and require no intervention by the MPU to illuminate fault indicators.

2.10 In the presence of a power supply failure, the MPU reads fault status information from the Power Supply and activates MINOR and UNIT alarm indications to identify a potentially traffic-affecting problem within the equipment bay.

2.11 TABLE A contains a listing of power supply fault and status LEDs and their relationship to equipment performance.

TABLE A. Power Supply Module Indicators and Test Points

LED INDICATOR	DESCRIPTION OF MONITORED POINT	ILLUSTRATION
FLT (Fault) (red)	Illuminates when the Power Supply module has a failure, or there is a loss of input voltage.	
RUN (green)	Illuminates during normal operation.	
TEST POINT	TEST POINT DESCRIPTION	
V1	-5.2 Vdc Test Point	
V2	+5.1 Vdc Test Point	
V3	+15 Vdc Test Point	
COM	Ground Test Point	

Note: If both the FLT and RUN LEDs are not illuminated, the input voltage may be below specified tolerance.

3. OPERATIONAL THEORY

3.01 Refer to Figure 2A-3 which illustrates the internal operation of the Power Supply module on the block diagram level.

3.02 Incoming -48 Vdc power is applied to a reverse polarity protection circuit which prevents damage to the module if input terminal polarity is reversed. An input filter circuit filters out high-frequency dc bus noise which could adversely affect equipment performance.

3.03 The output of a swing oscillator within the input control circuit is rectified, filtered and regulated to provide the required secondary voltage potentials.

3.04 A detector circuit detects the presence of switching current and illuminates the RUN LED on the power supply card. A voltage comparator circuit compares each secondary voltage with an internal fixed reference voltage and illuminates the FAULT LED if the voltages drift out of tolerance.

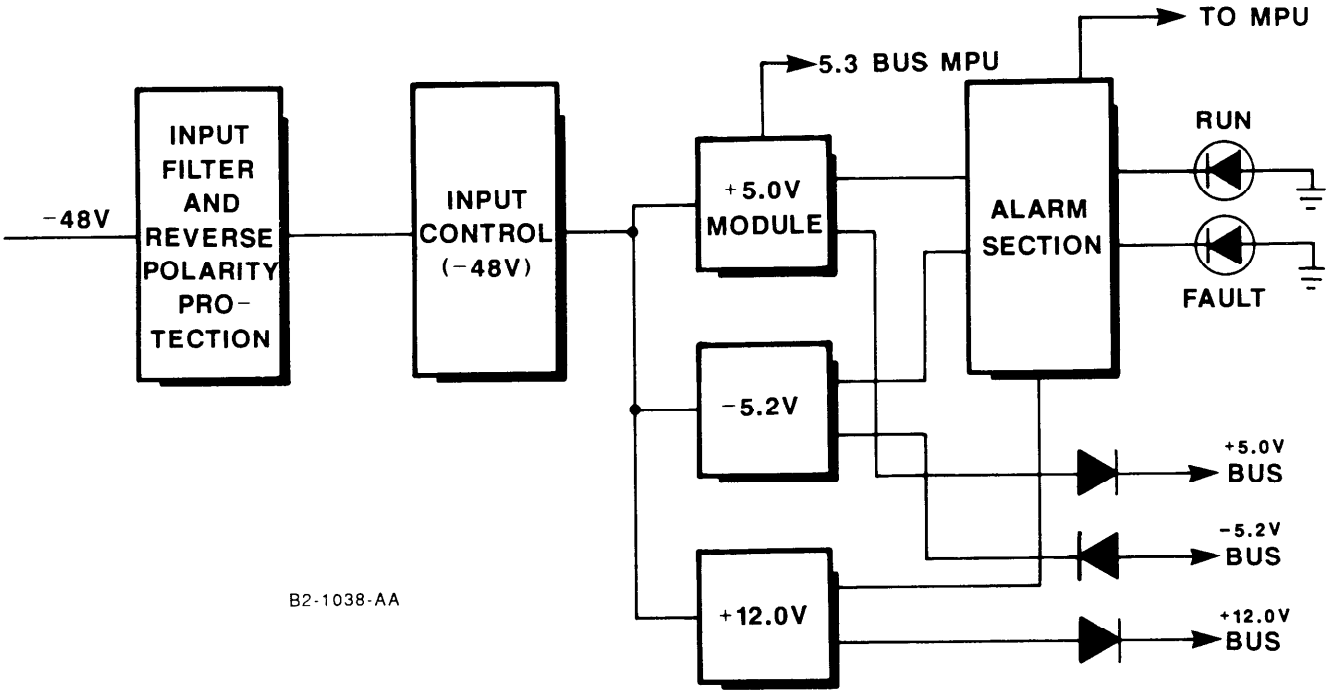


Figure 2A-3. Power Supply Module Block Diagram

FOX-2R DS-2 FIBER OPTIC EXTENSION UNIT
CONTROL MPU CARD THEORY OF OPERATION
CCA137G21

CONTENTS PAGE

1. SCOPE

1.01 This subsection presents a functional description of the Control Microprocessor Unit (MPU) Card used in the FOX-2R. Figure 2B-1 illustrates the Control MPU card as viewed from the front and side perspectives.

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

2. FUNCTIONAL DESCRIPTION

A. General

2.01 The Microprocessor Unit (MPU) is responsible for monitoring equipment operation, illuminating fault and status LEDs in response to equipment performance failure or degradation, and initiating automatic switching to redundant circuitry to maintain uninterrupted service operation.

2.02 In the presence of a fault condition, the MPU automatically performs the following operations:

a. Illuminates fault LED(s) on the suspected card, while suppressing sympathetic fault reporting.

b. Initiates LTU and/or Low-Speed Interface card switching to redundant circuitry to preserve traffic integrity.

c. Illuminates unit-level status LEDs on the front of the MPU, including MAJOR or MINOR LEDs to classify the magnitude of the failure as either traffic-affecting or potentially traffic-affecting.

d. Generates a drive signal to illuminate the UNIT and REM 1 or REM 2 fault indicators on the front of the Fuse and Alarm Panel Assembly, to readily identify the faulted unit.

e. Activates MAJOR, MINOR, REMOTE and UNIT relays to provide relay contact closure for use by customer premises audible or visual alarm reporting equipment.

f. Utilizes the serial communications channel embedded in the 3B6B optical line coding overhead to transmit remote fault information to the far-end FOX-2R MPU, to illuminate far-end remote fault status indicators.

g. If equipped for TELTRAC interface, the MPU transmits alarm telemetry information to a central TELTRAC master terminal station.

2.03 During maintenance or test functions, the MPU will respond to loopback commands generated either manually via the Loopback card or remotely via TELTRAC control and will initiate local or remote, DS-1/1C or DS-2 channel loopbacks. To perform circuit card maintenance, the MPU allows manual override of protective switching to manually lock either main or standby LTU transmission paths on line.

2.04 If the system is equipped for TELTRAC network monitoring and control, the MPU transmits alarm telemetry information and responds to remote commands and interrogation from a central TELTRAC master terminal station. This communications between the MPU and the TELTRAC master terminal station is accomplished via a bidirectional communications channel, embedded in the 3B6B optical line coding overhead between the FOX-2R unit and the LTU(s) of an 828M/F or 828A/AF multiplexer in DS-2 optical extension applications.

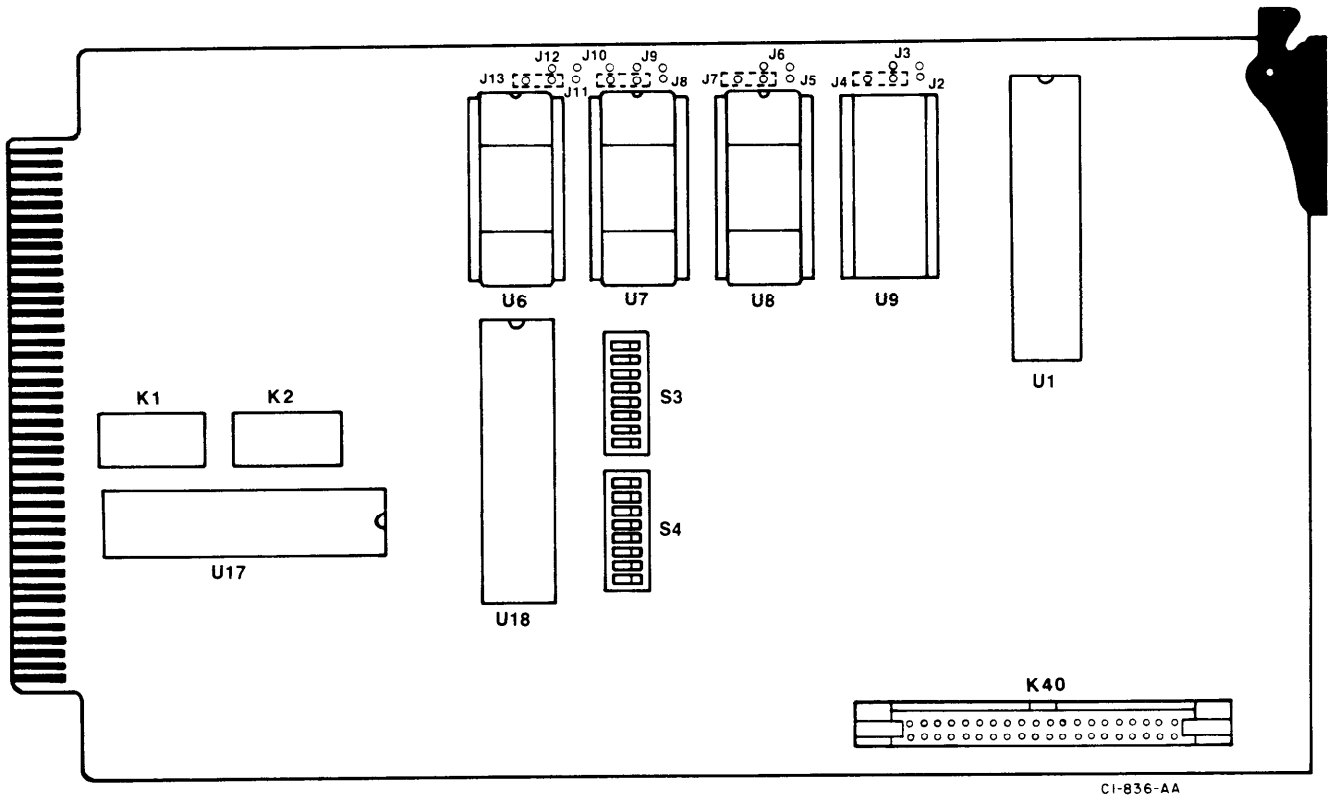


Figure 2B-1. Control MPU Card (CCA137G21)

B. Interfaces

2.05 The MPU utilizes internal unidirectional module select lines in conjunction with an eight-bit bidirectional data bus to transfer command and status information to/from FOX-2R circuit cards. Since MPU circuit card insertion and removal can induce transients in bus operation, an MPU REPLACE switch on the optional Maintenance Interface card is used to momentarily disable bus operation during MPU maintenance functions.

2.06 For remote communications to the far-end FOX-2R, the MPU utilizes a serial channel which is transmitted as part of the overhead data comprising the 3B6B optical line coding via the LTU circuit card. This channel is used to communicate remote fault status, remote loopback commands, and TELTRAC command and status information.

2.07 Consult Figure 2B-2 for a pictorial representation of circuit card interfaces to/from the Control MPU.

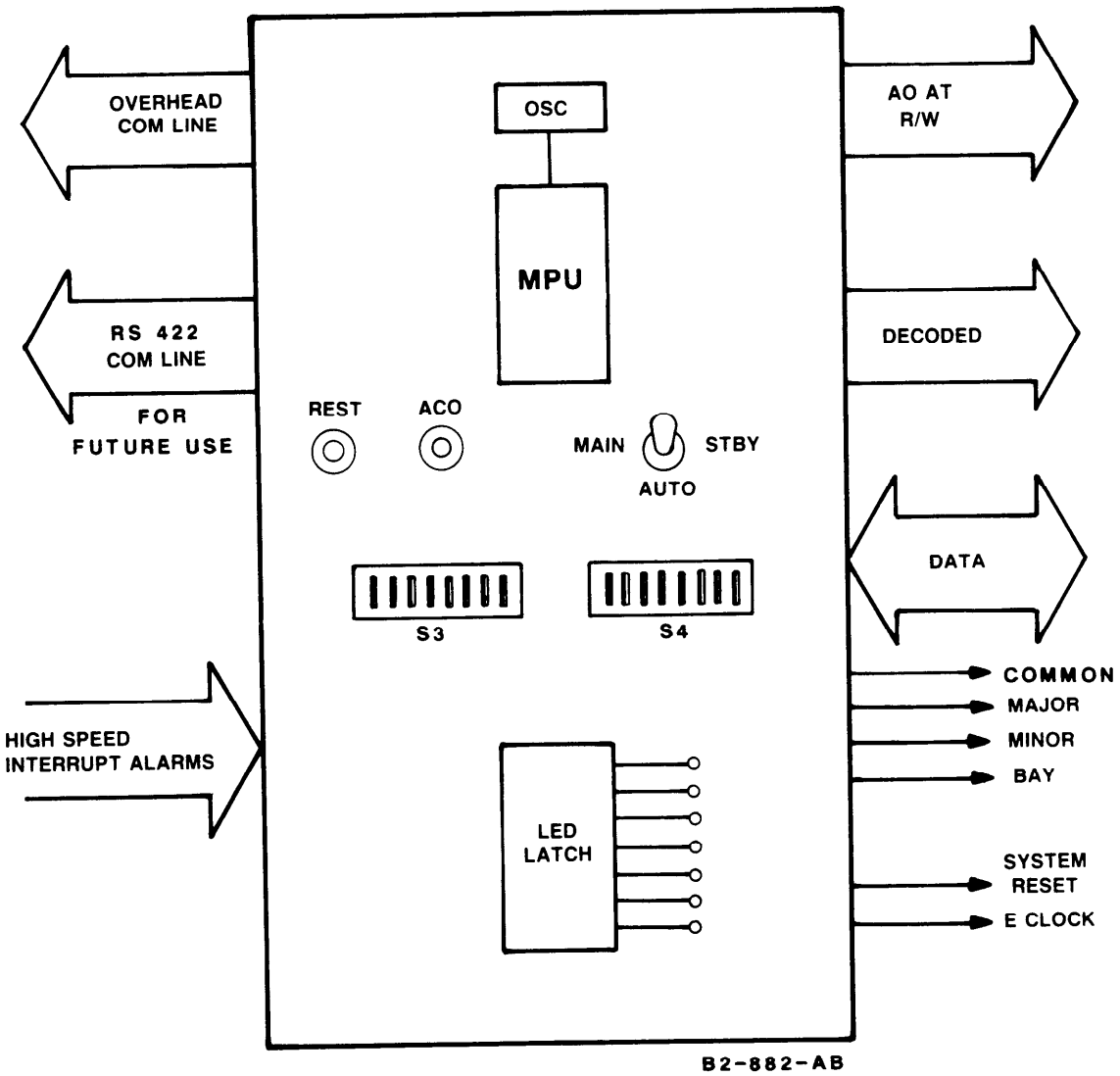


Figure 2B-2. Control MPU Interfaces

C. Options

2.08 The Control MPU contains two DIP switches which are used to configure FOX-2R unit operation and select TELTRAC station address, if equipped for TELTRAC interface.

2.09 The 8-pole DIP switch designated S3 (see Figure 2B-1) is used to select various unit-level configuration options. TABLE A shows the settings for this switch. The switch positions are described as follows:

S3 - Poles 1 and 2:

Determines BER switching threshold. Switching occurs only when the threshold is equaled or exceeded.

S3 - Pole 3:

Enables or disables the relays (ACO). When the relays are disabled, remote alarm reporting is no longer in effect.

S3 - Pole 4: Not used.

S3 - Pole 5:

Configures MPU operation for either FOX-to-FOX or FOX-to-828A system applications.

S3 - Poles 6, 7, 8:

Not used at present. Reserved for future applications.

2.10 The 8-pole DIP switch designated S4 (see Figure 2B-1) is used to configure the FOX-2R MPUs for TELTRAC communications.

S4 - Pole 8:

Enables or disables TELTRAC communications.

ON: TELTRAC disabled
OFF: TELTRAC enabled

S4 - Poles 1-7:

Select the TELTRAC station identification number (0-119). Each of the seven positions represents one bit in an 8-bit identification word as follows:

Pole	7	6	5	4	3	2	1
Addr	64	32	16	8	4	2	1

S4 - Poles 1-7: TELTRAC Address

ON designates a logic one (1) and OFF designates a logic zero (0). Therefore, to assign address 25, poles 1, 4, and 5 are set to the OFF position

TABLE A. Control MPU S3 DIP Switch Settings

MPU FUNCTIONS	S3 SWITCH POLES							
	8	7	6	5	4	3	2	1
Switching Threshold 10^{-9}:	N/U	N/U	N/U	X	N/U	X	OFF	OFF
Switching Threshold 10^{-8}:	N/U	N/U	N/U	X	N/U	X	OFF	ON
Switching Threshold 10^{-7}:	N/U	N/U	N/U	X	N/U	X	ON	OFF
Switching Threshold 10^{-6}:	N/U	N/U	N/U	X	N/U	X	ON	ON
FOX-to-FOX Application:	N/U	N/U	N/U	ON	N/U	X	X	X
FOX-to-828A/AF Application:	N/U	N/U	N/U	OFF	N/U	X	X	X
Enable Relays (ACO):	N/U	N/U	N/U	X	N/U	ON	X	X
Disable Relays (ACO):	N/U	N/U	N/U	X	N/U	OFF	X	X

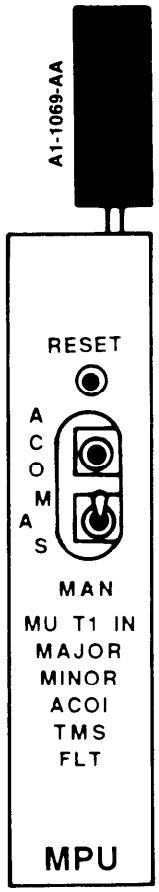
X indicates don't care.

N/U indicates not used at present (future applications).

D. Controls

2.11 The front panel switches of the Control MPU card are used to control manual switching to redundant circuit cards, alarm cutoff, and system reset. TABLE B illustrates the function of each front panel control switch.

TABLE B. Control MPU Switch Controls

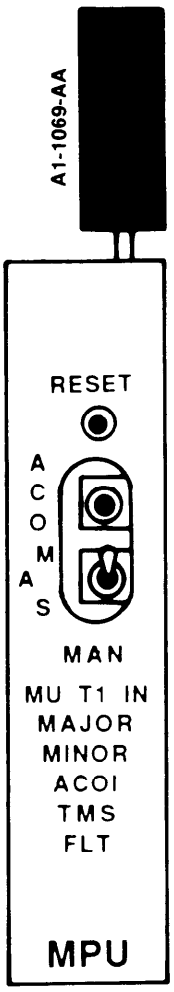
CONTROL	CONTROL DESCRIPTION	ILLUSTRATION
RESET	Caution: Use of the RESET button while in service may result in a minor on-line hit. Momentary-contact switch that forces the Control MPU card into initialization.	
ACO (Alarm Cutoff)	Momentary-contact switch that disables the current fault conditions from initiating local and remote audible alarms. However, new fault conditions are still recognized.	
M/A/S (Main/Auto/Stby)	In the M (Main) position, the Main LTUs and associated optical fibers at both ends of the DS-2 optical span are locked on line. In the S (Stby) position, the Stby LTUs and associated optical fibers at both ends of the DS-2 optical span are locked on line. In either the M (Main) or S (Stby) modes, automatic LTU protection switching is disabled until the switch is returned to the A (Auto) position.	

E. Alarms

2.12 Seven active LEDs are mounted on the front of the Control MPU which indicate system fault and status information.

2.13 TABLE C contains a listing of the functions of all Control MPU LEDs.

TABLE C. Control MPU Card Indicators

LED INDICATOR	DESCRIPTION OF MONITORED POINT	ILLUSTRATION
MAN (Manual) (red)	Illuminates when protection switching in the FOX-2R is under control of the MAIN/AUTO/STBY switch, TELTRAC, or the Manual Control Interface card (both Local and Remote switching).	
MU T1 IN (Multi T1 Input) (red)	Illuminates when more than one DS-1, or at least one DS-1C input has failed.	
MAJOR (red)	Illuminates when a traffic-affecting fault exists in the FOX-2R.	
MINOR (red)	Illuminates when a potentially traffic-affecting fault, or a mux-to-mux communications failure exists. Also illuminates when a manual switch condition is present and the MAN LED is illuminated.	
ACOI (Alarm Cutoff Indicator) (red)	Illuminates when the alarm cutoff function is enabled, disabling Audible Major and Minor contact closure.	
TMS (Too Many Switches) (red)	Illuminates when four or more automatic DS-2 switches have occurred within a 10-minute period, inhibiting further automatic protection switching. The TMS condition will automatically reset within one hour or can be manually reset by toggling the M/A/S switch.	
FAULT (red)	Illuminates when the Control MPU card has failed.	

3. OPERATIONAL THEORY

3.01 Consult Figure 2B-3 for a detailed block diagram of the operation of the Control MPU card.

Microprocessor (MPU)

3.02 The microprocessor utilized in the Control MPU card is the Motorola 6809 CMOS MPU using a system clock of 3.6864 MHz. Using the bidirectional data bus, the MPU can either read or write data to any circuit addressed by the unidirectional address bus, including the individual circuit card comprising the FOX-2R unit. In response to instructions read from ROM (Read-Only Memory), the MPU performs arithmetical and logical operations on data as directed.

Address Decoder/Data Buffer

3.03 A bidirectional data buffer controls the transfer of data to and from the microprocessor in response to the state of the read/write control line. An address decoder converts parallel binary addresses from the microprocessor into selected hardware enable lines to cue the operation of DUART, PIA, PTM, ROM, RAM, watchdog timer, and latches.

3.04 These buffered bus structures interface with all other unit circuit cards via backplane connection. A PIA (Programmable Interface Adapter) provides a latching interface for all related bus control signals.

Memory

3.05 Resident software programming permanently stored in 32K bytes of ROM contains the instructions required to direct MPU operation. Hardware options allow the use of higher density ROMs to increase total memory capacity as required for future applications.

3.06 In the course of program execution, 8K of RAM (Random Access Memory) is used to store and retrieve transitory data including the results of arithmetical/logical processing, BER computations, fault/status information, etc.

PTM (Programmable Timer Module)

3.07 A programmable timer module clocks the passage of time, allowing the microprocessor to perform time-base BER computations.

Serial Communications

3.08 Two data channels are generated by the DUART (Dual Universal Asynchronous Receiver/Transmitter) which converts eight-bit parallel data from the MPU into a serial data stream. One serial port provides interface for TELTRAC communications while the other serial channel is multiplexed into the embedded LTU overhead channel for transmission to the far-end FOX-2R.

Remote Hardware Alarm Notification

3.09 When a fault condition has been detected, the microprocessor addresses and writes data into a latch circuit. Individual latch circuits provide drives for fault/status LED illumination on the MPU and energize relays to provide contact closure to customer premises visual and audible alarm equipment. If the alarm cutoff (ACO) switch is set, the microprocessor reads the state of the switch and disables all relay drive latches, releasing the relays and silencing remote reporting functions.

Watchdog Timer

3.10 If program execution should halt, this 200 msec. timer, which is periodically set by software, resets and automatically initiates a hardware reset to reinitialize the MPU.

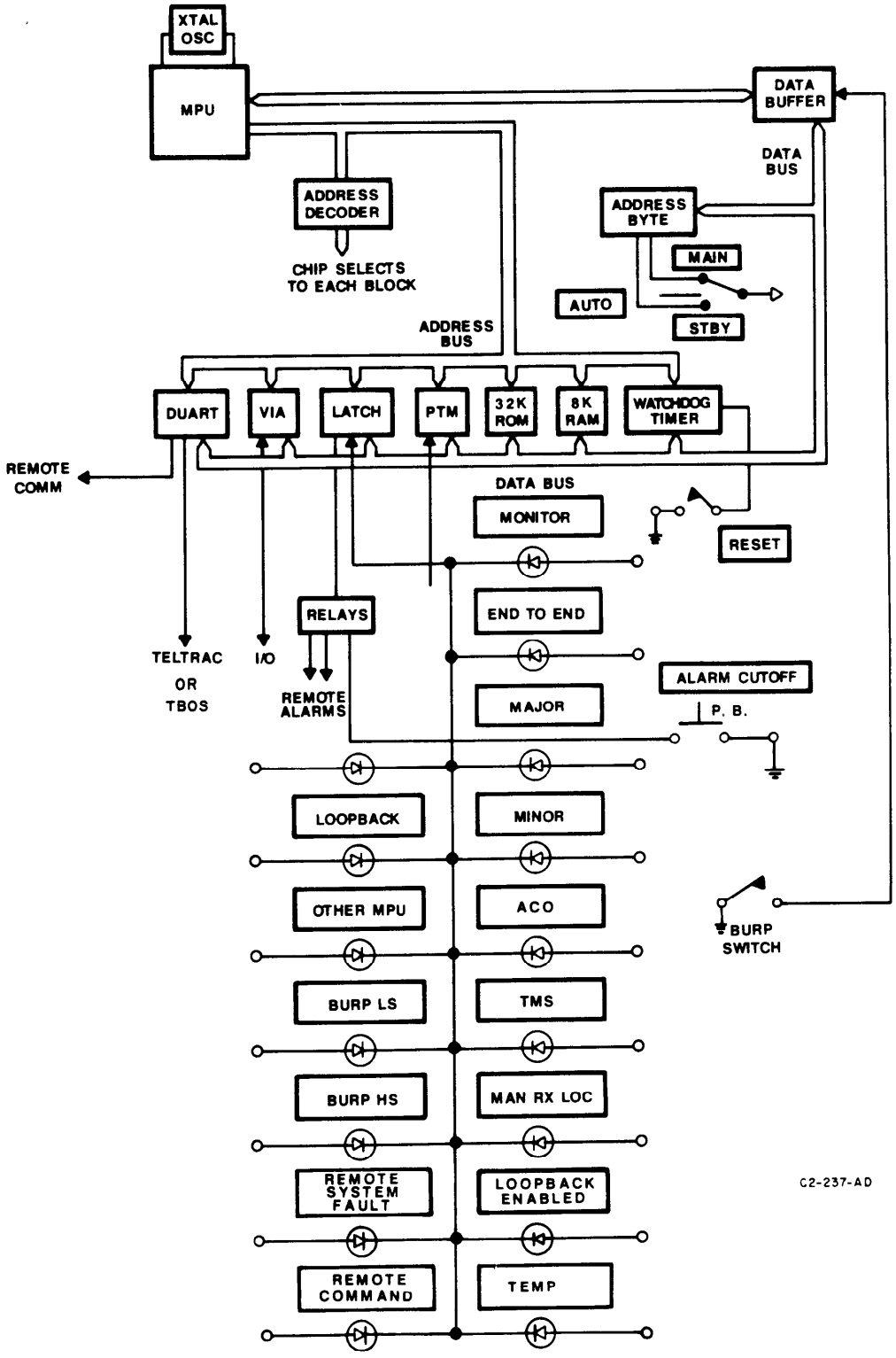


Figure 2B-3. Control MPU Block Diagram

FOX-2R DS-2 FIBER OPTIC EXTENSION UNIT
MAIN and STBY LINE TERMINATING UNITS (LTUs)
CCA148G1/CCA149G1

CONTENTS PAGE

1. SCOPE

1.01 This subsection presents a functional description of the Main and Standby Line Terminating Unit (LTU) used in the FOX-2R. Both Main and Standby LTUs are electrically identical, but are physical mirror images of one another to facilitate installation. Figure 2C-1 illustrates the Line Terminating Unit from the front and side perspectives.

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

2. FUNCTIONAL DESCRIPTION

A. General Description

2.01 The LTU provides an electrical-to-optical interface between the T1/T1C Low-Speed Interface circuit card and the optical transmission fiber. In the transmit direction, the LTU receives a 6.312 Mb/s DS-2 data channel from the T1/T1C Low-Speed Interface, and optically modulates the intensity of a single-mode LED to generate a 12.624 Mb/s optical transmission carrier using 3B6B optical data encoding. Receive circuitry within the LTU accepts an incoming optical carrier from the transmission fiber, converts it into an equivalent electrical signal, and extracts associated receive timing from the phase of recovered data transitions.

2.02 The LTU contains both transmit and receive optical transmission circuitry. Single-mode optical transmission is accomplished through the use of a intensity-modulated LED, operating at a center wavelength of 1250 to 1320 nm with an 80 nm spectral width. Within the receive circuitry, a PIN photodiode detector with a sensitivity of -45 dBm (at 10^{-8} BER) is used to convert incoming optical signals into equivalent electrical signals. Clock recovery circuits generate receive clock timing in phase with the timing of received data transitions.

2.03 A 1:1 protected system requires the use of two LTUs (Main and Standby) in each FOX-2R unit. These LTUs typically transmit and receive information via separate main and standby, transmit and receive optical fibers.

2.04 The LTU performs the following unit-level functions within the FOX-2R:

1. Accepts DS-2 data from the T1/T1C Low-Speed Interface at 6.312 Mb/s rate, and converts this information from unipolar electrical signals into a 12.624 Mb/s intensity-modulated single-mode optical transmission channel.

2. Converts an incoming intensity-modulated single-mode optical channel into unipolar electrical signals, and extracts receive clock timing derived from data transitions.

3. Generates a 12.624 Mb/s crystal-stabilized transmit system clock to be used as the master timing for all transmit circuit cards.

4. Provides internal local or remote DS-2 loopback on MPU command.

5. Reports all optical transmission status back to the MPU, to initiate fault LED illumination and automatic protection switching.

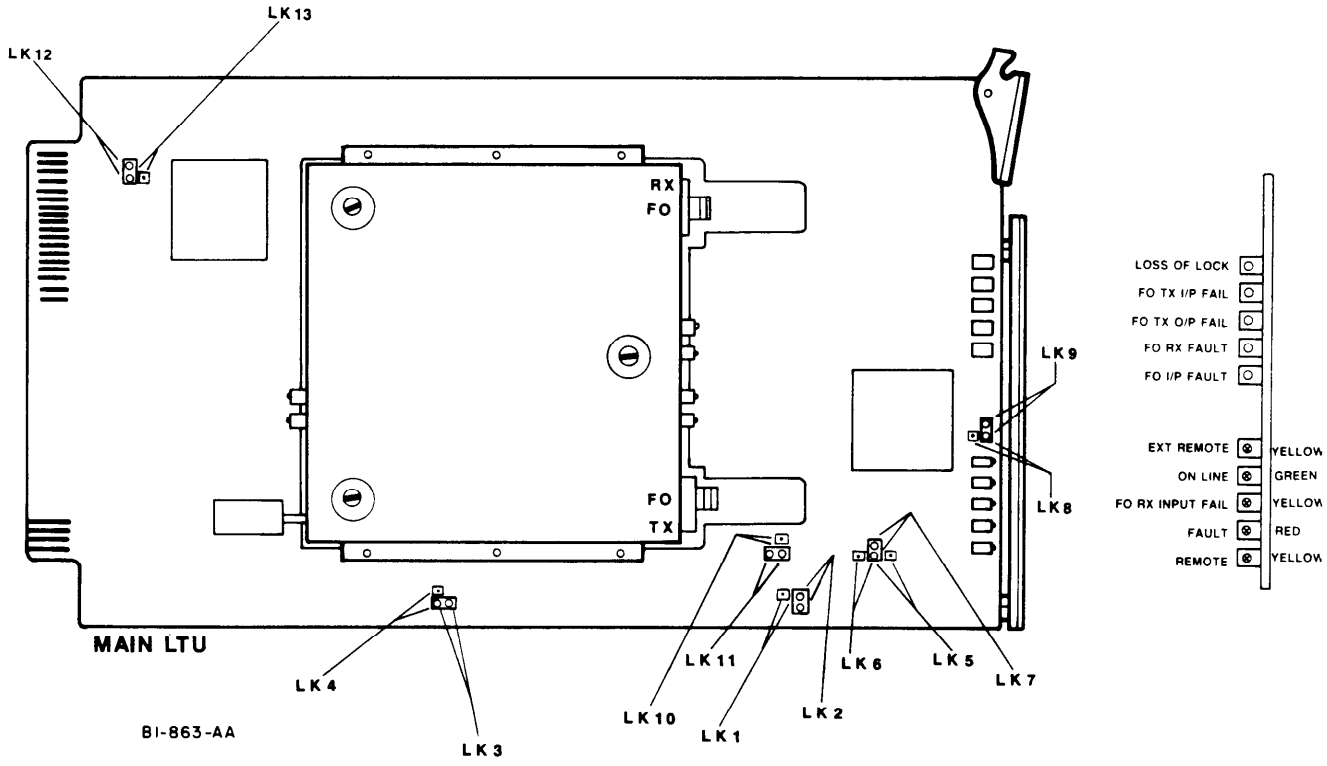


Figure 2C-1. Line Terminating Unit (Main LTU Illustrated)

B. Interfaces

2.05 The LTU processes 6.312 Mb/s DS-2 data and timing signals from the T1/T1C Low-Speed Interface circuit card. Unipolar electrical interface between the LTU and the T1/T1C Low-Speed Interface occurs via motherboard interconnection.

2.06 Optical interface is accomplished through the use of transmit and receive single-mode FC-type connectors mounted on the LTU circuit card. Optical patch cords or pigtails are used to interconnect the LTUs with fiber termination equipment, such as a splice tray or optical patch panel.

2.07 Microprocessor (MPU) interface is accomplished through the use of an 8-bit bidirectional data bus, unidirectional module select lines, and associated control lines. This bus network is used by the MPU to selectively address the LTU and send local or remote DS-2 loopback commands or receive fault and operational status.

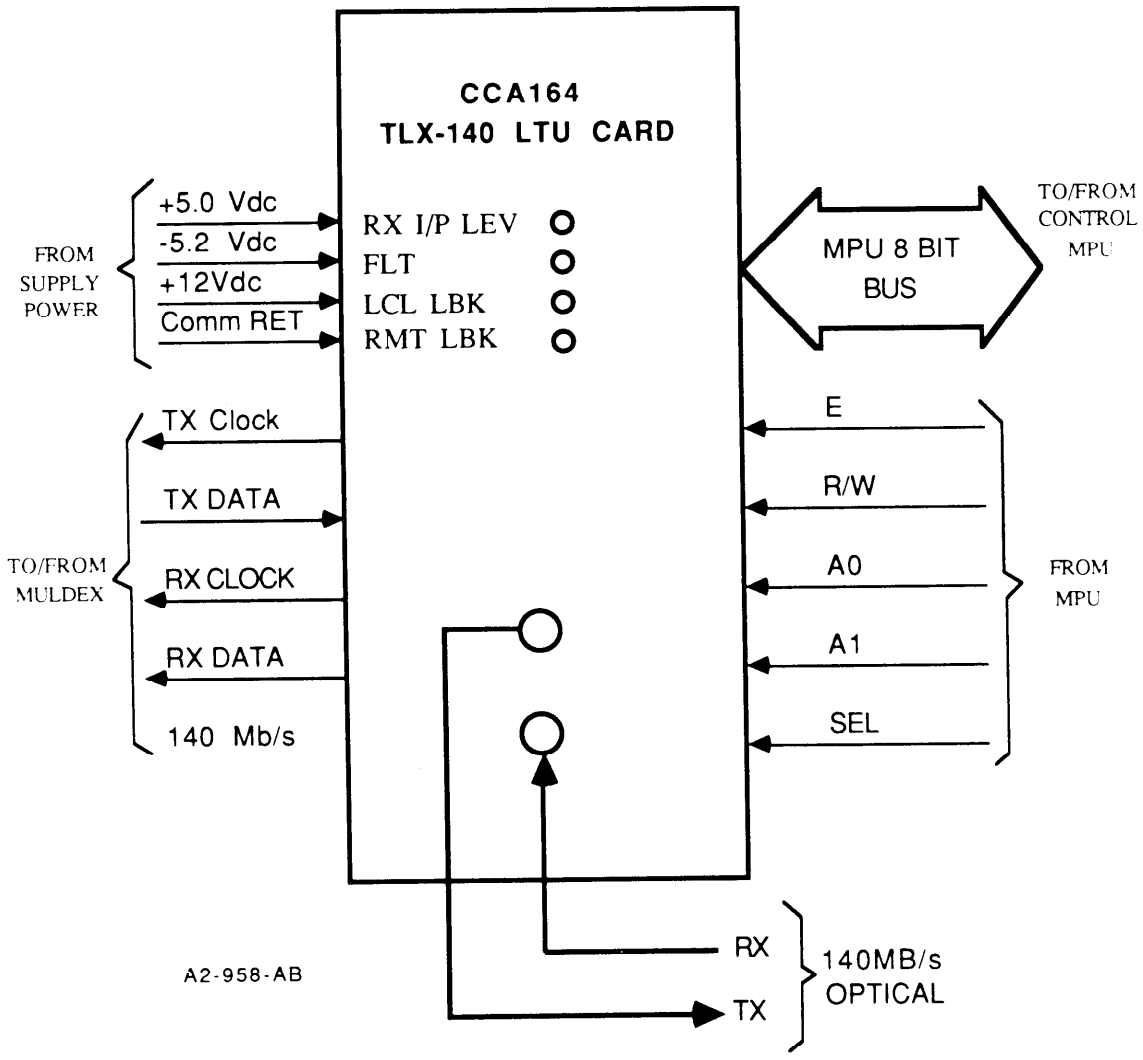


Figure 2C-2. Line Terminating Unit (LTU) Interfaces

C. Control and Options

2.08 There are no controls or option switches contained in the LTU circuit card. Loopback switches on the optional Loopback card allows the MPU to perform local or remote DS-2 electrical loopbacks within the LTUs.

2.09 A series of factory-set jumpers are installed to configure the circuit card for 828M/F, 828A/AF or FOX-2/2R system applications. The configuration of these jumpers is detailed in TABLE A.

TABLE A. MAIN and STBY LTU Card Option Jumpers

LINK GROUP	LINKS INSTALLED	LTU LOCATION/APPLICATION
LK1/LK2	LK1	Used in 828 only
	LK2	Used in 828A/828AF/FOX-2
LK3/LK4	LK3	Used in 828A/828AF/FOX-2
	LK4	Used in 828 only
LK5/LK6/LK7	LK5	Used in 828 only
	LK6	Used in 828A/828AF/FOX-2 with TELTRAC
	LK7	Used in 828A/828AF/FOX-2 without TELTRAC
LK8/LK9	LK8	Used in 828 only
	LK9	Used in 828A/828AF/FOX-2
LK10/LK11	LK10	Used in 828 only
	LK11	Used in 828A/828AF/FOX-2
LK12/LK13	LK12	Used in FOX-2 only
	LK13	Used in 828/828A/828AF

LTU CIRCUIT CARD CONFIGURATIONS:

1. LTU card utilized in FOX-2 or FOX-2R unit not equipped for TELTRAC:
   LK2, LK3, LK7, LK9, LK11, LK12 are installed only
   LK1, LK4, LK5, LK6, LK8, LK10, LK13 are removed

2. LTU card utilized in 828M/828F Multiplexer unit:
   LK1, LK4, LK5, LK8, LK10, LK13 are installed only
   LK2, LK3, LK6, LK7, LK9, LK11, LK12 are removed

3. LTU card utilized in 828A multiplexer unit equipped for TELTRAC:
   LK2, LK3, LK6, LK9, LK11, LK13 are installed
   LK1, LK4, LK5, LK7, LK8, LK10, LK12 are removed

4. LTU card utilized in 828A multiplexer unit <u>not</u> equipped for TELTRAC:
   LK2, LK3, LK7, LK9, LK11, LK13 are installed
   LK1, LK4, LK5, LK6, LK8, LK10, LK12 are removed

D. Alarms

2.10 Fault detection circuitry contained in LTU transmit and receive circuitry monitors the presence of data/timing activity, timing phase lock, and optical input/output levels.

2.11 All fault and status information is reported to the control MPU via the data bus. The Control MPU processes this information and illuminates fault LED(s) only on suspected circuit card(s) such as the LTU, while suppressing sympathetic alarm conditions on down-line circuits such as the T1/T1C Low-Speed Interface card.

2.12 Transmit and receive activity, and phase lock detectors monitor the data and timing activity of the DS-2 data channel. In the absence of transmit or receive, data activity or timing phase lock, the Control MPU will illuminate the FLT LED on the front of the LTU circuit card.

2.13 Transmit and receive input, output, and loss of lock fault test jacks can be used to test alarm reporting and automatic switchover functions within the FOX-2R unit under test.

2.14 Current detectors in transmit circuitry monitor LED bias and modulation currents and indicate an LTU fault condition to the MPU in the absence of modulation current.

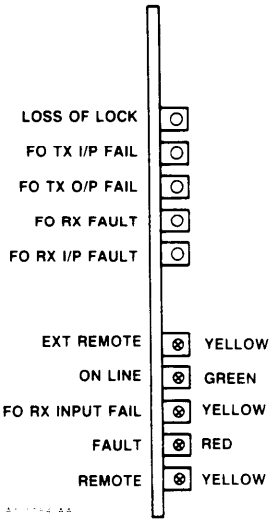
2.15 A receive signal level detector signals the MPU in the event of a loss of incoming optical level. The MPU will respond by illuminating the input LED on the front of the LTU. The FO I/P test jack can be used to test fault detection and switchover circuit operation, resulting from an optical input failure.

2.14 TABLE B lists all MAIN and STBY LTU test points while TABLE C details LTU fault and status LEDs.

TABLE B. LTU (Main and Standby) Test Jacks

TEST POINT	TEST POINT DESCRIPTION	ILLUSTRATION
TP1 LOSS OF LOCK	Simulates a loss of receive timing phase lock.	[A1-1084-AA top half only]
TP2 FO TX I/P FAIL	Simulates a fiber optic transmitter input failure.	
TP3 FO TX O/P FAIL	Simulates a fiber optic transmitter output failure.	
TP4 FO RX FAULT	Simulates a fiber optic receiver failure.	
TP5 FO I/P FAULT	Simulates a fiber optic input failure.	

TABLE C. LTU (Main and Standby) Card Fault/Status Indicators

LED INDICATOR	DESCRIPTION OF MONITORED POINT	ILLUSTRATION
EXT. REMOTE (yellow)	When utilized in an 828A or 828AF equipment cage, this LED indicates a FOX-2/R failure at the opposite end of the DS-2 optical extension. When utilized in FOX-2 or FOX-2R units, this LED is not used.	
ON LINE (green)	Illumination indicates that LTU transmit and receive circuitry and its associated fiber path are currently on-line carrying traffic.	
INPUT (yellow)	Illumination indicates an LTU receive optical input failure. The illumination of this LED can be due to either a defective far-end LTU transmitter, severed optical fiber, or a near-end LTU photodetector failure.	
FAULT (red)	Illumination indicates a failure of the LTU transmit or receive circuitry.	
REMOTE (yellow)	When utilized in an 828A or 828AF equipment cage, the illumination of this LED indicates a failure in the far-end LS Interface card. When utilized in FOX-2 or FOX-2R units, this LED is not used.	

3. OPERATIONAL THEORY

3.01 Consult Figure 2C-3 for a detailed block diagram of the operation of the Main or Standby LTU circuit card.

A. Transmit Circuitry:

Input Switch

3.02 Input gates route the DS-2 data and timing outputs of either the Main or Standby muldems circuits of the Low-Speed Interface card into the LTU transmit circuitry.

System Clock

3.03 A phase locked loop (PLL) stable clock source is used to derive the master transmit timing for all transmit circuitry.

Elastic Store

3.04 Input elastic store circuitry provides input data buffering and synchronization in phase with PLL transmit timing.

Loopback Switch

3.05 When a local or remote DS-2 loopback command is entered via the Loopback card, the Control MPU controls the state of the loopback switch circuits. During normal operation, data selector gates route the data from the elastic store register to the LED modulator circuit. In the local loopback mode, transmit data and timing from the transmit elastic store is looped back to the receive elastic store, to provide equipment loopback in the direction of the T1/T1C Low-Speed Interface card. For remote span loopback in response to far-end MPU command, receive data and timing outputs from the 3B6B decoder circuit are looped back through selector gates to the 3B6B coder circuitry to provide span loopback. Since both local and remote loopbacks utilize the same selector gates for data/timing routing, only one loopback mode can be evoked at a time.

3B6B Coder and Overhead Interface

3.06 A 3B6B scrambler encodes the 6.312 Mb/s DS-2 data channel into a 12.624 Mb/s data channel. This encoding process ensures the presence of repetitive data transitions regardless of data channel content, to facilitate receive clock recovery. Since DS-2 data is encoded in groups of three bits into five 3B6B bits, a sixth bit is available within the line coding for end-to-end overhead channel communications, via the overhead interface circuit. This overhead channel is utilized to provide remote fault status transmission and serial TELTRAC communications, via the DS-2 optical span.

3.07 In the presence of a loss of incoming DS-2 data or timing activity, an AIS (Alarm Indication Signal) is transmitted to the far-end to suppress the generation of input optical fault indications.

LED Modulator

3.08 Pulsed into full conduction by the occurrence of data logic ones, this current regulator is used to intensity modulate the output of the single-mode LED device.

Modulation Fail Detector

3.09 This circuit monitors LED bias, and indicates a failure of the LED device or associated current regulators used for modulation control.

B. Receive Circuitry

PIN Detector

3.10 Incoming optical transmission is applied to a PIN photodiode detector, which converts optical power into current flow proportional to incident light power intensity.

Timing Extractor

3.11 Clock recovery circuitry utilizes logic level transitions in the received data stream to regenerate receive timing in phase with the far-end master transmit clock.

3B6B Decoder and Overhead Interface

3.12 Once receive clock has been recovered from the data stream, 3B6B optical line coding used to ensure span data activity is no longer required. Consequently, a decode circuit restores the original 6.312 Mb/s DS-2 data channel.

3.13 The overhead information channel, embedded as the sixth bit of the 3B6B encoding process, is extracted and transferred to the Control MPU for processing. This channel is used to transmit remote fault status information, and TELTRAC serial communications to an 828M/F or 828A/AF multiplexer used in DS-2 optical extension applications.

Loopback Switch

3.14 The receive loopback switch operates in conjunction with the transmit loopback switch previously described, to perform DS-2 local or remote loopbacks. See discussion in paragraph 3.05 for further details.

Elastic Store

3.15 The output elastic store provides output data buffering for data strobed out of the LTU to the T1/T1C Low-Speed Interface card.

Switch

3.16 Output gates route the DS-2 data and timing streams from the LTU to the main or standby M12 muldem circuits of the T1/T1C Low-Speed Interface card. As with the transmit switch circuit, the state of the receive switch is controlled by the Control MPU in response to manual or automatic switch request.

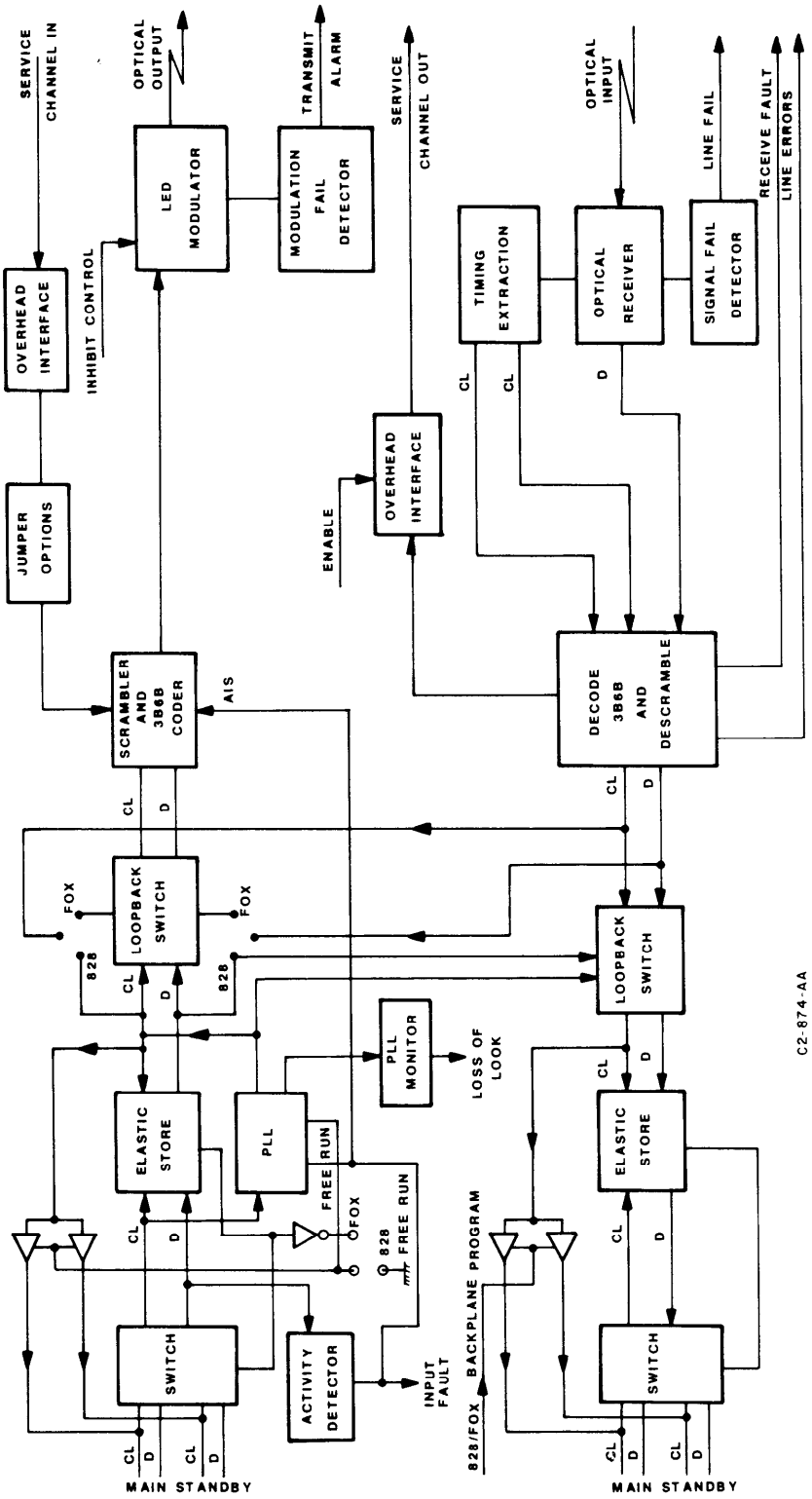


Figure 2C-3. LTU Card CCA148G1/CCA149G1 Block Diagram

FOX-2R DS-2 FIBER OPTIC EXTENSION UNIT
T1 or T1C LOW-SPEED INTERFACE CARD
CCA050G1
CCA124G1
CCA161G2
CCA006G1

CONTENTS PAGE

1. SCOPE

1.01 This subsection presents a functional description of the T1 and T1C Low-Speed Interface (LS INTER T1 or T1C) card used in the FOX-2R. See Figure 2D-1, for views of the LTU cards. Tables are provided in this subsection that describe the LEDs and test jacks located on the circuit cards.

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

2. FUNCTIONAL DESCRIPTION

A. General

2.01 The T1 Low-Speed Interface card accepts up to four DS-1 (1.544 Mb/s) signals in bipolar line coding format and multiplexes these channels into a single unipolar DS-2 (6.312 Mb/s) data channel. The T1C Low-Speed Interface card accepts up to two T1C (3.152 Mb/s) data channels in bipolar format and likewise converts these into a unipolar DS-2 data channel. Optical transmission of this DS-2 data channel is accomplished by the LTU card(s).

2.02 Industry-standard electrical interface for T1 or T1C data channels is AMI (Alternate Mark Inversion) line coding. All T1 and T1C Low-Speed Interface cards are equipped for AMI line coding and decoding. However, the CCA161G2 T1 Low-Speed Interface card is equipped with channel selectable AMI or B8ZS line coding. B8ZS (Bipolar with Eight Zero Substitution) has been adopted in an attempt to provide a uniquely identifiable data pattern, which can be substituted for eight or more consecutive zeros, to maintain line activity to facilitate clock recovery. B8ZS line coding is typically employed in T1 applications involving data or integrated voice/data transmission via T1 carrier.

2.03 Each Low-Speed Interface card contains transmit and receive, main and standby circuitry. In the event of M12 muldem failure, the Control MPU will initiate a switch to internal redundant transmit and/or receive muldem circuit, to preserve DS-2 transmission integrity. An optional Maintenance Interface card can be inserted into a special bridge slot position to allow traffic to be transferred to a spare Low-Speed Interface card. Special test circuits allow the replacement card to be thoroughly tested off line, via DS-2 loopback or bridged to receive traffic, prior to in-service operation.

2.04 If a previously active T1 or T1C channel becomes inactive (as indicated by 175 consecutive zeros ± 75 zeros) due typically to equipment failures external to the FOX-2R, a selectable unframed all ones or all zeros* AIS (Alarm Insertion Signal) is routed from the Low-Speed Interface card to down-line equipment. This blue signal suppresses down-line activity detectors and maintains line activity necessary for network timing synchronization.

* AIS select option contained only on CCA161G2 T1 LS Interface card

2.05 The transmit circuitry of the T1 or T1C Low-Speed Interface card performs the following unit-level functions within the FOX-2R:

a. Converts incoming T1 or T1C bipolar line coded channels into unipolar data channels.

b. Extracts transmit clock timing from incoming data transitions.

c. Synchronizes T1 channels to a common master clock rate, using bit stuffing techniques.

d. Multiplexes four T1 (1.544 Mb/s) data channels and an associated overhead channel, to facilitate far-end demultiplexing into a single DS-2 (6.312 Mb/s) composite data channel.

e. Switching circuitry routes the output of either main or standby M12 muldems on line to the on-line LTU card. Conversely, this switching circuit also routes the off-line muldem output to the off-line LTU card.

2.06 The receive circuitry of the T1 or T1C Low-Speed Interface card performs the following unit-level functions within the FOX-2R:

a. Switching circuits route the output of the on-line LTU to the on-line main or standby muldem circuit, while routing the off-line LTU data to the off-line muldem circuits.

b. Receive muldem circuits locate embedded framing information and synchronize internal counters to demultiplex the composite DS-2 data channel into its four T1 component channels.

c. Once identified by overhead channel information, the stuffing bits are removed and the resulting data stream is retimed to minimize phase jitter.

d. The unipolar data and timing channels are converted into AMI or B8ZS line coding suitable for metallic T-carrier transmission.

B. Interfaces

2.07 Consult Figure 2D-2 for a pictorial representation of circuit card interfaces. The Low-Speed Interface card processes bipolar T1 (1.544 Mb/s) or T1C (3.152 Mb/s) incoming data channels derived from jacks J2, J3, J4, and J5 (Unit-I) or J10, J11, J12, and J13 (Unit-II) of the interface panel. Incoming asynchronous T1/T1C rates are bit stuffed up to a slightly faster master clock rate, as a requirement of time-division multiplexing.

2.08 The DS-2 data and timing streams to/from the Low-Speed card interface with the MAIN and STBY LTU cards for optical transmission. DS-2 master clock timing is derived from the on-line LTU card and is subdivided to provide DS-2 and DS-1 input clock rates.

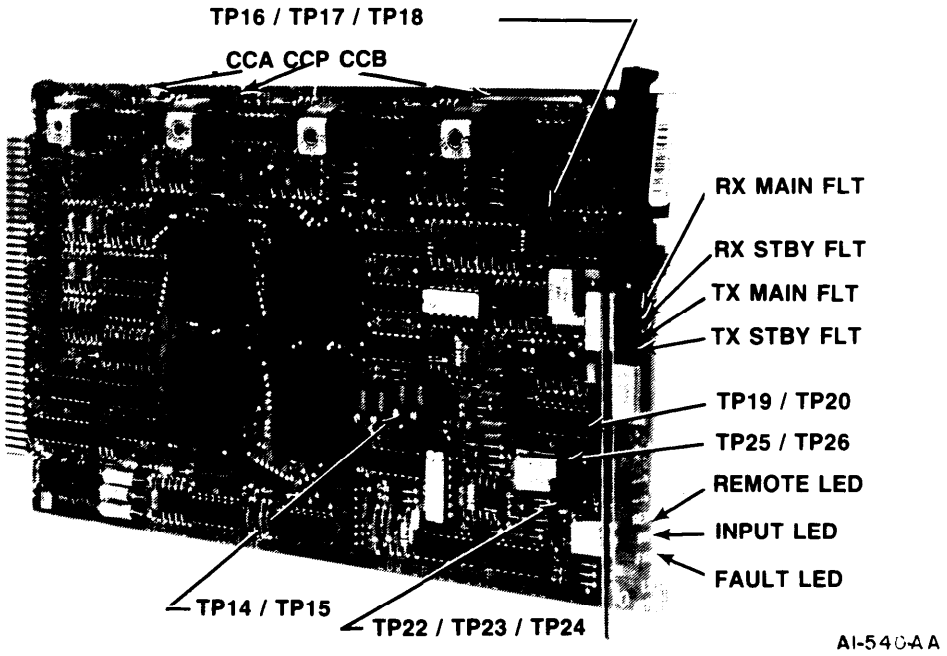


Figure 2D-1. T1 Low-Speed Interface Card (CCA050G1)

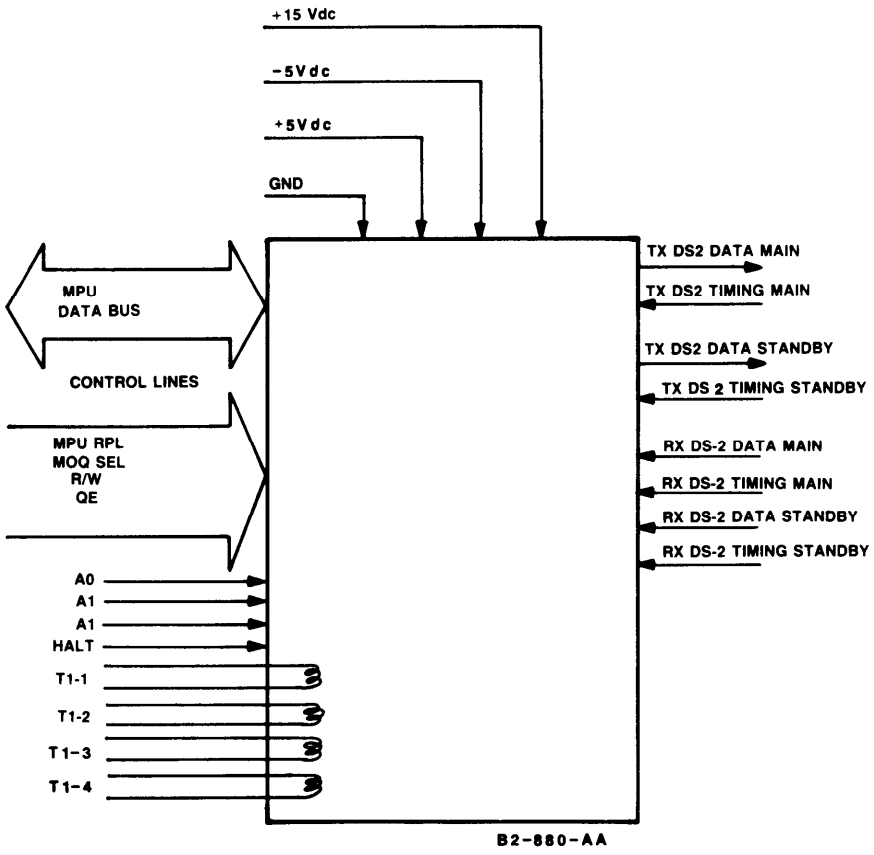


Figure 2D-2. T1/T1C Low-Speed Interface Card Interfaces

2.09 Microprocessor (MPU) interface is accomplished via an 8-bit bidirectional data bus, unidirectional module select lines, and associated control lines. This bus network is used by the MPU to selectively address the Low-Speed Interface card to send switch commands or receive fault and switching status.

C. Control and Options

2.10 Only the CCA161G2 T1 Low-Speed Interface card contains a field-selectable option. A four pole DIP switch mounted on the front of the card selects either AMI or B8ZS line coding and decoding for each T1 channel individually. Consult TABLE A for details on the configuration of this line coding option.

2.11 There are no controls or option switches contained in the CCA050G1 or CCA124G1 T1 Low-Speed Interface card nor the CCA006G1 T1C Low-Speed interface card. However, a series of front-mounted test jacks are provided on all Low-Speed Interface cards to simulate circuit card failures, to test fault reporting and automatic switchover functions.

TABLE A. T1 Low-Speed Interface Card Controls

CONTROL	CONTROL DESCRIPTION	ILLUSTRATION
S1 CH. 1-4 AMI/B8ZS (CCA161G2 version only)	Selects either Alternate Mark Inversion (AMI) or Bipolar with Eight-Zero-Substitution (B8ZS) individually for each low speed channel equipped.	[Middle of A1-1083-AA]

D. Alarms

2.12 Fault detection circuitry contained in the Low-Speed Interface card transmit and receive circuitry monitors the presence of data/timing activity, timing phase locked, and T1/T1C input/output levels.

2.13 All fault and status information is reported via the data bus to the Control MPU. This information is processed and illuminates a fault LED(s) only on a suspected circuit card(s), such as the Low-Speed Interface card. Sympathetic alarm conditions are suppressed on down-line circuits.

2.14 Transmit and receive activity, and phase locked detectors monitor the data and timing activity of the DS-1 and DS-2 data channels. In the absence of incoming transmit data, the Control MPU illuminates an INPUT status fault indicator. Transmit and receive frame detection circuits monitor the outgoing and incoming DS-2 data channel for the presence of the required DS-2 masterframe format necessary for far-end demultiplexing. Phase locked loop detectors within the T1/T1C input and output circuitry examine timing phase lock between external line timing and an internally generated master clock timing.

2.15 TABLE B lists the identity and function of the fault LED and status indicators mounted on the front of the Low-Speed Interface card.

2.16 TABLE C lists the identity and function of the four front-mounted test jacks on the card.

TABLE B. T1/T1C Low-Speed Interface Card Indicators

LED INDICATOR	DESCRIPTION OF MONITORED POINT	ILLUSTRATION
REMOTE (yellow)	Illuminates when the corresponding Low-Speed Interface card at the far end has a fault. In FOX-2R units, this LED indicator illuminates to indicate <u>any</u> far-end circuit card problem.	
INPUT (yellow)	Illuminates when a loss of DS-1 input occurs on a previously functional DS-1 channel associated with the card.	[Top half of A1-831-AA and bottom cutaway]
FAULT (red)	Illuminates when the T1 Low-Speed Interface card has a failure.	

TABLE C. T1/T1C Low-Speed Interface Card Test Points

TEST POINT	TEST POINT DESCRIPTION	ILLUSTRATION
TP1/TP2	Simulates a failure of the receive Main Muldem circuitry.	[A1-831-AA]
TP3/TP4	Simulates a failure of the receive Standby Muldem circuitry.	
TP5/TP6	Simulates a failure of the transmit Main Muldem circuitry.	
TP7/TP8	Simulates a failure of the transmit Standby Muldem circuitry.	

3. OPERATIONAL THEORY

A. Transmit Circuitry

3.01 Consult Figure 2D-3 for a detailed block diagram of the operation of the T1 Low-Speed Interface card. Since the functional operation of the T1 and T1C Low-Speed Interface cards is very similar, theory discussion will highlight T1 circuitry primarily. However, where unique differences arise between T1 and T1C Low-Speed Interface card operation, reference will be made to Figure 2D-4 for T1C operation.

Bipolar/Unipolar Converter

3.02 Incoming bipolarly coded T1 or T1C data is converted into unipolar data channels compatible with logic circuitry operation. Data edge transitional changes are utilized to recover transmit timing. In AMI coding, 12.5% average ones data activity must be ensured by T1 terminal equipment per industry DSX-1 specifications.

3.03 Using B8ZS T1 line coding (CCA161G2), consecutive strings of eight or more zeros are replaced with a 000VB0VB pattern. This industry-standard pattern deliberately introduces forced bipolar violations (V) to uniquely identify this consecutive zeros pattern, while preserving required T1 pulse activity to facilitate clock recovery functions.

T1C to T1 Muldem (T1C LS Interface Card Only)

3.04 Since digital hierarchy is developed from the T1 level to progressively higher levels, each incoming T1C (3.152 Mb/s) data channel must be demultiplexed into two T1 channels before these channels can be multiplexed to the T2 level. To accomplish demultiplexing, the T1C muldem locates and synchronizes on embedded T1C framing overhead generated by T1C terminal equipment. See Figure 2D-5 for DS-1C masterframe structure.

Dual Channel Switching and Elastic Store (SWEL) Circuit

3.05 Time division multiplexing requires exact channel synchronization. To accomplish the synchronization of asynchronous T1 channels, each channel is applied to an elastic store under phase locked loop control. Each elastic store is used to proportionally bit stuff each channel individually to raise the incoming timing rate to a slightly faster master clock, derived from the LTU circuit card.

Main/Stby Muldem

3.06 M12 muldem circuitry bit interleaves the four T1 channels into a single 6.176 Mb/s data channel. To control far-end demultiplexing, an embedded overhead channel is introduced one bit at a time every 49th bit to raise the DS-2 data rate to 6.312 Mb/s. This embedded overhead channel contains two repetitive framing patterns (F and M framing) to identify frame and bit location within each received DS-2 masterframe. Other overhead bits are used to identify the time occurrence of inserted stuffing bits used for transmit T1 line synchronization. Once located, these stuffing bits can be deleted by far-end receive circuitry to return the T1 data channels to their original data composition. See Figure 2D-6 for pictorial representation of DS-2 masterframe structure.

3.07 Switching circuitry embedded in the output circuits of the main and standby muldems route main or standby DS-2 data and timing streams to/from the on-line and off-line LTU circuit cards. The state of this

switch network is controlled by the Control MPU in response to manual or automatic switch requests. T1 timing routing from the on-line muldem circuits is performed within the switching section of the dual channel SWELs for each T1 channel individually.

B. Receive Circuitry

Main/Stby Muldem

3.08 An input switching network in the receive circuits of each muldem, route the data from the on-line and off-line LTU circuit cards to the main and standby muldems. The state of these switch networks is controlled by the Control MPU, in response to manual or automatic switch requests.

3.09 Receive frame circuits within the muldems, locate and synchronize on the F and M frame patterns within the embedded DS-2 overhead channel (see Figure 2D-6) prior to DS-2 to DS-1 channel demultiplexing. Stuffing bit indicators within the overhead channel identify the time occurrence of stuffing bits inserted by the far-end transmit circuits for channel synchronization. Once identified, the muldem controls the operation of the receive SWEL circuits to delete these stuffing bits from each T1 channel.

Dual Channel Switching and Elastic Store (SWEL):

3.10 Phase jitter timing discontinuities caused by stuffing bit insertion and deletion are corrected by phase locked loop retiming and elastic store circuits within the receive SWEL circuitry.

3.11 Switching circuits within the receive SWEL route master T1 timing, subdivided from on-line LTU master clock timing, to the unipolar to bipolar converters.

T1C to T1 Muldem (T1C Low-Speed Interface card only)

3.12 See Figure 2D-4 for T1C operation. A T1C muldem, within T1C Low-Speed Interface cards multiplexes the four DS-1 data channels demultiplexed from the DS-2 channel into two T1C (3.152 Mb/s) data channels. The muldem formats the data into standard DS-1C masterframe format including an embedded DS-1C overhead channel (see Figure 2D-5).

Bipolar/Unipolar Converter

3.13 Unipolar data and timing streams are coded into AMI or B8ZS bipolar line format, suitable for industry-standard transmission of these channels via metallic carrier facility.

Note: Only the CCA161G2 T1 Low-Speed Interface card is equipped for selectable AMI/B8ZS per channel line coding option.

MPU Interface

3.14 When addressed by the Control MPU using the module select lines, switch or LED command data can be written into or status data read out from the Low-Speed Interface card, depending upon the state of the MPU read/write line. During MPU replacement, the MPU RPL line goes low and disables bus access by the MPU interface circuit until the MPU replacement is complete.

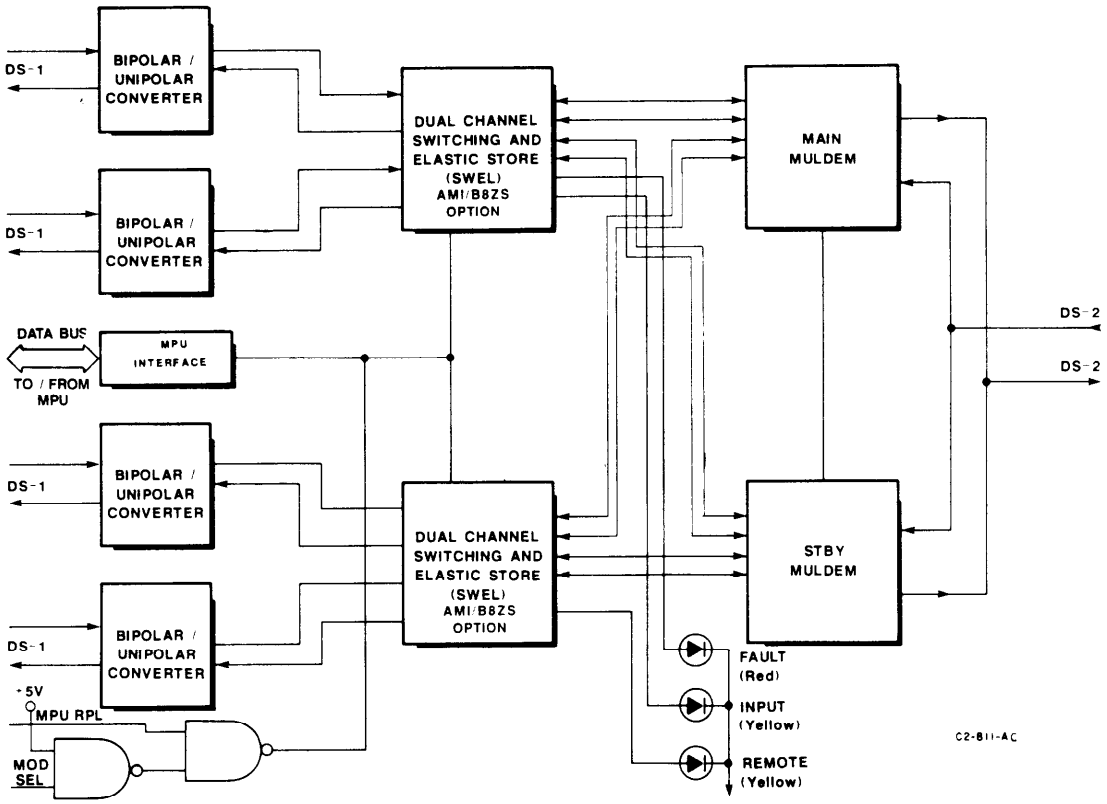


Figure 2D-3. T1 Low-Speed Interface Card Block Diagram

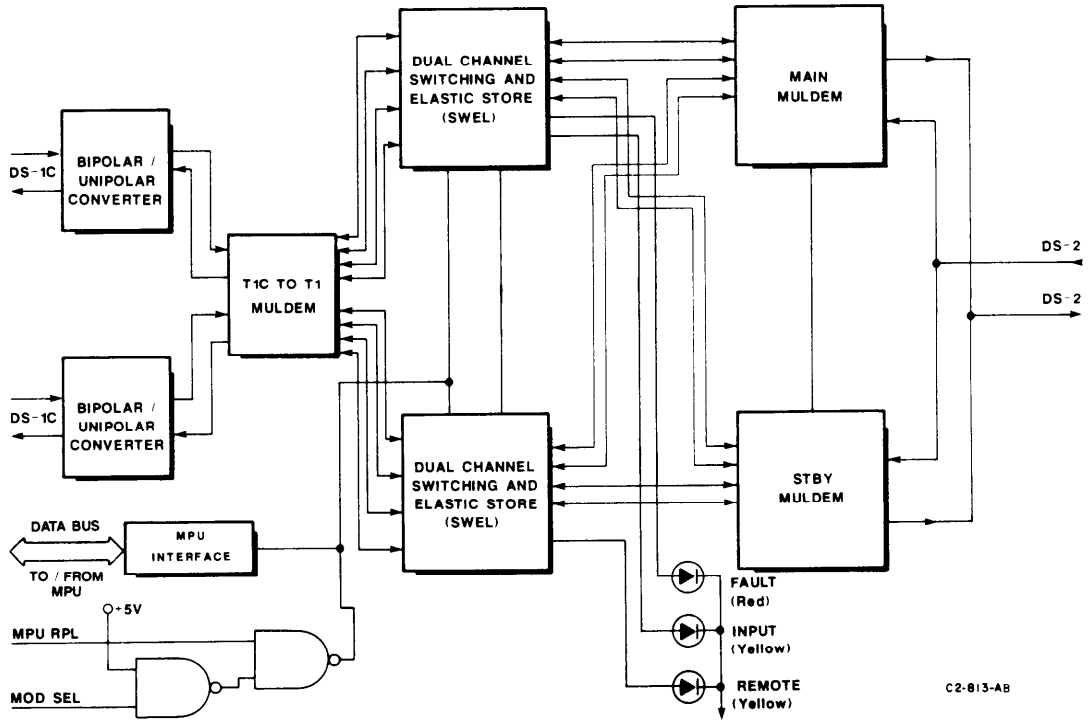
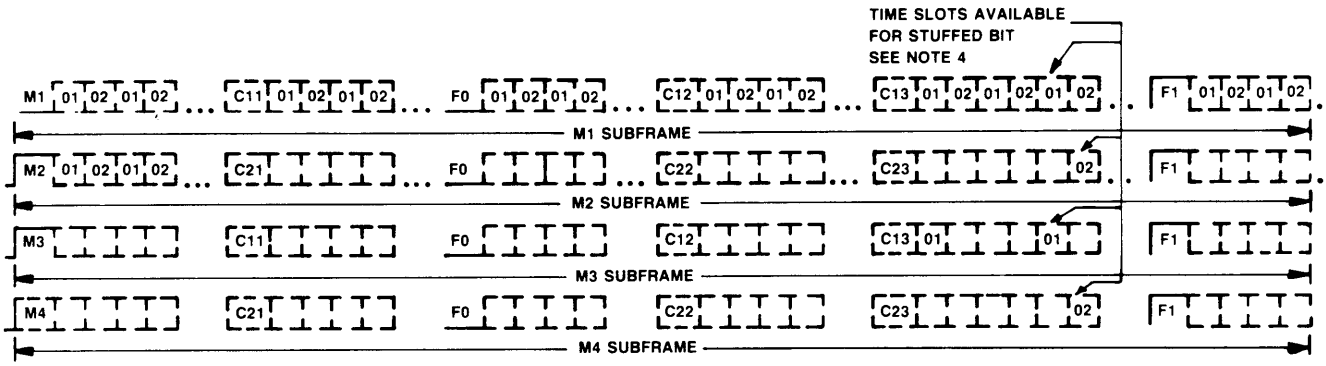


Figure 2D-4. T1C Low-Speed Interface Card Block Diagram



CONTROL BIT SEQUENCE - EACH CONTROL BIT OCCUPIES A CONTROL BIT TIME SLOT

...C23,F1,M1,C11,F0,C12,C13,F1,M2,C21,F0,C22,C23,F1,M3,C11,F0,C12,C13,F1,M4,C21,F0,C22,C23,F1,M1,C11,F0...

M FRAME

NOTES:

(1) THE FRAME ALIGNMENT SIGNAL IS F0 = 0 AND F1 = 1.

(2) M1 M2 M3 M4 ... IS THE MULTIFRAME ALIGNMENT SIGNAL AND IS 011X ... WHERE X IS AN ALARM SERVICE DIGIT. THE NORMAL (NO ALARM) STATE IS X = 1.

(3) C11 C12 C13 = STUFFING INDICATOR WORD FOR INPUT.
000 INDICATES NO STUFFING AND III INDICATES STUFFING WAS DONE.

(4) THE TIME SLOT AVAILABLE FOR STUFFING INPUT 1 IS THE THIRD SLOT FOR INPUT 1, 01, FOLLOWING C13.

(5) THE MAXIMUM STUFFING RATE PER DS1 INPUT IS 4956 BITS/SEC.

(6) THE NOMINAL STUFFING RATE PER DS1 INPUT IS 2264 BITS/SEC.

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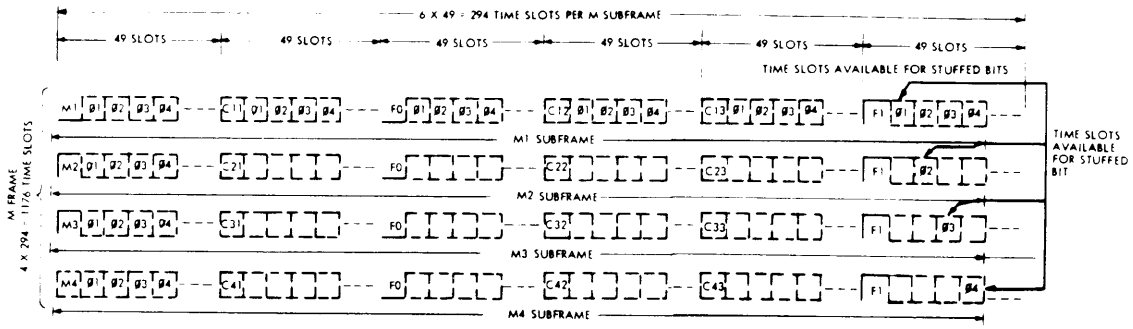
Figure 2D-5. T1C (3.152 Mb/s) Masterframe Structure



CONTROL BIT SEQUENCE - EACH CONTROL BIT OCCUPIES A CONTROL BIT TIME SLOT

...C43,F1,M1,C11,F0,C12,C13,F1,M2,C21,F0,C22,C23,F1,M3,C31,F0,C32,C33,F1,M4,C41,F0,C42,C43,F1,M1,C11,F0...

M FRAME

NOTES:

(1) THE FRAME ALIGNMENT SIGNAL IS $F_0 = 0$ AND $F_1 = 1$.

(2) M1 M2 M3 M4...IS THE MULTIFRAME SIGNAL AND IS 011X...WHERE X MAY BE USED FOR AN ALARM SERVICE DIGIT

(3) C11 C12 C13 = STUFFING INDICATOR WORD FOR DS1 INPUT 1. 000 INDICATES NO STUFFING AND 111 INDICATES STUFFING WAS DONE.

(4) THE TIME SLOT AVAILABLE FOR STUFFING DS1 INPUT 1 IS THE FIRST SLOT FOR INPUT 1 (Ø1) FOLLOWING F1 IN THE M1 SUBFRAME.

(5) THE MAXIMUM STUFFING RATE PER DS1 INPUT IS 5367 BITS/SEC.

(6) THE NOMINAL STUFFING RATE PER DS1 INPUT IS 1796 BITS/SEC.

(7) FIRST SLOT BEFORE EACH Ø1 TIME SLOT IS A CONTROL BIT TIME SLOT.

(8) Ø1 DESIGNATES A TIME SLOT DEVOTED TO DS1 INPUT 1. THE INFORMATION FROM INPUTS 1 AND 3 AND THE STUFFED BITS USED TO SYNCHRONIZE THESE INPUTS ARE CONTAINED IN Ø1 AND Ø3 RESPECTIVELY. THE LOGICAL INVERSE, OR COMPLEMENT, OF THE INFORMATION FROM INPUTS 2 AND 4 AND THE STUFFED BITS USED TO SYNCHRONIZE THESE INPUTS ARE CONTAINED IN Ø2 AND Ø4 RESPECTIVELY

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Figure 2D-6. DS-2 (6.312 Mb/s) Masterframe Structure

FOX-2R DS-2 FIBER OPTIC EXTENSION UNIT
LOOPBACK CARD
CCA181G1

CONTENTS PAGE

1. SCOPE

1.01 This subsection presents a functional description of the Loopback card used in the FOX-2R. Figure 2E-1 illustrates the front of the Loopback card highlighting the control switches and LEDs.

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

2. FUNCTIONAL DESCRIPTION

A. General Description

2.01 The optional Loopback card is a maintenance tool designed to provide a user interface to the FOX-2R equipment cage to communicate local or remote, T1, T1C, or T2 loopback commands to Unit-1 or II Control MPUs. Loopbacks are helpful for diagnostic unit- and system-level testing of the FOX-2R transmission network. Since the Loopback card is not required for normal equipment operation, a single card can be installed in a given unit as required for loopback testing.

2.02 Toggle switches mounted on the front of the circuit card select the unit for either local loopback (near-end transmit looped to receive) or remote loopback (far-end receive looped to transmit) test functions. A thumbwheel switch is used to select the specific T1, T1C or T2 channel for loopback.

2.03 Status and fault LEDs indicate the presence of a Unit-I or II, local or remote loopback, the presence of a Loopback card failure, and whether TELTRAC has enabled or disabled the functional operation of the card.

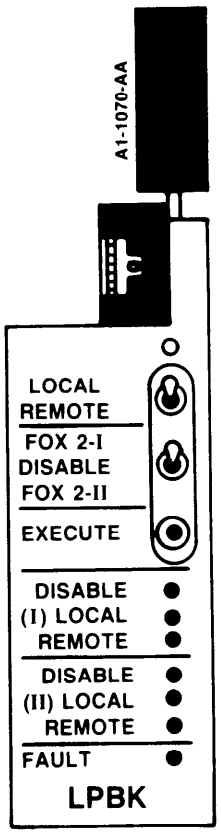


Figure 2E-1. FOX-2R Loopback Card

B. Interfaces

2.04 The Loopback card interfaces with the module select lines, control bus, and data bus of both Unit-I and Unit-II Control MPU circuit cards. Command information entered into the Loopback card is read by the selected Control MPU via the data bus. Control MPU selection is determined by the state of the FOX 2-I/FOX 2-II toggle switch on the front of the Loopback card.

C. Controls and Options

2.05 The Loopback card contains no field selectable options but does contain front-mounted control switches used to enter loopback command information.

2.06 A thumbwheel switch mounted on the front of the card selects the desired loopback function. At present, the following commands can be entered; the remaining positions are reserved for future application:

0 = Clears all loopbacks
1 = T1/1C channel 1 loopback
2 = T1/1C channel 2 loopback
3 = T1 channel 3 loopback
4 = T1 channel 4 loopback
5 = T2 loopback

2.07 A three-position toggle switch selects either FOX-2R Unit-I, Unit-II, or idle state while a second toggle switch selects either local (near-end) or remote (far-end) loopbacks.

2.08 A push button switch executes the entered command, and indicators on the front of the Loopback card illuminate to display loopback status.

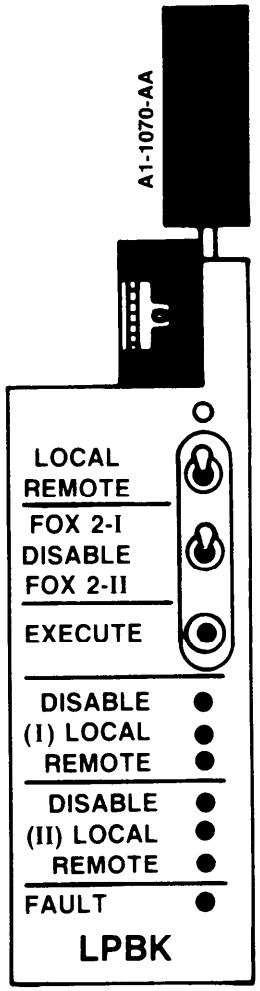
D. Alarms

2.09 A FAULT LED on the front of the Loopback card illuminates if power is lost to the circuit card as a result of internal fuse failure. The Control MPUs read the fault status of the loopback card and illuminate a MINOR and UNIT alarm.

2.10 Status LEDs indicate the presence of a local or remote, Unit-I or Unit-II loopback command. DISABLE LEDs indicate that TELTRAC has disabled Loopback card operation for Unit-I or II on command from the master terminal station. TABLE A lists the identity and function of the fault/status LEDs and controls of the FOX-2R Loopback card.

TABLE A. Loopback Card Indicators and Controls

LED INDICATOR	DESCRIPTION OF MONITORED POINT
(I) DISABLE	Illuminates to indicate that the DISABLE switch is set to the FOX-2 I position inhibiting all FOX-2 I loopback functions.
(I) LOCAL	Illuminates to indicate that FOX-2R I is in local loopback mode.
(I) REMOTE	Illuminates to indicate that FOX-2R I is in remote loopback mode.
(II) DISABLE	Illuminates to indicate that the DISABLE switch is set to the FOX-2 II position inhibiting all FOX-2 I loopback functions.
(II) LOCAL	Illuminates to indicate that FOX-2R II is in local loopback mode.
(II) REMOTE	Illuminates to indicate that FOX-2R II is in remote loopback mode.
FAULT	Illuminates to indicate a Loopback card failure.
CONTROL	**CONTROL DESCRIPTION**
LOCAL/ REMOTE	Two-position toggle switch selects either local or remote loopback test connections.
FOX-2 I/ DISABLE/ FOX-2 II	Three-position toggle switch which selects either FOX-2 units I or II for local or remote loopback as determined by the LOCAL/REMOTE switch. Center position (DISABLE) is used as an idle position selecting neither unit for loopback.
EXECUTE	A momentary contact switch which initiates the loopback commands selected by the FOX-2 I/II and LOCAL/REMOTE toggle switches.



3. OPERATIONAL THEORY

3.01 Consult Figure 2E-2 for a detailed block diagram of the operation of the FOX-2R Loopback card. Since the Loopback card consists of two identical circuit sets, one for each FOX-2R unit, only one circuit set will be described.

Address Decoder

3.02 An active module select line enables the address decoder to read the state of the Control MPU address bus. Address information on lines A0 and A1 enables one of three latch circuits to access the bidirectional data bus.

Octal Data Drivers/Receivers

3.03 Once enabled by the active module select line, command data can either be written into the card or read from the card, dependent upon the state of the read/write (R/W) line. If the MPU REPLACE line is active during MPU replacement procedures, the data drivers and receivers are disabled, preventing data bus access until MPU replacement is completed.

Octal LED Latches and Trigger

3.04 If the octal LED latch circuit is enabled, data from the Control MPU can be written into the latch to illuminate the corresponding LED. A 300 msec trigger circuit holds the latch in an enabled state, as long as the MPU continues to address the card as part of normal program execution. If the MPU is removed, the latches are automatically disabled, preventing spurious bus transients from generating erroneous fault LED illumination.

Command Latches

3.05 Once enabled by the address decoder, command data from the thumbwheel and toggle switches can be read and processed by the Control MPU.

Fault Latch

3.06 Allows simulated and actual fault status information to be read and processed by the Control MPU.

FOX 2-I/FOX 2-II Switch

3.07 Two position toggle switch allows the command latch circuit to be read by the other Control MPU.

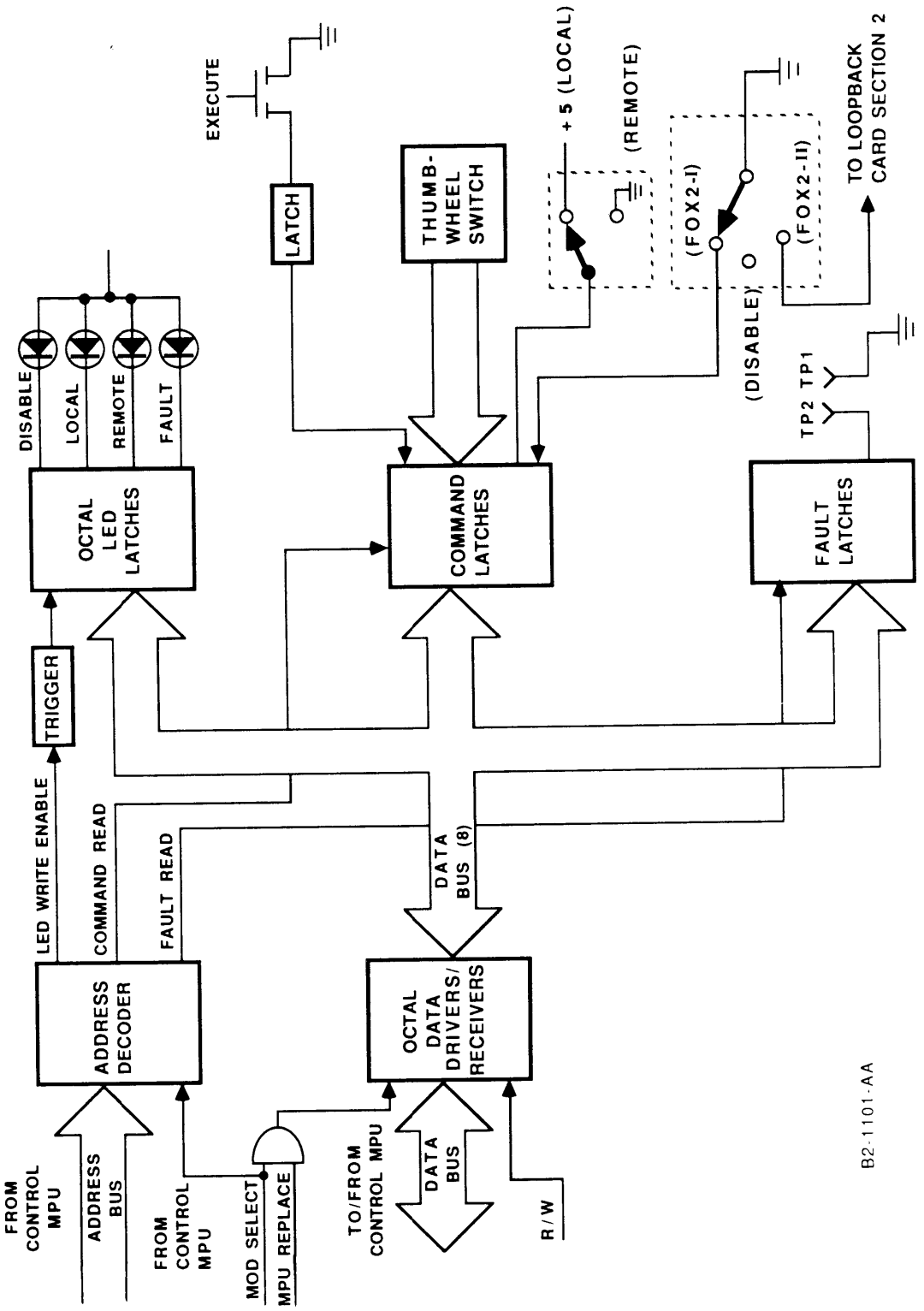


Figure 2E-2. FOX-2R Loopback Card