DIGITAL TRANSMISSION SYSTEM
828A DIGITAL MULTIPLEXER
THEORY OF OPERATION

1. GENERAL

1.01 This section is a cover sheet for the Telco Systems Fiber Optics Corporation Digital Transmission System 828A Digital Multiplexer Theory of Operation. This section is reproduced with permission of Telco Systems Fiber Optics Corporation and is the equivalent of Telco practice 828-102-002, Issue 3.

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

1.03 This section presents a functional description of the 828A Digital Multiplexer and a detailed description of the circuit cards.

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 365-407-842SW 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
Digital Transmission System
828A Digital Multiplexer
Theory of Operation

DIGITAL TRANSMISSION SYSTEM
828A DIGITAL MULTIPLEXER
THEORY OF OPERATION

CONTENTS PAGE

1. SCOPE..... 2-1

2. FUNCTIONAL DESCRIPTION..... 2-2

A. Operational Description... 2-2
B. Mechanical Detail..... 2-3
C. Equipment Interfaces..... 2-4
D. Equipment Protection..... 2-4

3. RELAY CARD DESCRIPTION..... 2-6

4. DETAILED CARD DESCRIPTIONS.... 2-7

Subsection 828-102-002A
T1 and T1C Low-Speed
Interface Card

Subsection 828-102-002B
T2 Low-Speed Interface Card

Subsection 828-102-002C
Line Terminating Unit Card

Subsection 828-102-002D
High-Speed Common Card

Subsection 828-102-002E
Wire-Line Entrance
Link Card

Subsection 828-102-002F
Control Microprocessor
Unit Card

Subsection 828-102-002G
Remote Alarm Card-II

Subsection 828-102-002H
Power Supply Module

Subsection 828-102-002I
Optional MPU-II Card

CONTENTS PAGE

5. SPECIAL TEST EQUIPMENT..... 2-7

A. Maintenance Interface
Card..... 2-7
B. Manual Control
Interface Card..... 2-10

6. SIGNAL FORMAT..... 2-13

A. DS-2 Format..... 2-13
B. DS-3 Format..... 2-13

1. SCOPE

1.01 This section presents a functional description of the 828A Digital Multiplexer (see Figure 2-1), and a detailed description of the circuit cards. Also included is a description of the Relay card in the ACX025 Fuse and Alarm Panel.

1.02 This section was reissued to provide descriptions of the RAC-II (Remote Alarm Card-II) and the LTU (Line Terminating Unit) cards and to include information on the CCA162 Control MPU (Microprocessor Unit) card, the Optional MPU-II (CCA135) card, and the ACX043 Fuse and Alarm Panel.

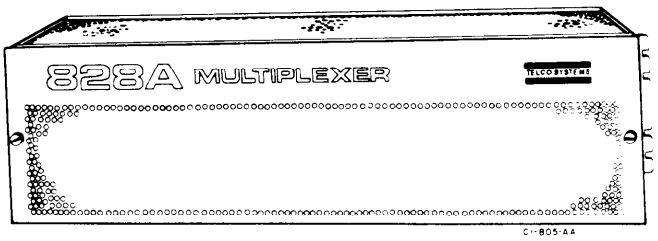


Figure 2-1. 828A Digital Multiplexer

2. FUNCTIONAL DESCRIPTION

A. Operational Description

2.01 A block diagram of the 828A is shown in Figure 2-2. The signal flow for each block is discussed as it relates to system operation.

2.02 The 828A accepts up to 28 DS-1, 14 DS-1C, 7 DS-2 channels, or any combination thereof up to an equivalent of 28 DS-1 (64 kb/s) channels.

2.03 Bit-stuffing is used to synchronize each of the asynchronous low-speed inputs to a common clock rate when multiplexing. DS-1 and DS-1C channels are bit-stuffed to the DS-2 level. The DS-2 channels are bit-stuffed to the DS-3 level.

2.04 Overhead data is also multiplexed into each of the seven resulting DS-2 mastergroup data streams, to allow far-end low-speed demultiplexing and stuffing bit extraction at the receiving end of the system. The DS-2 outputs from the low-speed interfaces are applied to the HS COM (High-Speed Common) card.

2.05 The HS COM card accepts up to seven DS-2 data streams, and multiplexes them into a single DS-3 data stream (44.736 Mb/s). The HS COM card also multiplexes the appropriate DS-3 overhead data and stuffing bits along with the DS-2 signals. The resulting data stream and timing signals are sent to the WLEL (Wire-Line Entrance Link) card, where an industry-standard DS-3 mastergroup structured data stream is developed and converted into a B3ZS signal for coaxial interface to external equipment.

2.06 In receive processing, the incoming DS-3 B3ZS data stream is amplified and sliced into two unipolar data streams, P-rail and N-rail. The two data streams are sent to the HS COM card, which frames on the DS-3 mastergroup overhead data and demultiplexes the composite data stream into its DS-2 components.

2.07 The DS-2 data streams from the HS COM card are input to the low-speed cards, where they are demultiplexed from DS-2 to DS-1 or DS-1C, as required. All stuffing bits added for bit synchronization at the transmitting end of the system are deleted from the data stream by low-speed interface circuitry prior to line signal encoding.

2.08 The Control MPU card monitors various alarm points throughout the 828A Digital Multiplexer unit, and performs the following functions:

- Illuminates appropriate fault and status indicators within the equipment, except for the Power Supply which controls its own indicators.
- Utilizes lockout software to isolate a fault condition to a specific card, thereby suppressing FAULT LED illumination due to sympathetic alarm conditions.
- Performs automatic switching from defective circuitry to appropriate redundant circuitry.
- Calculates DS-3 BER (Bit Error Rate) for the on-line and off-line incoming DS-3 channel.
- Calculates error seconds for each LS input.
- Provides remote alarm reporting external to the multiplexer, via relay contact closures, to indicate MAJOR and MINOR fault conditions.

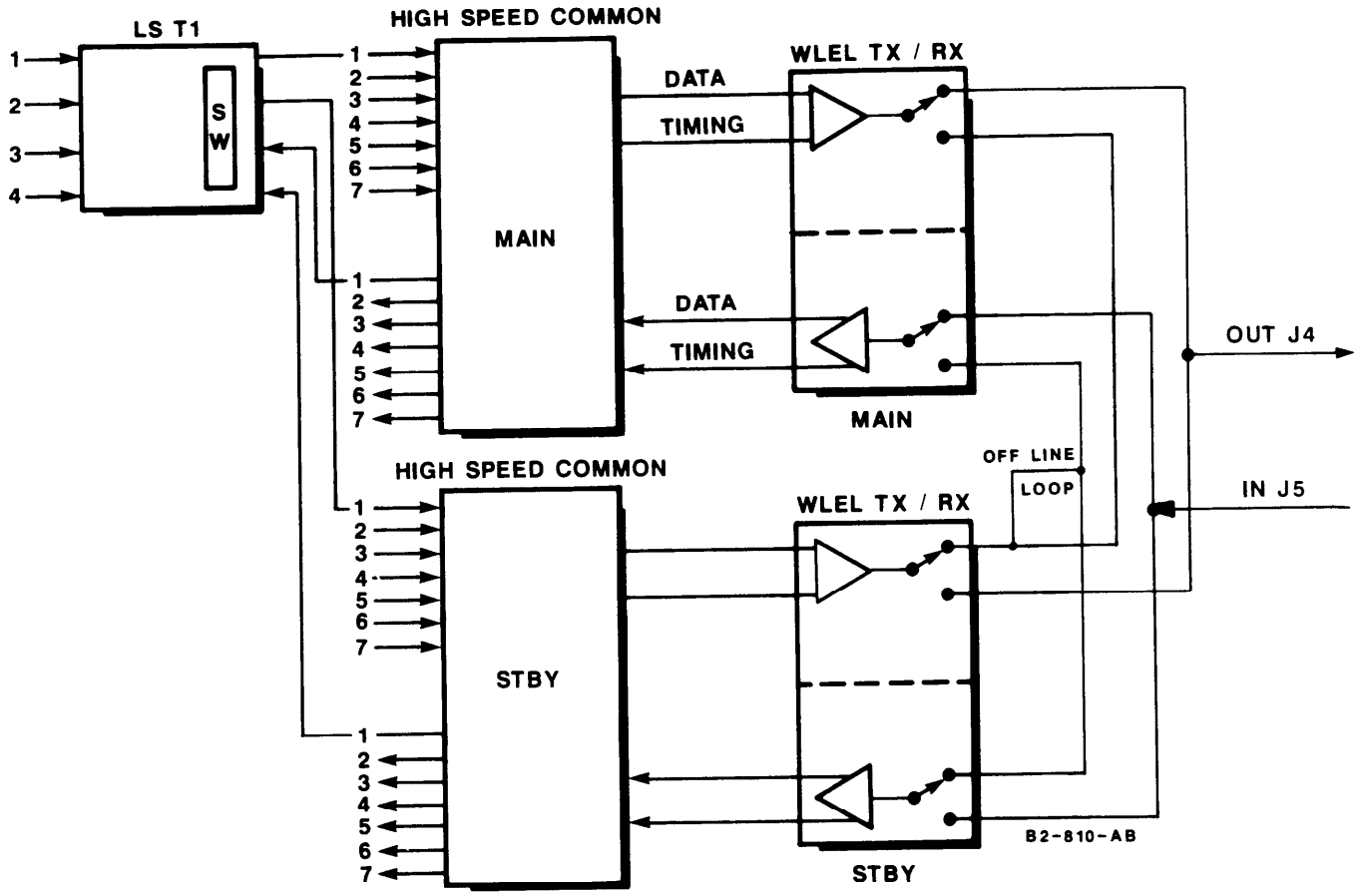


Figure 2-2. 828A Digital Multiplexer Block Diagram

- Optionally, communicates with TELTRAC (Telco Systems Telecommunications Remote Alarm and Control) or TBOS (Telemetry Byte Oriented Serial) system, which performs comprehensive fault alarm reporting and analysis of an entire telecommunications network at a central processor location.

2.09 The PS (Power Supply) module accepts -24 Vdc or -48 Vdc, and provides +15, +5, and -5.2 Vdc. Power Supply protection is provided via load sharing with a second PS module. Each supply is independently capable of providing all power necessary for the 828A unit. A built-in fault monitoring function, including LEDs, aids in troubleshooting.

B. Mechanical Detail

2.10 A single 828A measures 23-in. wide by 6-in. high by 11.5-in. deep, allowing up to twelve units to be mounted in a standard 7-foot rack, along with a Fuse and Interface Panel.

C. Equipment Interfaces

2.11 The low-speed interface cards contain all circuitry necessary to interface with DS-1, DS-1C, or DS-2 electrical signals, or 3B6B encoded DS-2 optical signals, and multiplex them to the DS-2 level with full 1:1 redundancy of the M12 MULDEM (DS-1 to DS-2 Multiplexer/Demultiplexer) circuitry. Electrical signal interfaces are wire-wrap pin blocks located on the backplane behind each Low-Speed Interface card. The optical DS-2 interface is located on the front of the LTU (Line Terminating Unit) card.

2.12 Electrical B3ZS DS-3 TX (Transmit) and RX (Receive) interfaces to external coaxial cable are BNC-type connector jacks mounted on the side of the 828A cage behind the backplane near the WLEL mounting connectors or, as an option, mounted to the inside of the cage for front accessibility.

2.13 TELTRAC or TBOS interface is accomplished through a connector on the Fuse and Interface Panel.

2.14 The ACX025 Fuse and Alarm Panel interfaces with a customer-provided -48 Vdc or -24 Vdc power source, and provides fused power for up to twelve 828A units.

2.15 On the full-featured ACX025 Fuse and Alarm Panel, (see Figure 2-3) wire-wrap pin connectors are available for customer interface for MAJOR and MINOR alarms for up to twelve individual 828A units mounted in the bay. Relay contact closures are available for AUDIBLE and VISUAL (MAJOR and MINOR) alarms, and FUSE, ACO, and REMOTE (with the RAC-II card) relay contacts are also available as separate closures. For VISUAL indications, the ACX025 also provides ACO, FUSE, INT FUSE, BAY FLT, and REMOTE (with RAC-II only) lamps. An RS-422 buffer exists so that TELTRAC or TBOS lines will always have only one load.

2.16 The cost-effective ACX043 Fuse and Alarm Panel interfaces with a customer-provided -48 Vdc or -24 Vdc power source, and provides fused power for up to six 828A units.

2.17 On the ACX043 Fuse and Interface Panel (see Figure 2-4), wire-wrap pin connectors are available for customer interface for MAJOR and MINOR alarms for up to six individual 828A units mounted in the bay. A 32-pin wire-wrap header can be used for customer interface with the opto-isolator inputs and relay contacts of one RAC-II card in the bay. A separate cable is required to connect the RAC-II card to the header. For visual indications, the ACX043 provides BAY FLT and FUSE lamps.

D. Equipment Protection

2.18 All power, low-speed and high-speed multiplexing, line coding, and optical interface circuitry can be 1:1 protected. T1 and T1C cards have protection circuitry built on the same card, while the other cards are protected by a redundant card. The Control MPU card initiates automatic switching to the protection circuitry when a hardware failure occurs. When the predetermined high-speed BER threshold is exceeded, the Control MPU also initiates an automatic switch. The multiplexer can be switched manually via the MPU, the Manual Control Interface card, or an external remote monitoring system, such as TELTRAC.

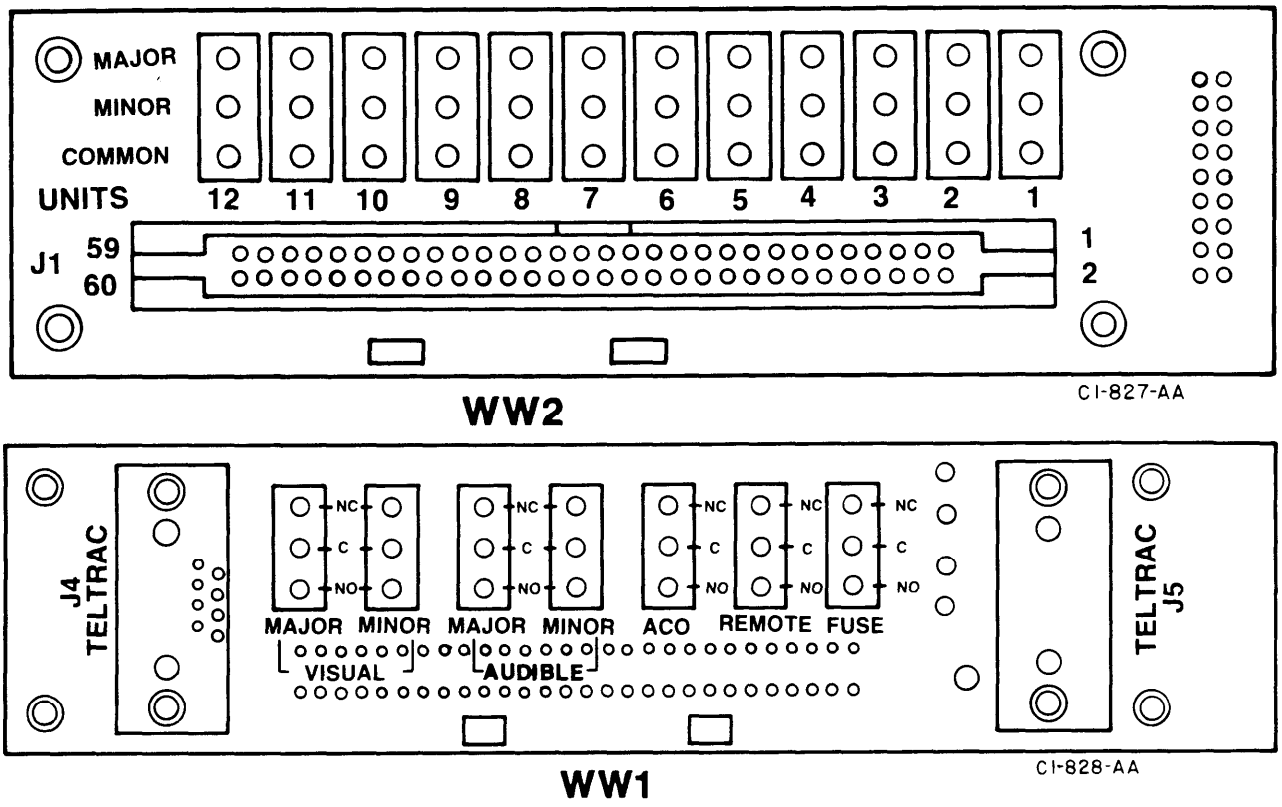


Figure 2-3. ACX025 Fuse and Alarm Panel

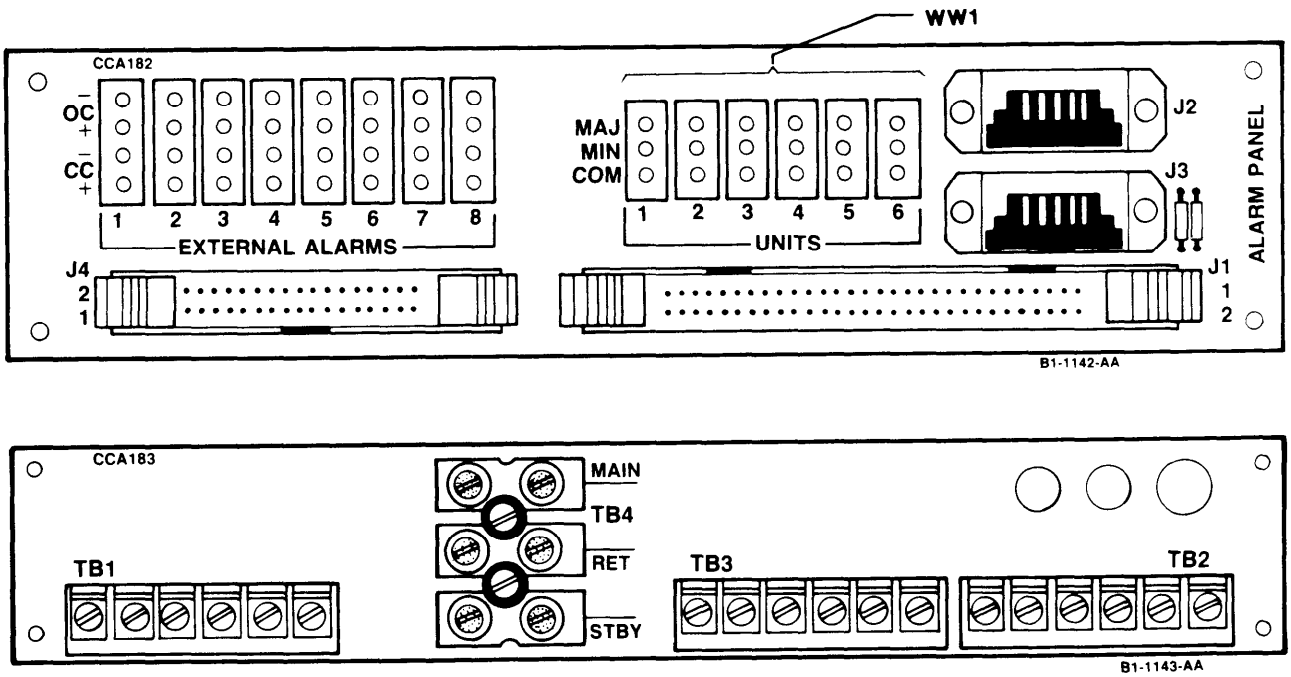


Figure 2-4. ACX043 Fuse and Alarm Panel

3. RELAY CARD DESCRIPTION

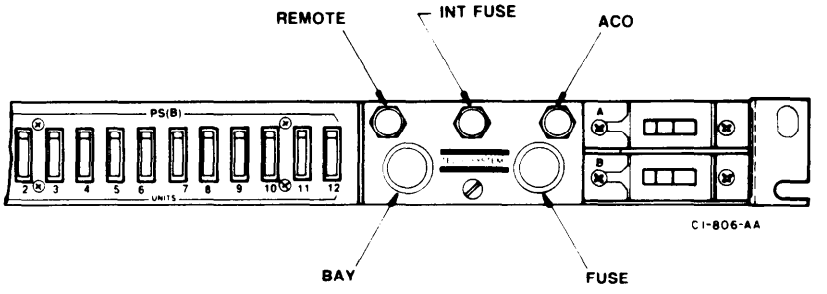
3.01 The Relay card is used in the ACX025 Fuse and Alarm Panel. The card contains relays, lamp indicators, and protective fuses. If any of these components fail, the card can be easily replaced without disconnecting power.

3.02 See Figure 2-3 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 protects the Fuse and Alarm Panel from the power source. The other provides protection for the FUSE lamp and FUSE relay.

3.04 A jumper on the Relay card provides the option of having VISUAL alarms cut off as well as AUDIBLE alarms through ACO feature. Position 1-2 affects only the BAY AUDIBLE alarms. Postion 1-3 allows both BAY VISUAL and AUDIBLE alarms to be cut off.

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

ALARM INDICATOR	DESCRIPTION OF MONITORED POINT
	
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 828A units connected to the Fuse and Alarm Panel. This indicator can also illuminate in response to a far-end alarm if Remote Bay Enable is active.
REMOTE (yellow)	Indicates a far-end alarm (if Remote Bay Enable has been selected on the Control MPU). Note: A RAC-II card is required to drive the REMOTE indicator lamp.
INT FUSE (red) (Internal Fuse)	Monitors the relay protection fuses. The FUSE lamp will illuminate in conjunction with INT FUSE.
ACO (yellow) (Alarm Cutoff)	Illuminates whenever the ACO switch is activated or a Control MPU card is reset.

4. DETAILED CARD DESCRIPTIONS

4.01 Separate subsections are included in this section to provide more detailed information on the individual circuit cards and Power Supply module. The subsections are as follows:

- T1/T1C Low-Speed Interface Card
- T2 Low-Speed Interface Card
- Line Terminating Unit Card
- High-Speed Common Card
- Wire Line Entrance Link Card
- Control Microprocessor Unit Card
- Remote Alarm Card-II Card
- Power Supply Module
- Optional MPU-II Card

5. SPECIAL TEST EQUIPMENT

A. Maintenance Interface Card

5.01 The Maintenance Interface card (see Figure 2-5) is used to replace faulted T1 and T1C Low-Speed cards, and permits testing of the Low-Speed Interface card before switching over traffic. The Maintenance Interface card is also used to replace a faulted Control MPU card. 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. A functional block diagram of the Maintenance Interface card is shown in Figure 2-6.

5.02 Testing is carried out in the TEST mode. In the Test mode, the TX and RX circuits are looped at the 6.312 MHz interface. In the NORMAL mode, the MULDEM works in conjunction with the HS COM cards. When the failed Low-Speed Interface card is removed from the shelf, traffic switches over automatically to the Low-Speed card under test. If a new card is then installed, traffic automatically switches to the new card.

5.03 The LEDs on the front of the Maintenance Interface card and their functions are listed in TABLE B. The switches on the front of the Maintenance Interface card, and their functions are listed in TABLE C.

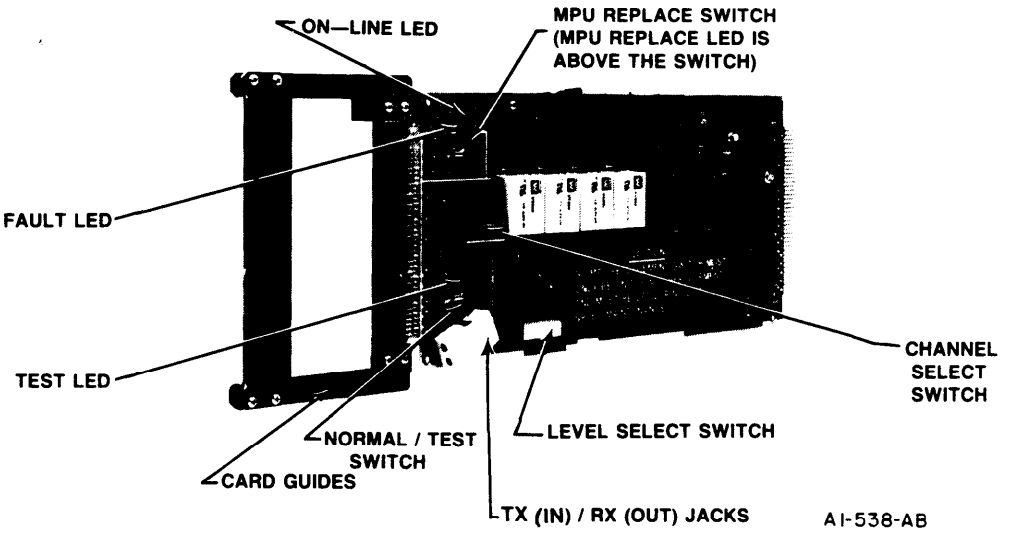


Figure 2-5. Maintenance Interface Card

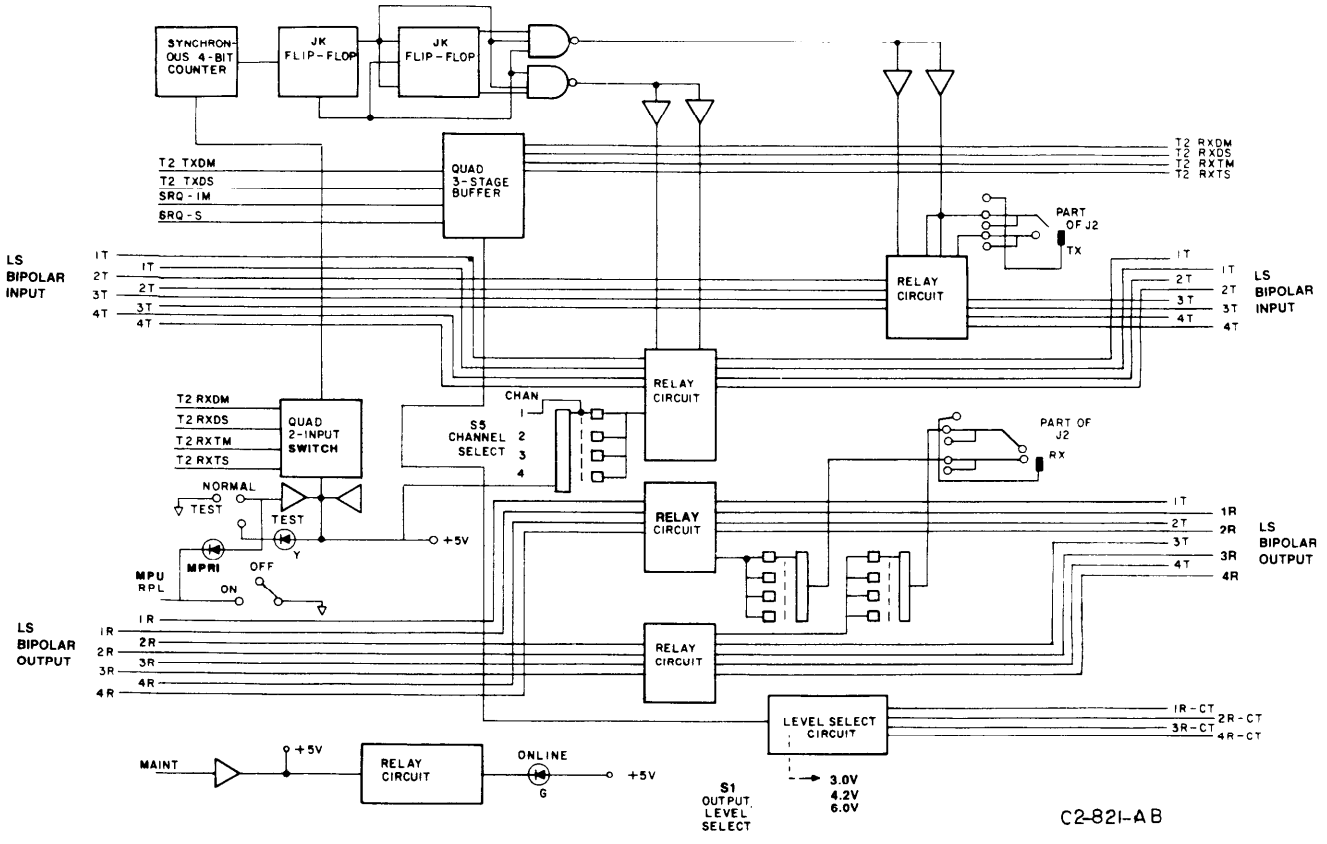


Figure 2-6. Maintenance Interface Card Block Diagram

TABLE B. 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 C. Maintenance Interface Card Switches

SWITCH	DESCRIPTION OF MONITORED POINT
MPU REPLACE	Set to ON when replacing the Control MPU card; otherwise, set to OFF.
CHANNEL SELECT	Four-position slide switch that selects channels 1 through 4 on the Low-Speed card to be tested. 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

5.04 The MCI (Manual Control Interface) card (see Figure 2-7) is an I/O (Input/Output) board allowing immediate and direct access to the Control MPU card. This access is used to initiate testing functions and provide status through interrogation of the local and remote terminals. A block diagram of the MCI card is shown in Figure 2-8.

5.05 All DS-1, DS-1C, or DS-2 lines can be looped individually or simultaneously at a Local or Remote terminal from any MCI card. Low-speed loopback enables the technician to monitor end-to-end system performance. When in REMOTE loopback function (see Figure 2-9) an input signal is multiplexed to a DS-3 level by the local terminal and transmitted to the remote terminal. At the remote terminal the DS-3 signal is demultiplexed and applied to the corresponding low-speed card. The low-speed card is looped back; the signal is remultiplexed and transmitted to the point of origin, completing the end-to-end system loop.

Note: The MCI card cannot perform remote testing if the 828A contains Control MPU card part number CCA137G1. Part number CCA137G2 and higher allows the MCI card to perform remote testing.

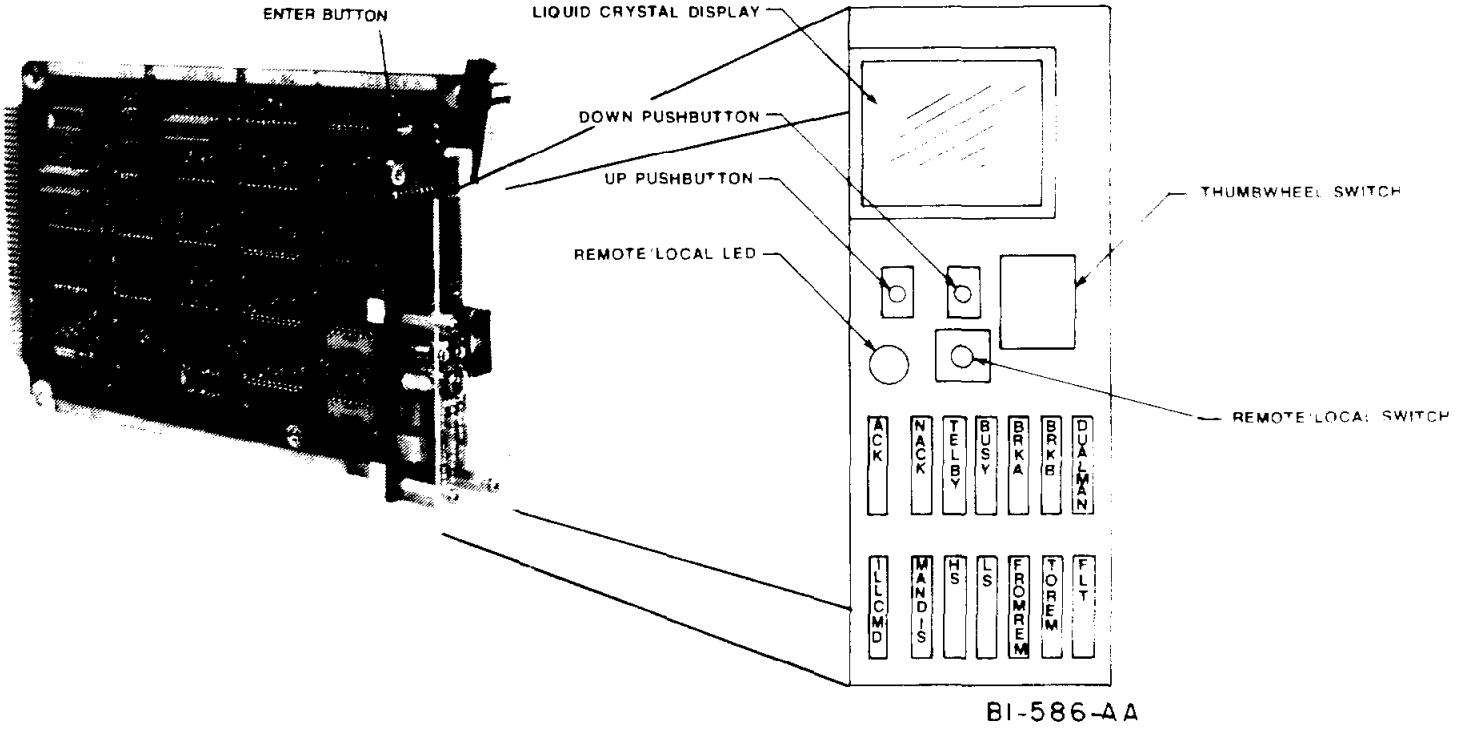


Figure 2-7. Manual Control Interface Card

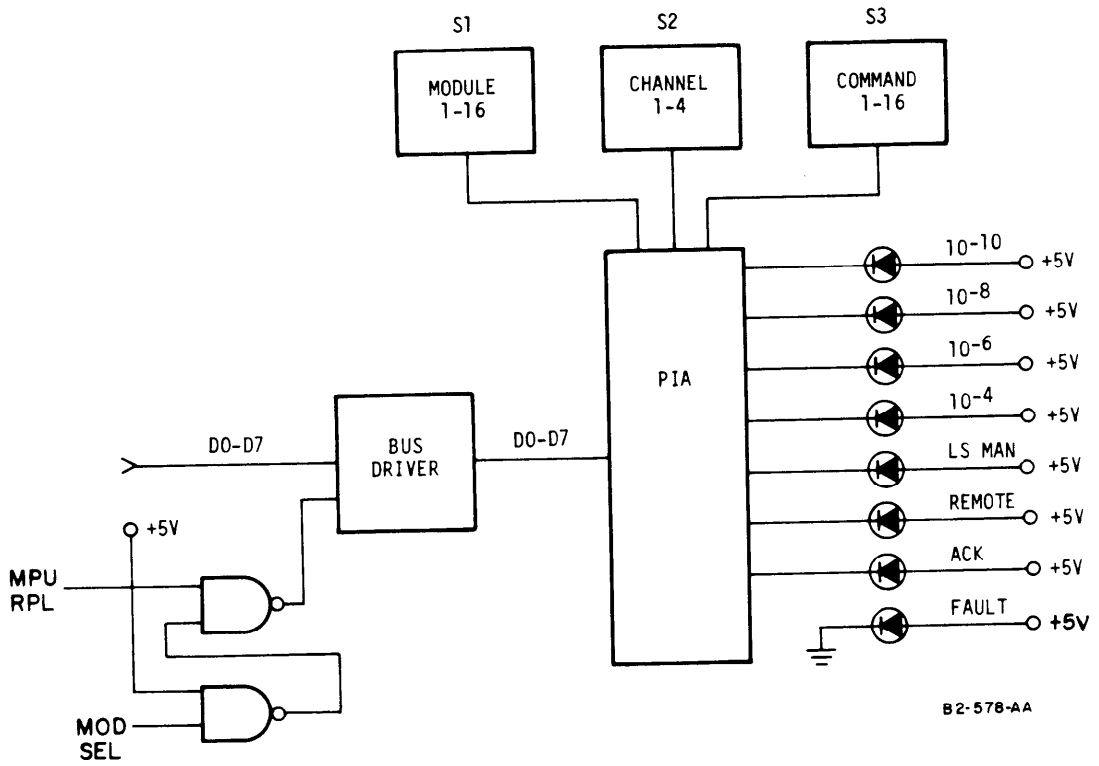


Figure 2-8. Manual Control Interface Card Block Diagram

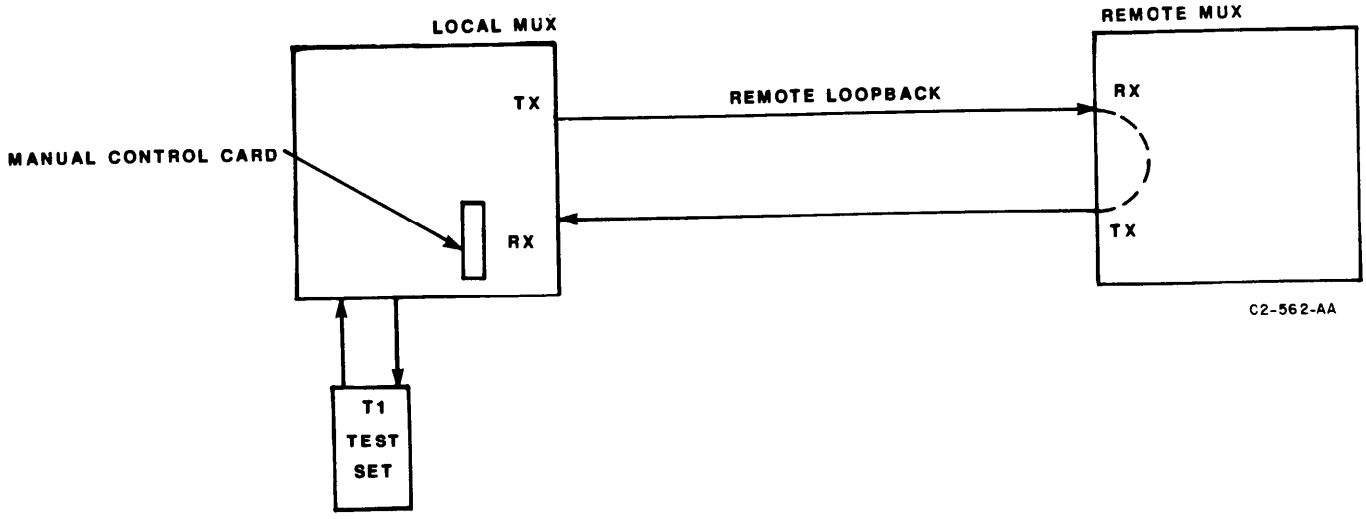


Figure 2-9. Remote Loopback

5.06 When in LOCAL loopback function (see Figure 2-10), an input signal is multiplexed to a DS-3 level by the remote terminal and transmitted to the local terminal. At the local terminal, this DS-3 signal is demultiplexed and applied to a low-speed card. The low-speed card is looped back and the signal is remultiplexed and transmitted to the point of origin, completing the end-to-end system loop. The receive DS-3 signal at the Local multiplexer also continues to be demultiplexed and sent to the low-speed cross-connect.

5.07 Communications between the terminals is carried over the designated mux-to-mux communication channel. The selection of cards, channels, and commands are activated by the thumbwheel switches, processed through the bus driver, and activated by pressing the ENTER pushbutton. Refer to SPECIAL TEST CARDS (Section 828-102-008) for a description of the indicators and switches on the Manual Control Interface card. The section also includes a procedure on operating the Manual Control Interface card, and a description of each test that the card can perform.

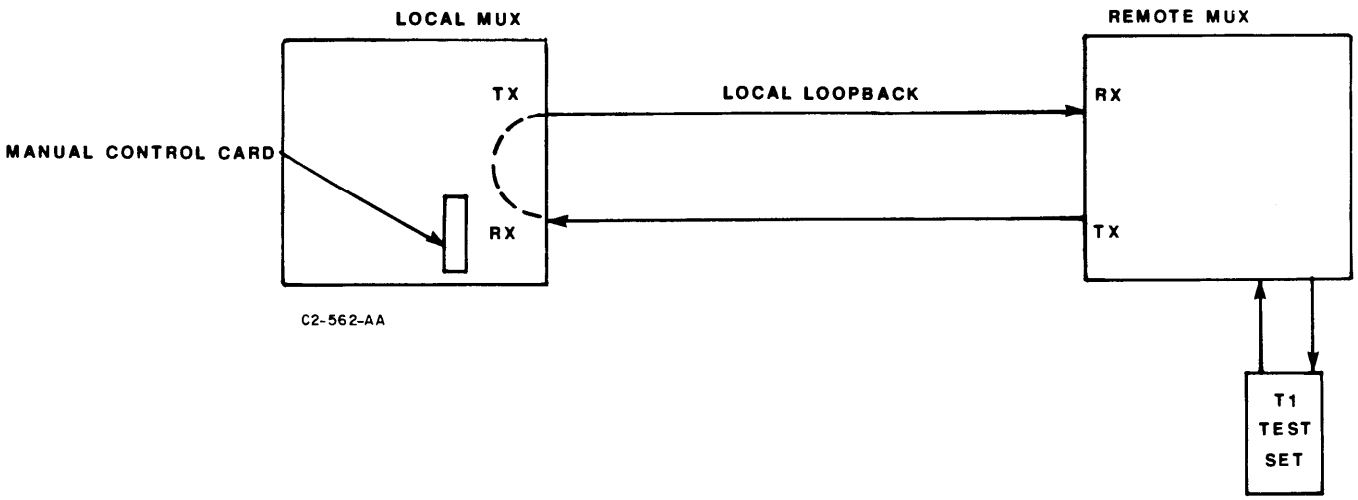


Figure 2-10. Local Loopback

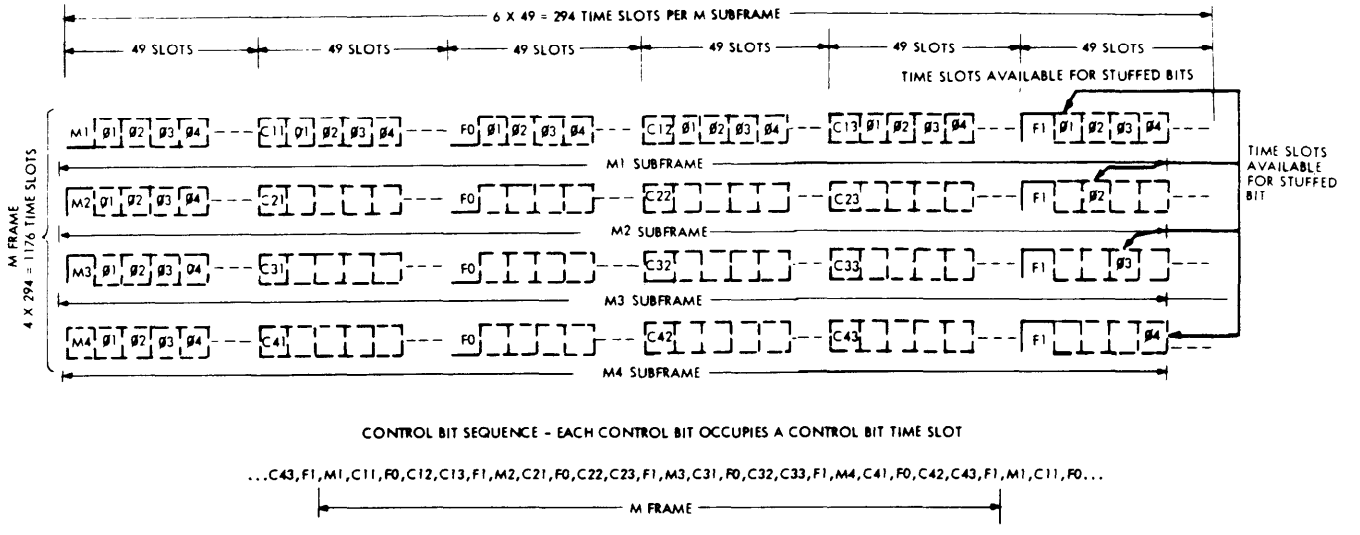
6. SIGNAL FORMATS

A. DS-2 Format

6.01 The format of the DS-2 (6.312 Mb/s) data stream is shown in Figure 2-11. Every M frame is divided into four subframes. The frame alignment signal ($F_0F_0F_1F_1$...) is used to identify all control bit time slots. The multiframe alignment signal $M_1M_2M_3M_4$ (011X) is used to locate all four subframes. A single time slot within each subframe is available for inserting a stuff bit. A three bit-stuffing indicator identifies whether or not a stuff bit has been inserted.

B. DS-3 Format

6.02 The format of the DS-3 (44.736 Mb/s) data stream is shown in Figure 2-12. Every M frame is divided into seven subframes. The frame alignment signal ($F_1F_0F_0F_1$) is used to identify all control bit time slots. The multiframe alignment signal ($M_0M_1M_0$) appears in the fifth, sixth, and seventh M subframes, and is used to locate all seven subframes. A single time slot within each subframe is available for inserting a stuff bit. A three-bit stuffing indicator word identifies whether or not a stuff bit has been inserted. At the beginning of the first and second M subframes is an X-bit which is used by the 828A/828AF.



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.

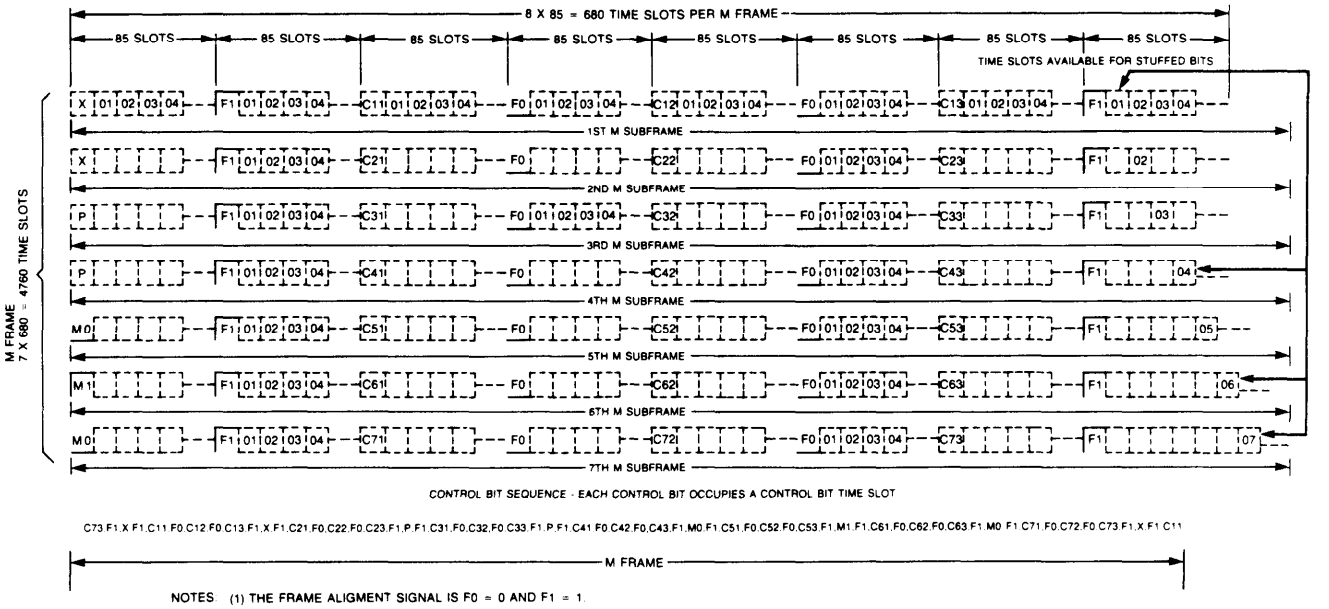
(6) THE NOMINAL STUFFING RATE PER DS1 INPUT IS 1796 BITS/SEC.

(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.

84-579-AA

Figure 2-11. DS-2 (6.312 Mb/s) Data Stream Format



NOTES: (1) THE FRAME ALIGMENT SIGNAL IS F0 = 0 AND F1 = 1.

(2) M0 M1 M0 IS THE MULTIFRAME ALIGMENT SIGNAL AND APPEARS IN THE 5TH, 6TH, AND 7TH M SUBFRAMES. M0=0 AND M1=1.

(3) PP IS PARITY INFORMATION TAKEN OVER ALL INFORMATION TIME SLOTS IN THE PRECEEDING M FRAME. PP=11 IF THE DIGITAL SUM OF ALL INFORMATION BITS IS 1 AND PP=00 IF THE SUM IS 0. THESE TWO PARITY BITS ARE IN THE 3RD AND 4TH M SUBFRAMES.

(4) XX MAY BE USED FOR AN ALARM SERVICE CHANNEL. IN ANY ONE M FRAME THE TWO X-BITS MUST BE IDENTICAL.

(5) C11 C12 C13 = STUFFING INDICATOR WORD FOR 6.312 MB/S INPUT 1. 000 INDICATES NO STUFFING AND 111 INDICATES STUFFING WAS DONE.

(6) THE TIME SLOT AVAILABLE FOR STUFFING 6.312 MB/S INPUT 1 IS THE FIRST SLOT FOR INPUT 1 (01) FOLLOWING F1 IN THE FIRST M SUBFRAME.

(7) THE MAXIMUM STUFFING RATE PER 6.312 MB/S INPUT IS 9398 BITS/SEC.

(8) THE NOMINAL STUFFING RATE PER 6.312 MB/S INPUT IS 3671 BITS/SEC.

(9) FIRST SLOT BEFORE EACH 01 TIME SLOT IS A CONTROL BIT TIME SLOT.

B4-580-AA

Figure 2-12. DS-3 (44.736 Mb/s) Data Stream Format

DIGITAL TRANSMISSION SYSTEM
828A DIGITAL MULTIPLEXER
T1/T1C LOW-SPEED INTERFACE CARD THEORY OF OPERATION
CCA050G1/CCA124G1/CCA161G2/CCA006G1

CONTENTS PAGE

1. SCOPE..... 2A-1

2. FUNCTIONAL DESCRIPTION..... 2A-2

A. General Description..... 2A-2
B. Interfaces..... 2A-3
C. Controls and Options..... 2A-4
D. Alarms..... 2A-5

3. OPERATIONAL THEORY..... 2A-7

A. Transmit Circuitry..... 2A-7
B. Receive Circuitry..... 2A-8

1. SCOPE

1.01 This subsection presents a functional description of the LS INTER T1 or T1C (T1 or T1C Low-Speed Interface) card used in the 828A/828AF. See Figure 2A-1. 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.

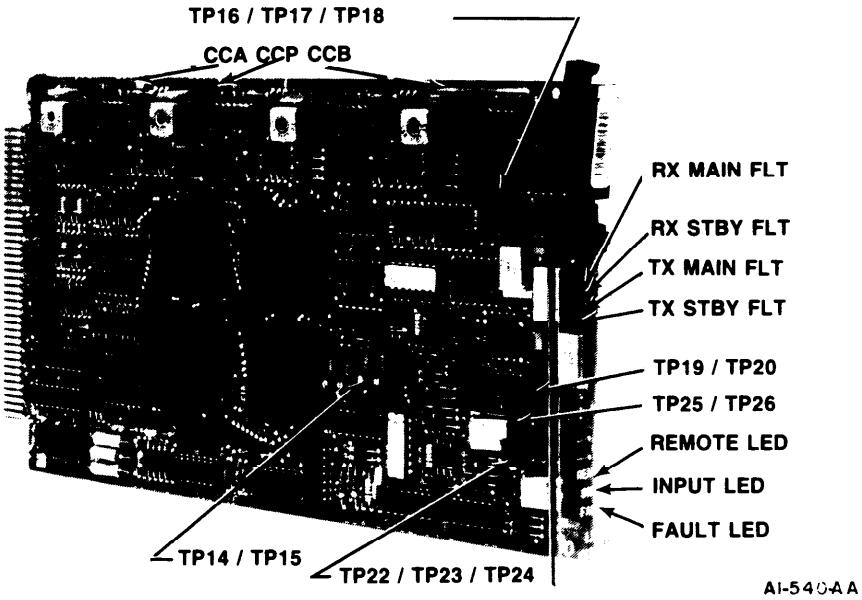


Figure 2A-1. LS INTER T1 Card (CCA050G1)

2. FUNCTIONAL DESCRIPTION

A. General Description

2.01 The LS INTER T1 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.

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 LS INTER T1 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. The CCA161G2 card may be used in any combination with other Low-Speed cards when the AMI option is selected. When used with the B8ZS option selected in a particular slot at one end, the corresponding slot on the far end should also have a CCA161G2 card with the same option selected.

2.03 Each Low-Speed Interface card contains transmit and receive, main and standby circuitry. In the event of M12 MULDEM (DS-1 to DS-2 Multiplexer/Demultiplexer) failure, the Control MPU will initiate a switch to internal redundant transmit and/or receive MULDEM circuits, to preserve DS-2 transmission integrity. A Maintenance Interface card is used for replacing a bad low-speed card or MPU card without losing traffic. A 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 828A/828AF, an AIS (Alarm Indication Signal) is routed from the Low-Speed Interface card to down-line equipment. CCA050G1 provides an all ones AIS. On CCA124G1 an all ones or all zeros AIS is selectable. The all zeros AIS will cause down-line activity detectors to activate. The all ones blue signal suppresses down-line activity detectors and maintains line activity necessary for network timing synchronization.

2.05 The transmit circuitry of the LS INTER T1 or T1C card performs the following unit-level functions within the 828A/828AF:

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) or two T1C (3.152 Mb/s) data channels, and 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 STBY M12 MULDEMs on line to the on-line HS COM card. This circuitry also routes the off-line MULDEM output to the off-line HS COM card.

2.06 The receive circuitry of the LS INTER T1 or T1C card performs the following unit-level functions within the 828A/828AF:

a. Switching circuits route the output of the on-line HS COM to the on-line MAIN or STBY MULDEM circuit, while routing the off-line HS COM 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 or two T2 component channels.

c. Once identified by DS-2 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 2A-2 for a pictorial representation of circuit card interfaces. The Low-Speed Interface

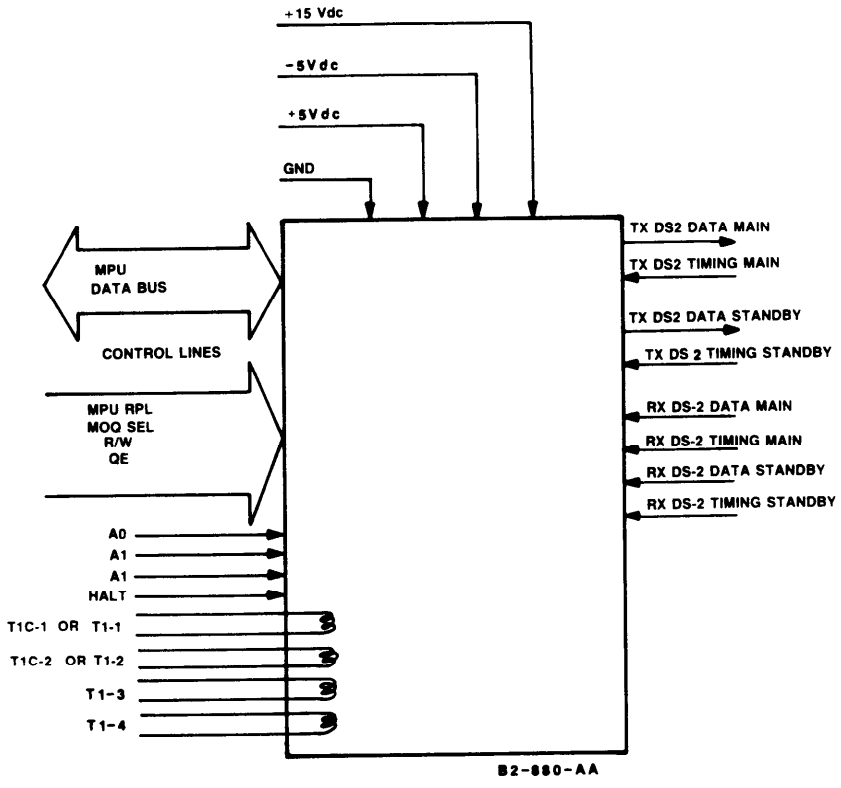


Figure 2A-2. LS INTER T1/T1C Card Interfaces

card processes bipolar T1 (1.544 Mb/s) or T1C (3.152 Mb/s) incoming data channels. 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 HS COM. DS-2 master clock timing is derived from the on-line HS COM card and is subdivided to provide DS-2 and DS-1 input clock rates.

2.09 MPU (Microprocessor Unit) 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. Controls and Options

2.10 The T1 Low-Speed Interface card contains a four-pole DIP switch mounted on the front of the card which can select 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 on the CCA050G1 LS INTER T1 card, nor on the CCA006G1 LS INTER T1C card. The CCA124G1 contains a jumper setting to have either "all ones" or "all zeros" injected as an AIS signal. A series of front-mounted test jacks is provided on all Low-Speed Interface cards to simulate circuit card failures, and 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 AMI (Alternate Mark Inversion) or B8ZS (Bipolar with Eight-Zero Substitution) 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 lock, 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.

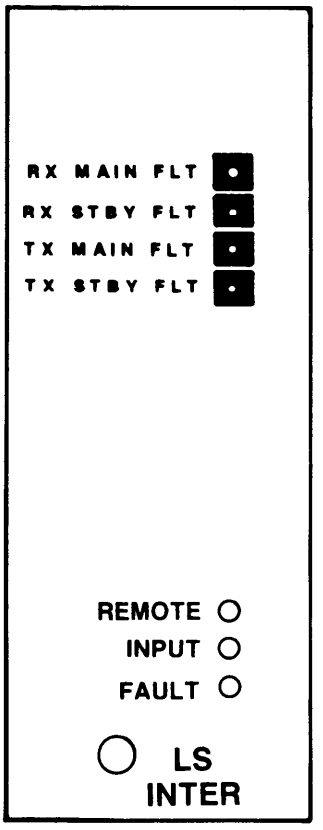
2.14 Transmit and receive activity, and phase-locked detectors monitor the data and timing activity of the DS-1 and DS-2 data channels. In the absence of incoming transmit data, the Control MPU illuminates an INPUT status fault indicator. Also, if a BPV (Bipolar Violation) error rate on any Low-Speed input reaches 10 consecutive error-seconds (corresponding to an error rate of approximately 10^{-6} on a DS-1 and DS-1C input), the MPU will cause the INPUT status LED to blink at one-second intervals. This action by the MPU will cease when the timing cycle produces no error-seconds.

2.15 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. PLL (Phase-Locked Loop) detectors within the T1/T1C input and output circuitry examine timing phase lock between external line timing and internally generated master clock timing.

2.16 TABLE B lists the identity and function of the fault LED and status indicators mounted on the front of the Low-Speed Interface card. TABLE B also lists the identity and function of the four front-mounted test jacks on the card.

TABLE B. LS INTER T1/T1C Card Indicators and Test Jacks

INDICATOR	DESCRIPTION OF MONITORED POINT
REMOTE (yellow)	Illuminates when the corresponding Low-Speed Interface card at the far end has a fault.
INPUT (yellow)	Illuminates when a loss of DS-1C input occurs on the previously functional DS-1 or DS-1C channel associated with the card. Flashing INPUT LED indicates the occurrence of 10 consecutive incoming BPV error-seconds. This translates into an equivalent BER worse than 10^{-6}.
FAULT (red)	Illuminates when the LS INTER T1C card has a failure.
TEST POINT	**FUNCTION**
TP1/TP2 RX MAIN FAULT	Used to simulate a fault in the MAIN M12 MULDEM receive circuitry.
TP3/TP4 RX STBY FAULT	Used to simulate a fault in the STBY M12 MULDEM receive circuitry.
TP5/TP6 TX MAIN FAULT	Used to simulate a fault in the MAIN M12 MULDEM transmit circuitry.
TP7/TP8 TX STBY FAULT	Used to simulate a fault in the STBY M12 MULDEM transmit circuitry.



AI-831-AA

3. OPERATIONAL THEORY

A. Transmit Circuitry

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

Bipolar/Unipolar Converter

3.02 Incoming bipolarly-coded T1 or T1C data enter the card through wire-wrap connector pins on the rear of the 828A/828AF motherboard (backplane) behind the LS INTER T1 or T1C card. Each AMI or B8ZS signal is converted into unipolar data channels compatible with logic circuitry operation, i.e. two unipolar "P" and "N" rails. Data-edge transitional changes are utilized to recover transmit timing. Therefore, in AMI coding, 12.5% average ones data activity must be ensured by T1 terminal equipment per industry DSX-1 specifications. With 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 (LS INTER T1C Card Only)

3.03 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 2A-5 for DS-1C masterframe structure.

Dual Channel SWEL (Switching and Elastic) Store Circuit

3.04 The "P" and"N" rails are then fed to the SWEL circuits where the data is monitored for BPVs and loss of data. In the event of loss of data (more than 193 consecutive zeros), an AIS is inserted into the data stream. The AIS is an unframed all ones signal on the CCA050G1, and is selectable as all ones or all zeros on CCA124G1 and CCA161G2. When the incoming data meets minimum density requirements (129 data bits), the incoming data is allowed to pass. The data is then fed to the AMI/B8ZS decoder. When programmed for B8ZS, the decoder will remove any B8ZS code words and substitute eight zeros. Each T1 Channel is individually programmable for B8ZS or AMI through S1.

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 PLL control. Each elastic store is used to proportionally bit stuff each channel individually. Bit stuffing is accomplished to equalize the channels to a common data rate. When removing the stuff bits a PLL and elastic store smooth the frequency of the outgoing low-speed signal to remove jitter.

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 are deleted by far-end receive circuitry to return the T1 data channels to their original data composition. See Figure 2A-6 for a pictorial representation of DS-2 masterframe structure.

3.07 Switching circuitry embedded in the output circuits of the MAIN and STBY MULDEMs route main or standby DS-2 data and timing streams to/from the on-line and off-line HS COM 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 HS COM circuit cards to the MAIN and STBY 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 2A-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 SWEL Store

3.10 Phase jitter timing discontinuities caused by stuffing bit insertion and deletion are corrected by PLL 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 HS COM master clock timing, to the unipolar-to-bipolar converters.

T1C to T1 MULDEM
(LS INTER T1C Card Only)

3.12 See Figure 2A-4 for T1C operation. A T1C MULDEM within LS INTER T1C 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 2A-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 LS INTER T1 card is equipped for selectable AMI/ B8ZS per channel line coding option.

AIS

3.14 The T1 card outputs an all ones AIS whenever there is a loss of receive demux timing (high- or low-speed), or the far-end incoming data has a stream of 175 (±75) consecutive zeros. The CCA124G1 and CCA161G2 can optionally be configured to output all zeros instead of all ones by setting JP5.

MPU Interface

3.15 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.

Mux-to-Mux Communication

3.16 The jumper at location JP7 controls DS-2 X-bit usage. In the OFF position the X-bit is enabled for normal Telco mux-to-mux communication. In the ON position it will reserve the DS-2 X-bit as a condition indicator bit for that card.

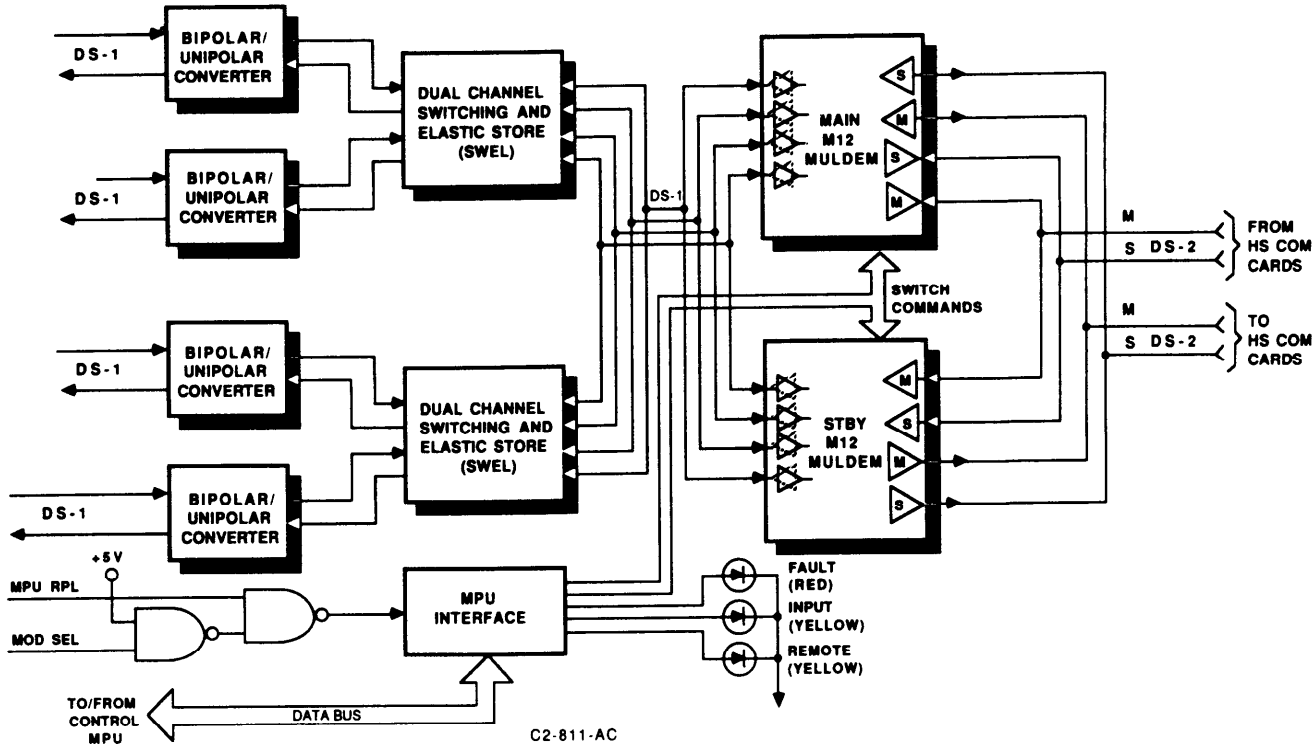


Figure 2A-3. LS INTER T1 Card Block Diagram

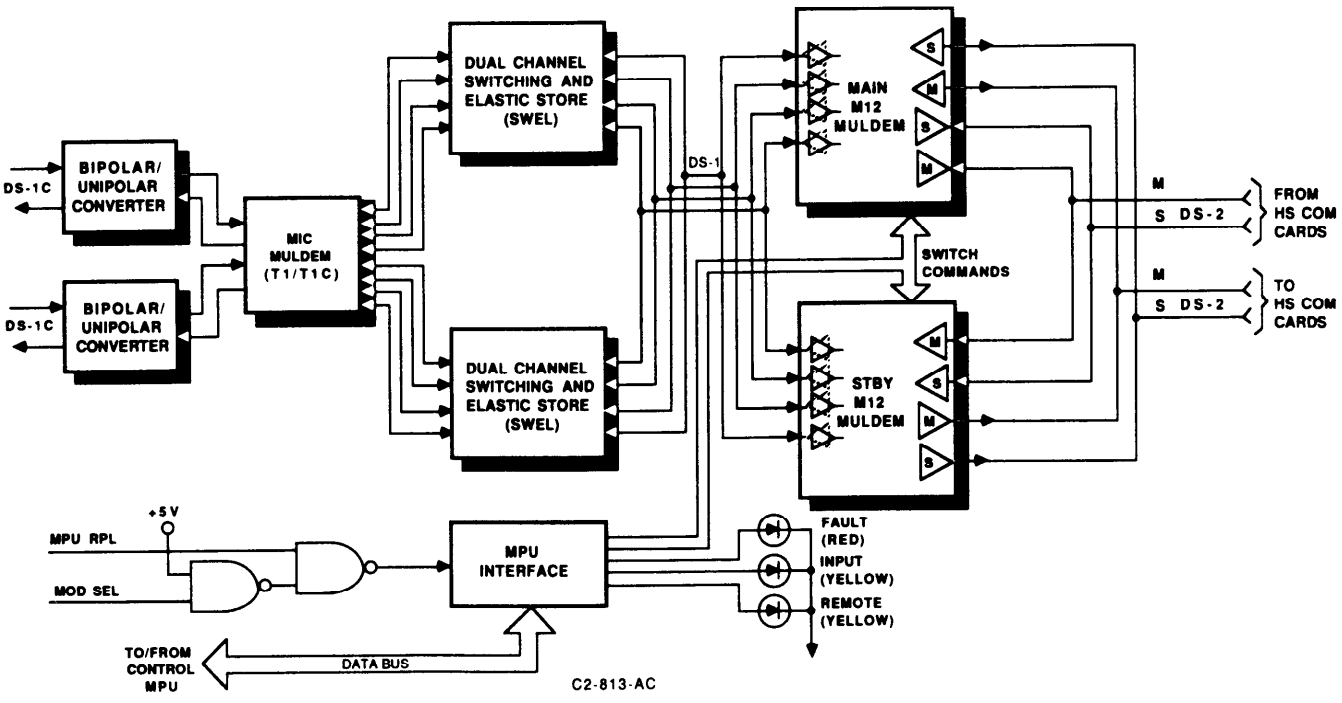
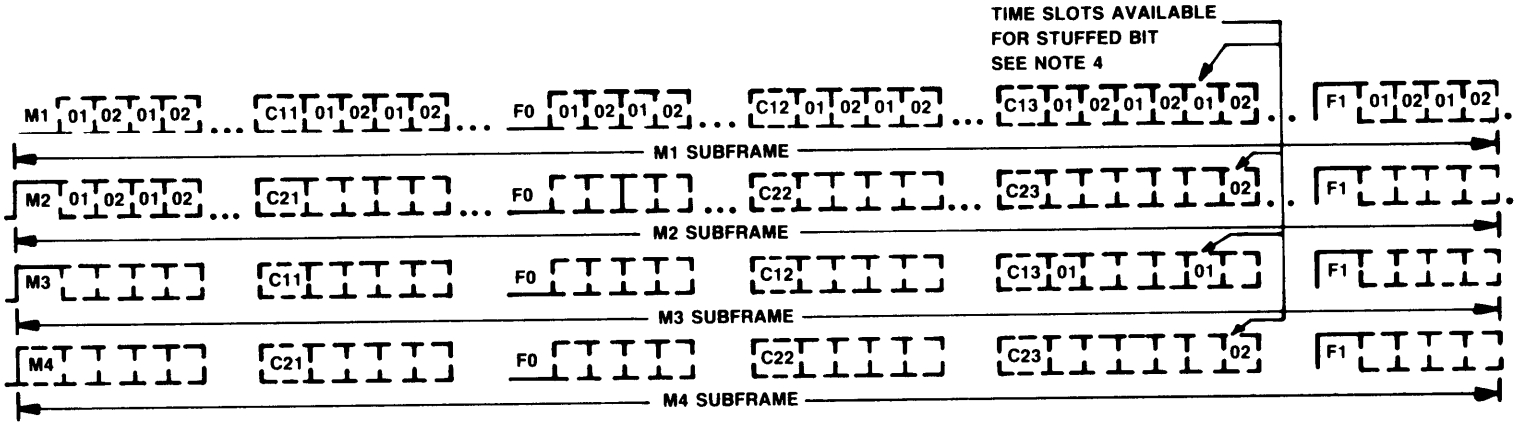


Figure 2A-4. LS INTER T1C Card Block Diagram



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.

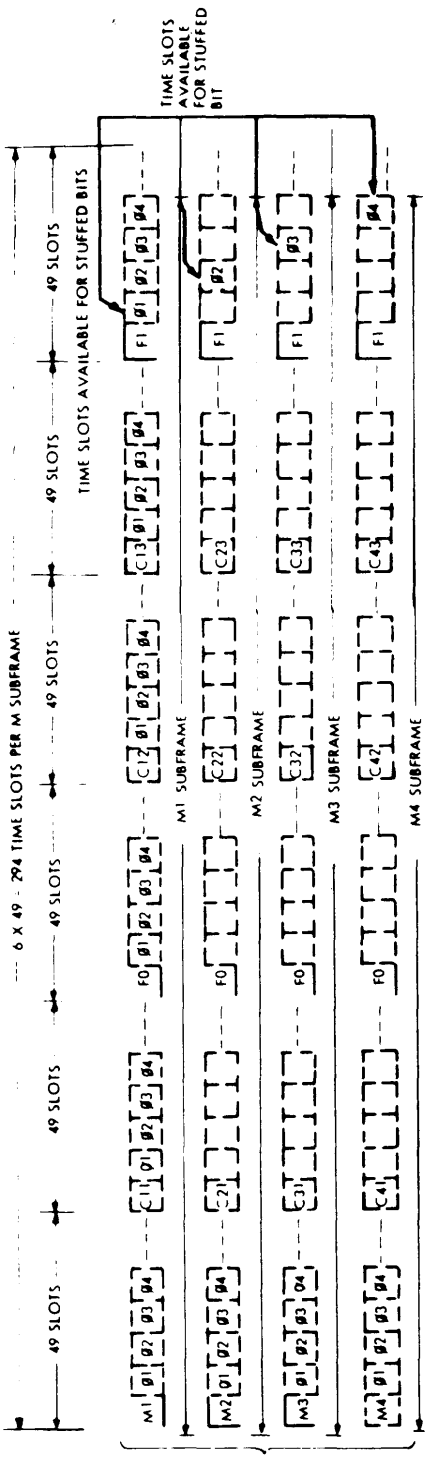
(4) THE TIME SLOT AVAILABLE FOR STUFFING INPUT 1 IS THE THIRD SLOT FOR INPUT 1, 01, FOLLOWING C13.

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

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

B2-1100-AA

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



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

84-579-AA

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

DIGITAL TRANSMISSION SYSTEM
828A DIGITAL MULTIPLEXER
T2 LOW-SPEED INTERFACE CIRCUIT CARD THEORY OF OPERATION
CCA007G1 (MAIN)/CCA068G1 (STBY)

CONTENTS PAGE

1. SCOPE..... 2B-1

2. FUNCTIONAL DESCRIPTION..... 2B-1

A. General Description..... 2B-1
B. Interfaces..... 2B-1
C. Controls and Options..... 2B-1
D. Alarms..... 2B-2

3. OPERATIONAL THEORY..... 2B-2

1. SCOPE

1.01 This subsection presents a functional description of the MAIN and STBY LS INTER T2 (T2 Low-Speed Interface) cards. The STBY INTER T2 card virtually mirrors the MAIN LS INTER T2 card. Minor differences are pointed out as relevant in the following paragraphs. A Table is provided that describes the LEDs, switches, and test jacks located on the circuit cards.

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

2. FUNCTIONAL DESCRIPTION

A. General Description

2.01 The LS INTER T2 card processes both transmit and receive signals. The 828A/828AF is equipped with MAIN and STBY T2 cards to provide protection. Up to six LS INTER T2 cards can be configured in the 828A/828AF, thereby allowing for one LS INTER T1 or T1C card, which provides the mux-to-mux communication. Only the transmit function is discussed, since receive is the reverse of transmit. A functional block diagram of the LS INTER T2 card (MAIN and STBY) is shown in Figure 2B-1.

B. Interfaces

2.02 The B6ZS (Bipolar with Six-Zero Substitution) DS-2 (6.312 Mb/s) external equipment signal interface consists of wire-wrap pins on the rear of the 828A/828AF Motherboard (backplane), behind the LS INTER T2 card mounting connector. The LS INTER T2 also interfaces internally with the HS COM (High-Speed Common) card and with the MPU (Microprocessor Unit) through the same connector.

C. Controls and Options

2.03 The MAIN and STBY LS INTER T2 cards contain no controls or options. However, the MAIN LS INTER T2 card has an MPU REPLACE switch on the front of the card. This switch is in the ON position only during the replacement of the Control MPU card.

2.04 Build-Out modules on LS INTER T2 cards compensate for various cable lengths between the 828A/828AF and the DSX-2 cross-connect to maintain industry-standard signal characteristics at the DSX-2 cross-connect facility. See TABLE A.

TABLE A. T2 Build-Out Module Selection

DS-2 CABLE LENGTH FROM 828A/828AF TO CROSS-CONNECT	PART NUMBER	COLOR CODE
0 - 200 ft.	AXX029G5	blue
201 - 400 ft.	AXX029G4	green
401 - 600 ft.	AXX029G3	yellow
601 - 800 ft.	AXX029G2	orange
801 - 1000 ft.	AXX029G1	red

D. Alarms

2.05 The Control MPU card forces the MAIN LS INTER T2 card to insert an AIS (Alarm Indication Signal) whenever there is a loss of DS-3 input to the multiplexer, or there is a loss of framing in the DS-3 input signal (see Figure 2B-2). AIS is automatically inserted when there is no far-end input. The AIS is an all ones data stream. The STBY LS INTER T2 card cannot output an AIS.

2.06 There are four LEDs on the MAIN LS INTER T2 card, and only one LED (FAULT) on the STBY card. The LEDs and their functions are listed in TABLE B.

3. OPERATIONAL THEORY

3.01 DS-2 signals enter and exit the T2 MAIN and STBY cards through wire-wrap pins on the backplane of the 828A/828AF behind the location of the DS-2 Low-Speed Interface card. These DS-2 signals are applied to relay K1, where they are 1:1 protected by the STBY card (see Figure 2B-1). The signal is then applied to a RCVR (Receiver) circuit, which extracts the clock, converts the bipolar signal to unipolar, amplifies, and provides an automatic line buildout that equalizes the signal. The output from the RCVR is fed to a bipolar violation detector and B6ZS decoder. The decoder converts the coded word to original data, and then applies the asynchronous signal to the elastic store. The elastic store performs pulse stuffing, and outputs a synchronous signal. The signal is fed to a switching circuit controlled by the Control MPU card, which switches the DS-2 traffic if a fault occurs. If a transmit fault occurs on the LS INTER T2 card, relay K1 on the MAIN and STBY card energizes. With K1 in the energized position, the DS-2 transmit data is applied to the transmit section of the STBY card. K2 is used for receive switching in the same manner.

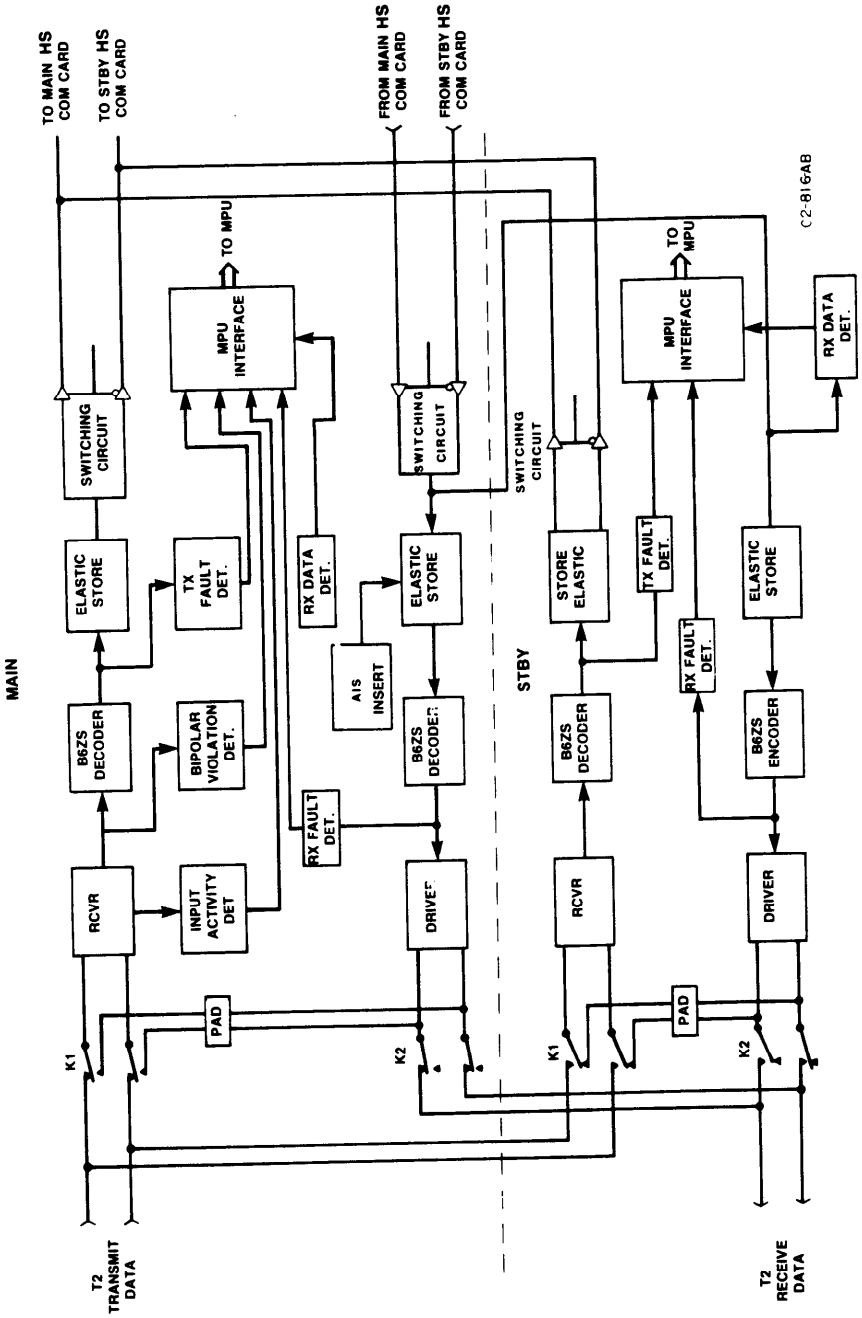
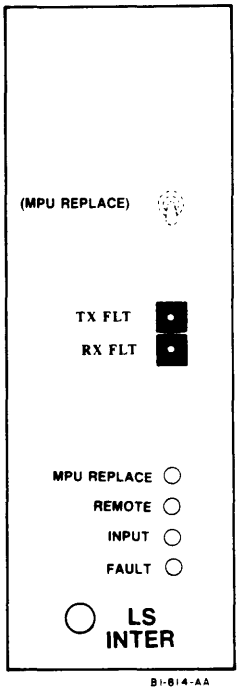
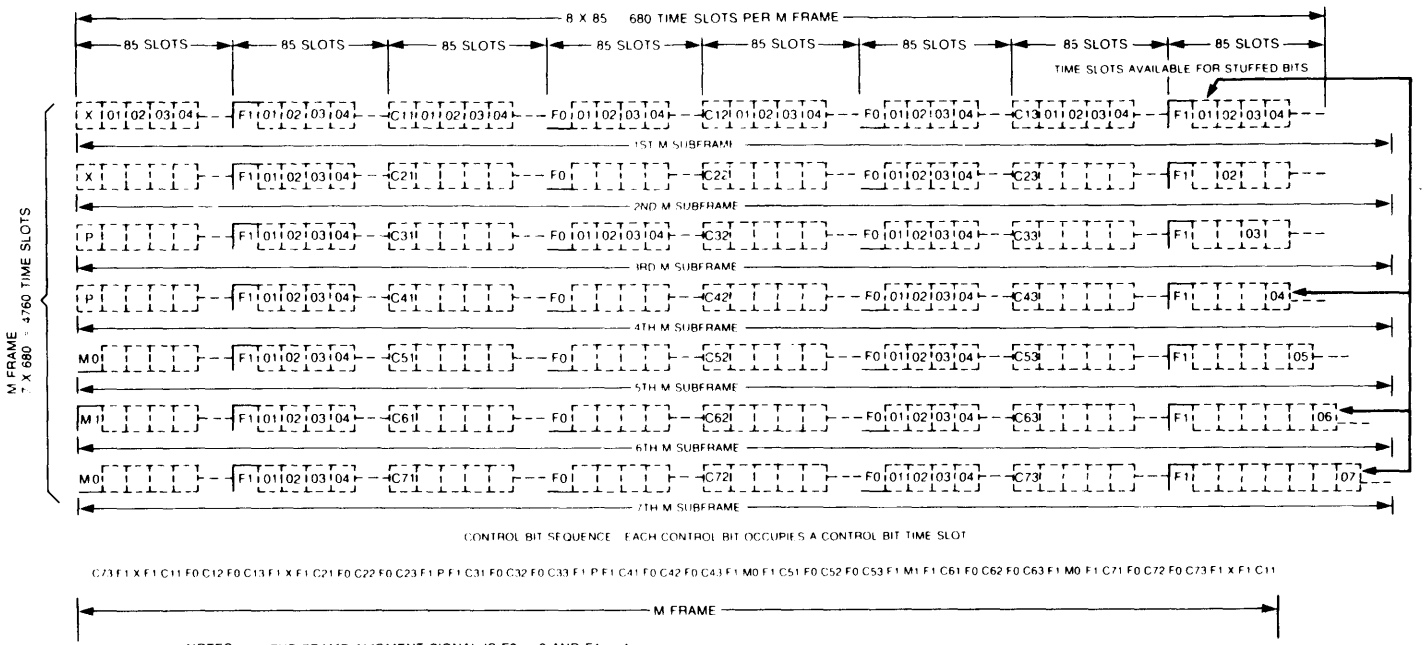


Figure 2B-1. LS INTER T2 Card (MAIN and STBY) Block Diagram

TABLE B. LS INTER T2 Card Indicators, Switch, and Test Jacks

INDICATOR	DESCRIPTION OF MONITORED POINT	ILLUSTRATION
*REMOTE (yellow)	Illuminates when the corresponding Low-Speed Interface card at the far end has a fault or loss of input.	
*INPUT (yellow)	Illuminates when a loss of DS-2 input occurs on the previously functional DS-2 channel associated with the card. Flashing INPUT LED indicates the occurrence of ten consecutive incoming B6ZS line coding error-seconds. This translates into an equivalent BER worse than 10^{-6} BER. Note: When the near-end INPUT LED is illuminated due to the loss of incoming DS-2 data, a REMOTE LED will be illuminated on the corresponding far-end Low-Speed Interface card.	
FAULT (red)	Illuminates when the LS INTER T2 card has a failure.	
*MPU REPLACE (red)	Illuminates when the MPU Replace Switch on the T2 card or the Maintenance Interface card is in the ON position. (All switching is disabled.)	
*MPU REPLACE Switch	The OFF (down) position is for normal operation. The ON (up) position is used when replacing the Control MPU card.	
TEST POINT	FUNCTION	
TX FLT Test Jack (Transmit Fault)	Used to simulate a fault in the B6ZS encoder transmit circuitry.	
RX FLT Test Jack (Receive Fault)	Used to simulate a fault in the B6ZS decoder receive circuitry.	

* These LEDs and the switch are not present on the STBY LS INTER T2 card.



NOTES (1) THE FRAME ALIGMENT SIGNAL IS F0 0 AND F1 1

(2) M0 M1 M0 IS THE MULTIFRAME ALIGMENT SIGNAL AND APPEARS IN THE 5TH, 6TH, AND 7TH M SUBFRAMES MO-0 AND M1-1

(3) PP IS PARITY INFORMATION TAKEN OVER ALL INFORMATION TIME SLOTS IN THE PRECEEDING M FRAME. PP 11 IF THE DIGITAL SUM OF ALL INFORMATION BITS IS 1 AND PP 00 IF THE SUM IS 0. THESE TWO PARITY BITS ARE IN THE 3RD AND 4TH M SUBFRAMES

(4) XX MAY BE USED FOR AN ALARM SERVICE CHANNEL IN ANY ONE M FRAME THE TWO X-BITS MUST BE IDENTICAL

(5) C11 C12 C13 STUFFING INDICATOR WORD FOR 6 312 MB/S INPUT 1 000 INDICATES NO STUFFING AND 111 INDICATES STUFFING WAS DONE

(6) THE TIME SLOT AVAILABLE FOR STUFFING 6 312 MB/S INPUT 1 IS THE FIRST SLOT FOR INPUT 1 (01) FOLLOWING F1 IN THE FIRST M SUBFRAME

(7) THE MAXIMUM STUFFING RATE PER 6 312 MB/S INPUT IS 9398 BITS/SEC

(8) THE NOMINAL STUFFING RATE PER 6 312 MB/S INPUT IS 3671 BITS/SEC

(9) FIRST SLOT BEFORE EACH 01 TIME SLOT IS A CONTROL BIT TIME SLOT

B4-580-AA

Figure 2B-2. DS-3 (44.736 Mb/s) Data Stream Format

DIGITAL TRANSMISSION SYSTEM
828A DIGITAL MULTIPLEXER
LOW-SPEED MAIN AND STBY LINE TERMINATING UNIT CIRCUIT CARDS
THEORY OF OPERATION
CCA148G1/CCA149G1

CONTENTS PAGE

1. SCOPE..... 2C-1

2. FUNCTIONAL DESCRIPTION..... 2C-2

A. General Description..... 2C-2
B. Interfaces..... 2C-2
C. Controls and Options..... 2C-3
D. Alarms..... 2C-5

3. OPERATIONAL THEORY..... 2C-8

A. Optical Transmit Circuitry..... 2C-8
B. Optical Receive Circuitry..... 2C-9

1. SCOPE

1.01 This subsection presents a functional description of the MAIN and STBY LTUs (Line Terminating Units) used in the 828A/828AF (and FOX-2/FOX-2R). Both MAIN and STBY LTUs are electrically identical, but are physically mirror images of one another to facilitate installation. Figure 2C-1 illustrates the LTU from the front and side perspectives.

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

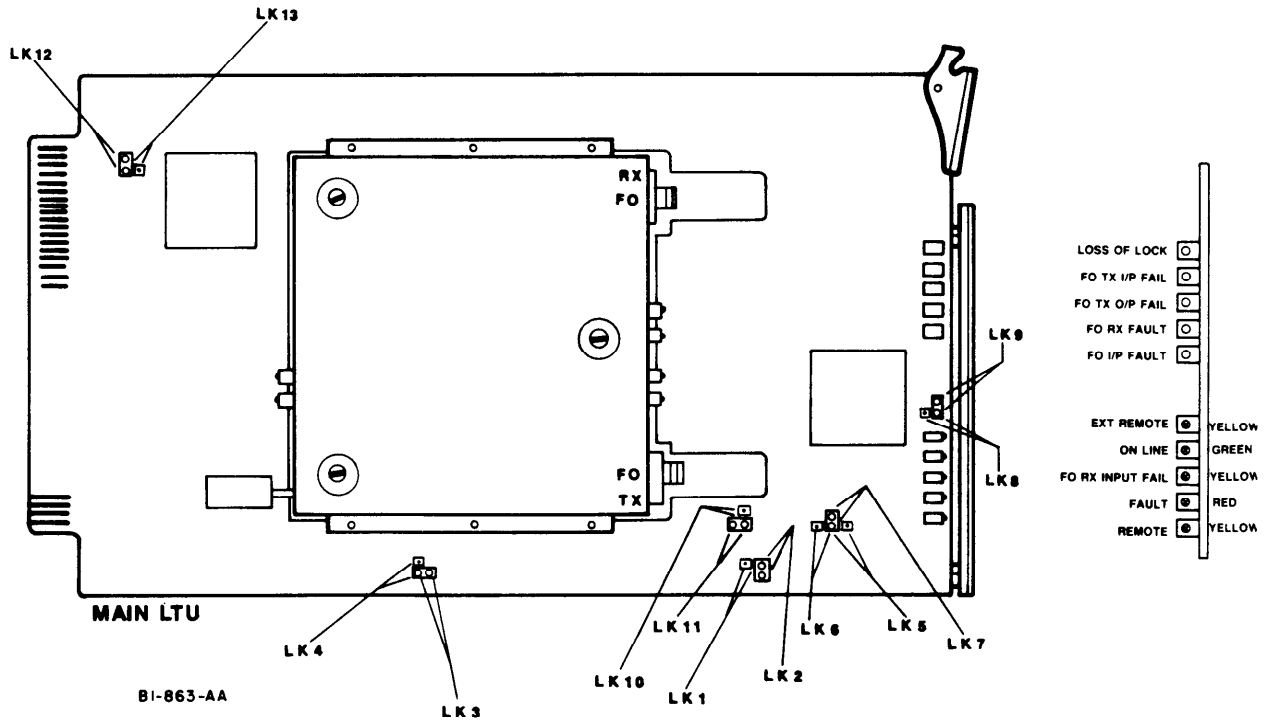


Figure 2C-1. LTU Low-Speed Interface Card (MAIN LTU Illustrated)

2. FUNCTIONAL DESCRIPTION

A. General Description

2.01 The LTU provides an electrical-to-optical interface between the DS-2 data stream in the 828A/828AF and the optical transmission fiber. In the transmit direction, the LTU receives a 6.312 Mb/s DS-2 data channel from the HS COM (High-Speed Common) card, 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 an 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 -43 dBm (at 10^{-9} 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 STBY) for each DS-2 optical extension span from the 828A/828AF unit. The LTUs 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 828A/828AF:

a. Accepts DS-2 data from the HS COM card at a 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.

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

c. Generates a 12.624 Mb/s crystal-stabilized transmit system clock to be used as the master timing for the MAIN and STBY LTU transmit circuit cards.

d. Provides internal local or remote DS-2 loopback on MPU (Microprocessor Unit) command.

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

B. Interfaces

2.05 The LTU processes 6.312 Mb/s DS-2 data and timing signals from the HS COM card in the 828A/828AF. Unipolar electrical interface between the LTU and the HS COM card 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 card (see Figure 2C-2). 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 MPU interface is accomplished through the use of an eight-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.

C. Controls and Options

2.08 There are no controls or option switches contained on the LTU card.

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

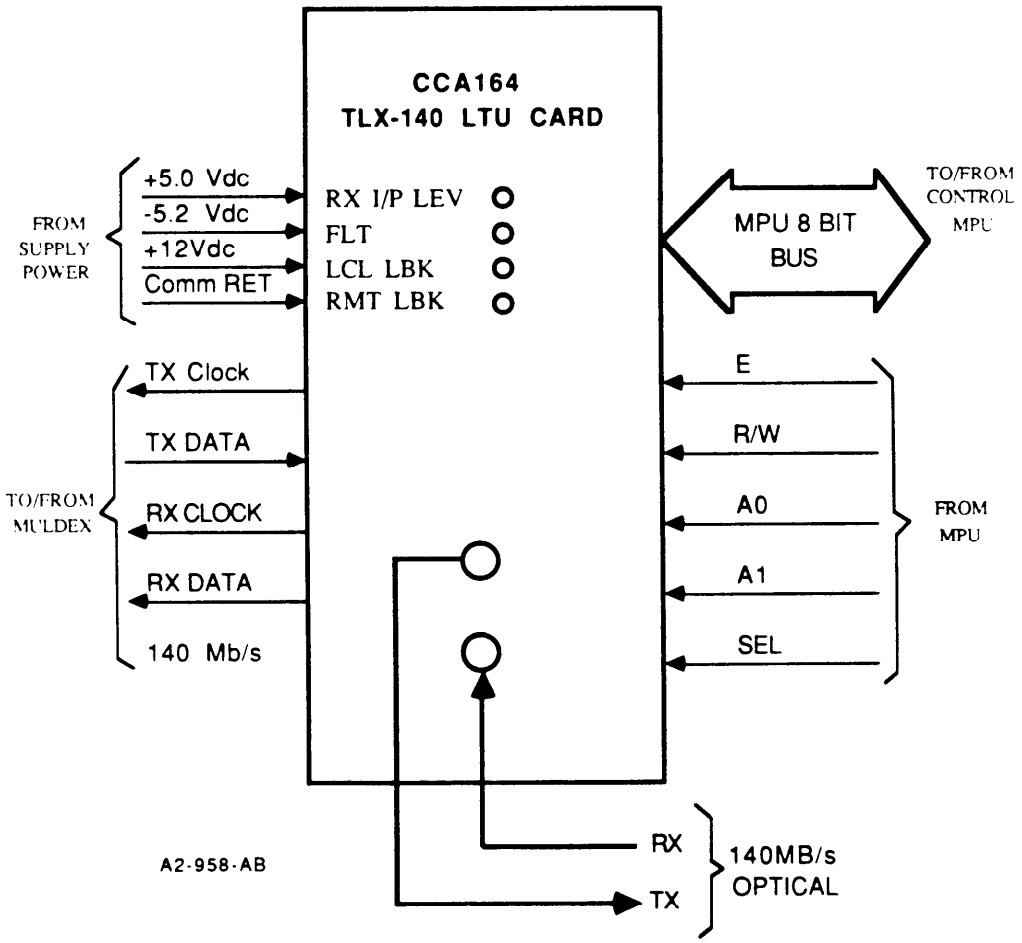


Figure 2C-2. LTU Interfaces

TABLE A. MAIN and STBY LTU Card Option Jumpers
(CCA148G1 MAIN LTU Card and CCA149G1 STBY LTU Card)

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

LTU circuit card configurations for application in FOX-2/FOX-2R, 828M, 828F, 828A, 828AF with and without TELTRAC are as follows:

1. LTU card utilized in FOX-2/FOX-2R unit not equipped for TELTRAC or RAC-II:

   LK2, LK3, LK7, LK9, LK11, LK12 are installed only.
   LK1, LK4, LK5, LK6, LK8, LK10, LK13 are removed.

2. LTU card utilized in FOX-2/FOX-2R unit equipped for TELTRAC or RAC-II:

   LK2, LK3, LK6, LK9, LK11, LK12 are installed only.
   LK1, LK4, LK5, LK7, LK8, LK10, LK13 are removed.

3. LTU card utilized in 828A multiplexer unit equipped for TELTRAC or RAC-II:

   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 or RAC-II:

   LK2, LK3, LK7, LK9, LK11, LK13 are installed.
   LK1, LK4, LK5, LK6, LK8, LK10, LK12 are removed.

Note: For TELTRAC or RAC-II card operation in FOX-2/FOX-2R DS-2 optical extension application, a CCA135G1 Optional MPU-II card must be used in the 828A/828AF.

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 HS COM 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 FAULT 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 828A/828AF 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.

2.16 TABLE B lists all MAIN and STBY LTU status indicators and test points.

TABLE B. LTU (MAIN and STBY) Card Indicators and Test Points

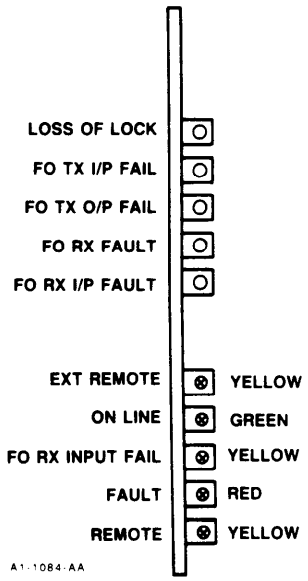
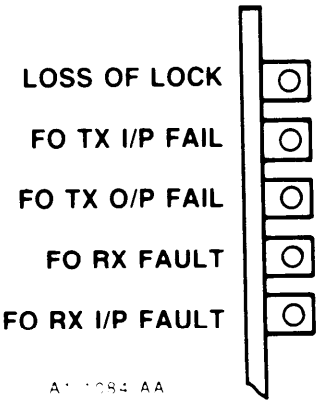
LED INDICATOR	DESCRIPTION OF MONITORED POINT	ILLUSTRATION
EXT REMOTE (yellow)	When utilized in an 828A/828AF equipment cage, this LED indicates a FOX-2/FOX-2R failure at the opposite end of the DS-2 optical Extension. When utilized in FOX-2/FOX-2R units, this LED is not used.	
ON LINE (green)	Illumination indicates that LTU fiber-optic input 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/828AF equipment cage, the illumination of this LED indicates a failure in the 828A or 828AF far-end LS Interface card. When utilized in FOX-2/FOX-2R units, this LED is not used.	

TABLE B. LTU (MAIN and STBY) Card Indicators and Test Points (Cont.)

TEST POINT	FUNCTION	ILLUSTRATION
TP1 LOSS OF LOCK	Simulates a loss of receive timing phase lock.	
TP2 FO TX I/P FAIL	Creates 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.	

3. OPERATIONAL THEORY

3.01 Consult Figure 2C-3 for a detailed block diagram of the operation of the MAIN or STBY LTU card.

A. Optical Transmit Circuitry

Input

3.02 Input gates route the DS-2 data stream from the on-line HS COM card into the transmit circuitry of both MAIN and STBY LTUs. Both LTUs transmit the optical signal encoded from the on-line HS COM card.

System Clock

3.03 A crystal-oscillator 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 Local or remote DS-2 loopback command is initiated by TELTRAC (Telco Systems Telecommunications Remote Alarm and Control), a Manual Control Interface card, or by the loopback switch in a FOX-2/FOX-2R. The Control MPU in the 828A/828AF controls the state of the loopback switch circuits in the LTU. Loopback occurs in both the equipment direction and the span direction. During normal operation, data selector gates route the data from the elastic store register to the LED modulator circuit. In loopback mode in the equipment direction, data and timing from the elastic store in the LED modulator circuit are looped back to the receive elastic store, to provide loopback to the HS COM card. In the span direction, receive data and timing outputs from the 3B6B decoder circuitry are looped back through selector gates to the 3B6B encoder circuitry to provide span loopback. Since both local and remote loopbacks utilize the same selector gates for data/timing routing, only one loopback mode, either local or remote, 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 optical span.

3.07 In the presence of a loss of incoming DS-2 data or timing activity, one of two conditions will occur, depending on whether or not the system is using TELTRAC. With TELTRAC, the optical drivers remain active to maintain TELTRAC communications via the overhead information in the 3B6B encoded signal. In the absence of TELTRAC, the optical output is extinguished as a result of loss of DS-2 input activity.

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. Optical Receive Circuitry

PIN Detector

3.10 Incoming optical transmission is applied to a PIN photodiode detector which has a sensitivity of -45 dBm. The PIN photodiode detector 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 from a FOX-2/FOX-2R 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 HS COM card.

Switch

3.16 Output gates route the DS-2 data and timing streams from the LTU to the MAIN or STBY HS COM cards. 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.

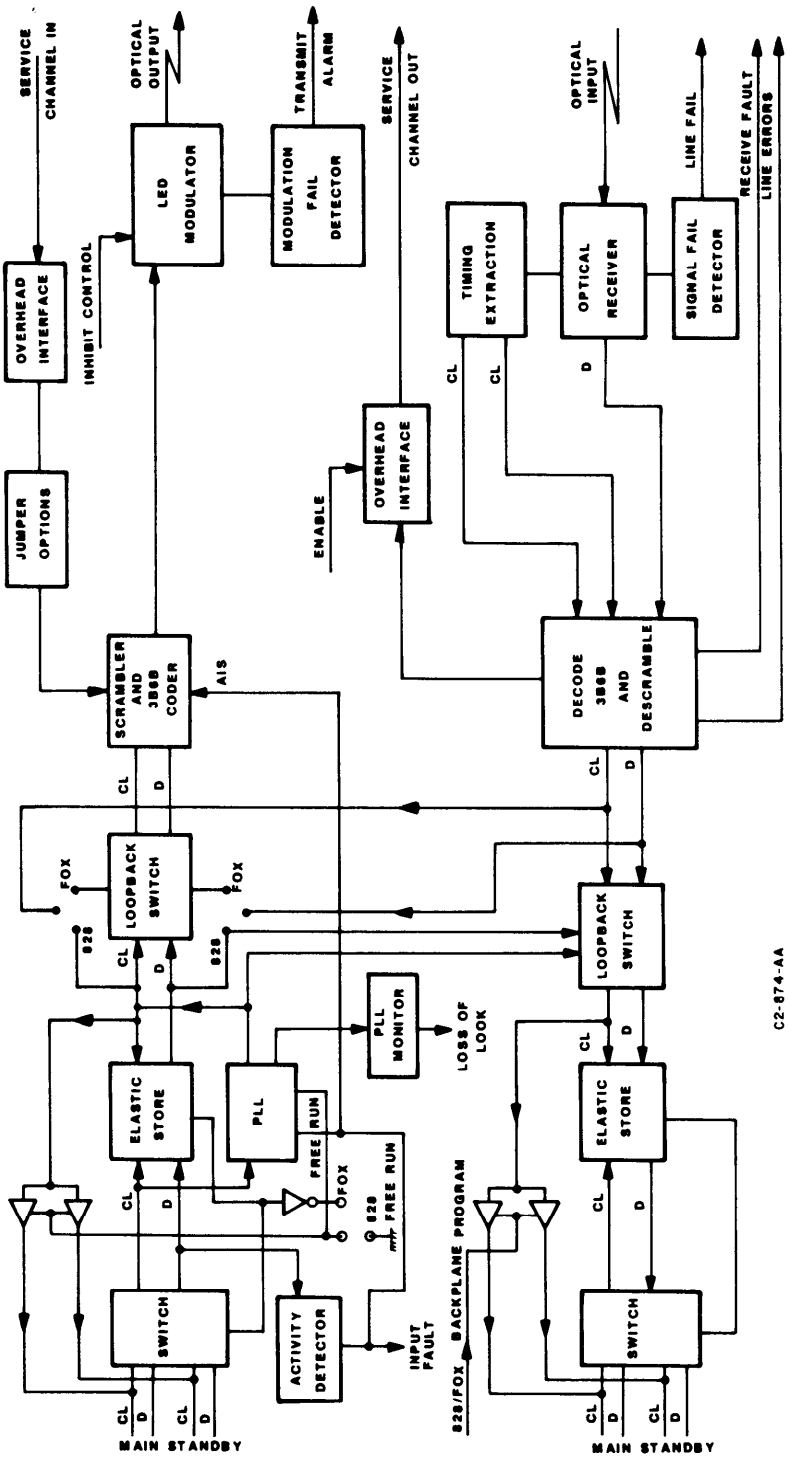


Figure 2C-3. LTU Card (CCA148G1/CCA149G1) Block Diagram

DIGITAL TRANSMISSION SYSTEM
828A DIGITAL MULTIPLEXER
HIGH-SPEED COMMON CIRCUIT CARD THEORY OF OPERATION
CCA120G1

CONTENTS PAGE

1. SCOPE..... 2D-1

2. FUNCTIONAL DESCRIPTION..... 2D-1

A. General Description..... 2D-1
B. Interfaces..... 2D-1
C. Controls and Options..... 2D-1
D. Alarms..... 2D-1

3. OPERATIONAL THEORY..... 2D-2

A. Transmit Circuitry..... 2D-2
B. Receive Circuitry..... 2D-2

1. SCOPE

1.01 This subsection presents a functional description of the HS COM (High-Speed Common) card used in 828A and 828AF units (see Figure 2D-1).

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 HS COM card multiplexes seven DS-2 data streams into one DS-3 mastergroup formatted data stream, and also demultiplexes a DS-3 mastergroup formatted data stream into its DS-2 components. The HS COM card can be 1:1 protected.

B. Interfaces

2.02 The HS COM card has no interfaces to external equipment. Internally the HS COM card interfaces with the High-Speed XCVR (Transceiver) in the 828AF unit or with the WLEL (Wire-Line Entrance Link) in the 828A unit, the Control MPU (Microprocessor Unit), and all Low-Speed Interface cards through the HS COM mounting connector on the motherboard.

C. Controls and Options

2.03 The HS COM card has no controls or option switches.

D. Alarms

2.04 The HS COM card has one alarm LED and four status LEDs mounted on the front of the card. The LEDs and their functions are listed in TABLE A.

3. OPERATIONAL THEORY

A. Transmit Circuitry

3.01 A functional block diagram of the HS COM card is shown in Figure 2D-1. The HS COM card accepts up to seven DS-2 data streams from the Low-Speed Interface cards, and multiplexes them into a single DS-3 (44.736 Mb/s) data stream. Timing is provided by a 44.736 MHz clock signal provided by the local oscillator mounted on the HS COM card. The HS COM card also multiplexes the appropriate DS-3 overhead data and stuffing bits with the DS-2 signals. The resulting DS-3 data stream is encoded in an industry standard DS-3 mastergroup format. In the 828AF unit the output of the M23 MULDEM (DS-2 to DS-3 Multiplexer/ Demultiplexer) is used to modulate a multimode laser or single-mode LED or laser on the High-Speed XCVR card. In the 828A unit, the output of the M23 MULDEM provides the input for the WLEL card.

3.02 The M23 MULDEM has a comparator multiplexer in addition to the transmitting multiplexer. The transmitting multiplexer sends the comparator multiplexer circuitry a sync pulse that keeps the framing bits in phase. The output of the multiplexers are compared, and a fault alarm signal is generated whenever the outputs do not agree. The alarm signal is sent to the Control MPU card, which illuminates the FLT LED on the HS COM card.

B. Receive circuitry

3.03 The unipolar data and recovered timing inputs from the XCVR card are applied to the channel drivers on the HS COM card, where the signals are converted from ECL to TTL logic. The signals from the channel drivers are also sent to a clock recovery circuit.

3.04 The clock recovery circuit on the 828A Multiplexer logically ORs the positive and negative signals from the channel drivers. The output is a receive timing signal. In the 828AF fiber-optic multiplexer, clock recovery is accomplished on the XCVR card.

3.05 The converted DS-3 data and timing signals are routed to the M23 MULDEM, which demultiplexes the signals into their component DS-2 data and timing signals. The DS-2 signals are sent from the HS COM card to the Low-Speed Interface cards, where they are demultiplexed from DS-2 to DS-1 or DS-1C, as required. All stuffing bits added for bit synchronization at the transmitting end of the system are deleted from the data stream prior to line signal encoding.

3.06 The M23 also performs frame and parity checks on the incoming DS-3 data stream. Any error generates an alarm signal, which is sent to the Control MPU card.

Latch Reset Circuit

3.07 The M23 MULDEM will go into a locked state after a fault condition occurs. The Latch Reset circuit utilizes various timing signals to unlock and reset the M23 MULDEM.

Protection Switching

3.08 The Control MPU automatically switches the on-line transmit or receive data to the STBY HS COM card whenever a failure is detected on the MAIN HS COM card. Transmit and receive traffic is switched independently between MAIN and STBY HS COM cards. A switch is also initiated in an 828AF when an AIS (Alarm Indication Signal) signal is received from the fiber-optic span.

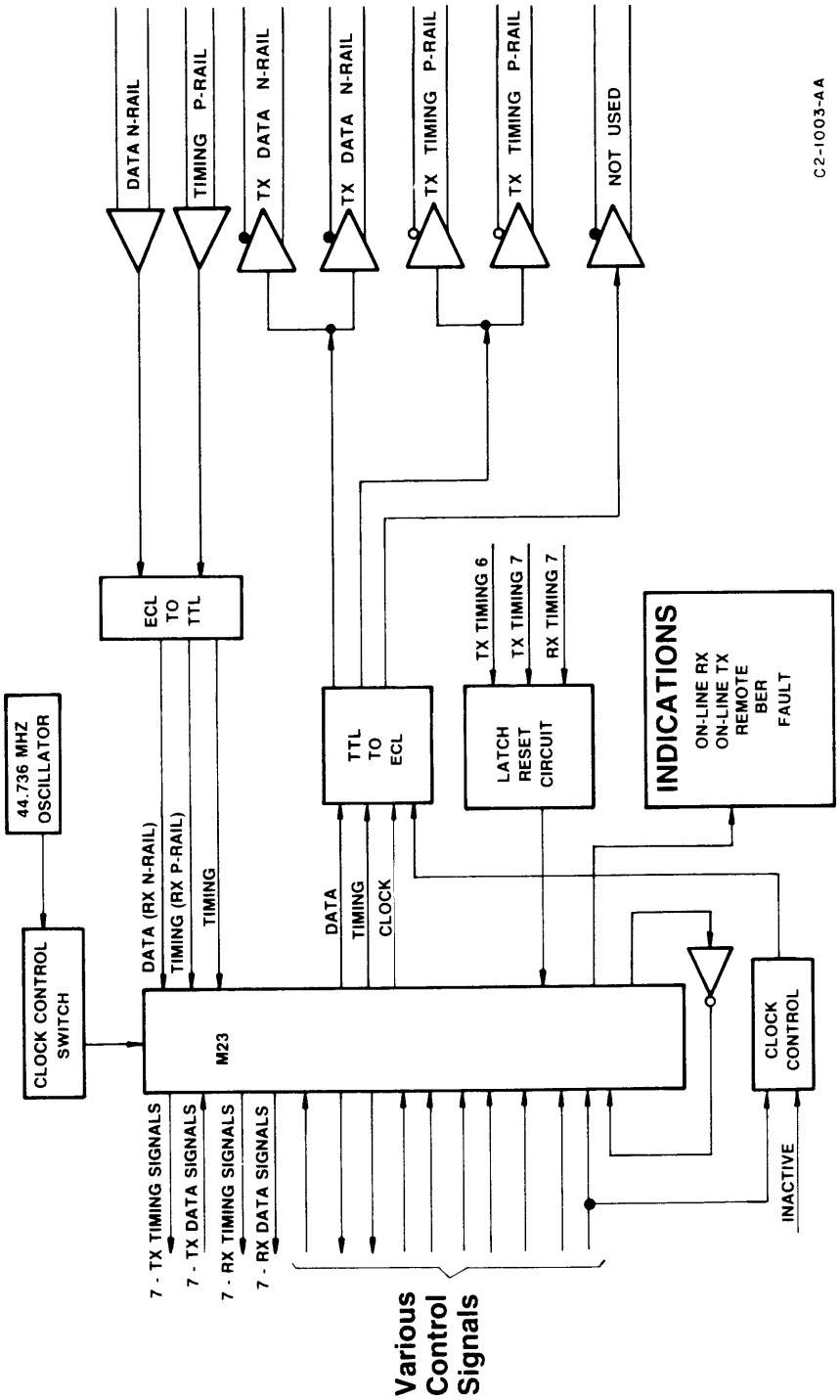
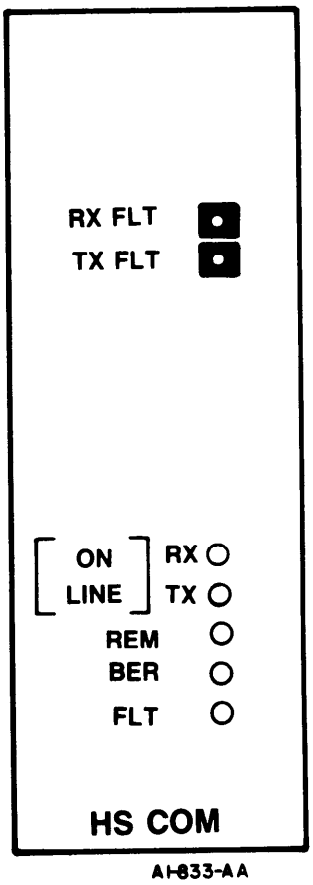


Figure 2D-1. HS COM Card Block Diagram

TABLE A. HS COM Card Indicators and Test Jacks

INDICATOR	DESCRIPTION OF MONITORED POINT	ILLUSTRATION
RX ON LINE (green)	Illuminates when the receive demultiplexer is carrying traffic.	
TX ON LINE (green)	Illuminates when the transmit multiplexer is carrying traffic.	
REM (yellow) (Remote)	Illuminates when the corresponding HS COM or WLEL (Wire Line Entrance Link) card at the far end has a fault.	
BER (red) (Bit Error Rate)	Illuminates when the BER exceeds the predetermined BER threshold.	
FLT (red) (Fault)	Illuminates when the HS COM card has a failure.	
TEST POINT	FUNCTION	
RX FLT Test Jack (Receive Fault)	Used to simulate a fault in the Receive circuitry.	
TX FLT Test Jack (Transmit Fault)	Used to simulate a fault in the Transmit circuitry.	

DIGITAL TRANSMISSION SYSTEM
828A DIGITAL MULTIPLEXER
WIRE-LINE ENTRANCE LINK CIRCUIT CARD THEORY OF OPERATION
CCA118G1

CONTENTS PAGE

1. SCOPE..... 2E-1

2. FUNCTIONAL DESCRIPTION..... 2E-1

A. General Description..... 2E-1
B. Interfaces..... 2E-3
C. Controls and Options..... 2E-3
D. Alarms..... 2E-4

3. OPERATIONAL THEORY..... 2E-6

A. Transmit Operation..... 2E-6
B. Receive Operation..... 2E-6
C. Switching..... 2E-6
D. Protection..... 2E-6

1. SCOPE

1.01 This subsection presents a functional description of the WLEL (Wire-Line Entrance Link) card used in 828A Digital Multiplexer.

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 MAIN and STBY WLEL cards mount in the two right-hand slots of an 828A Digital Multiplexer (see Figure 2E-1). The WLEL card transmits and receives B3ZS (Bipolar with Three-Zero Substitution) DS-3 signals between an 828A Digital Multiplexer and a DSX-3 cross-connect or transmission equipment.

2.02 In the transmit direction, the WLEL card converts unipolar data and timing signals from the HS COM (High-Speed Common) card into an industry-standard DS-3 B3ZS data stream for coaxial interface to digital microwave or fiber-optic transmission

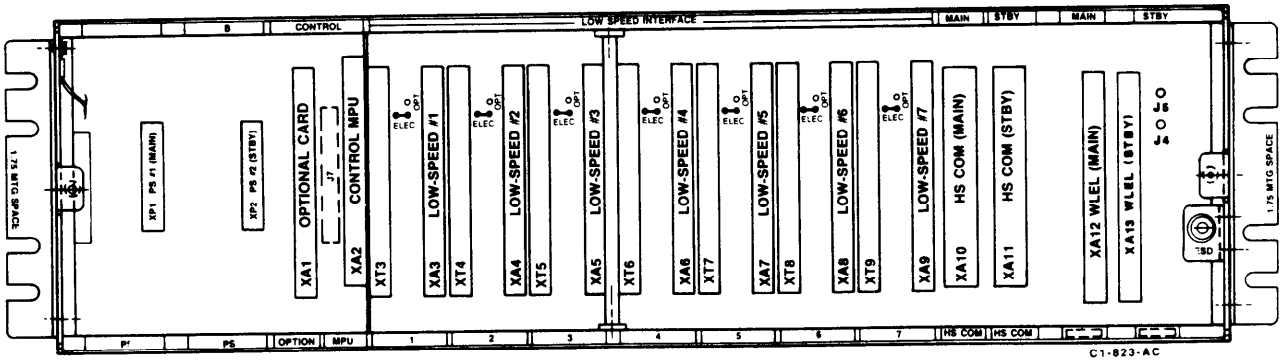


Figure 2E-1. Front of 828A Digital Multiplexer (Cover Removed)

equipment. In the receive direction, the WLEL card converts the received DS-3 B3ZS electrical signal into unipolar data and timing signals, which are sent to the HS COM card for demultiplexing into component DS-2 data streams and for clock recovery (see Figure 2E-2).

2.03 The WLEL card also functions to compensate for various lengths of cable between the 828A unit and the DSX-3 cross connect. In the transmit direction a build-out module assures that the transmitted DS-3 signal meets standards established for signal characteristics at the DSX-3 cross-connect. In the receive direction an equalizer circuit on the card compensates for impedance and reactances inherent in cable lengths of up to 450 feet.

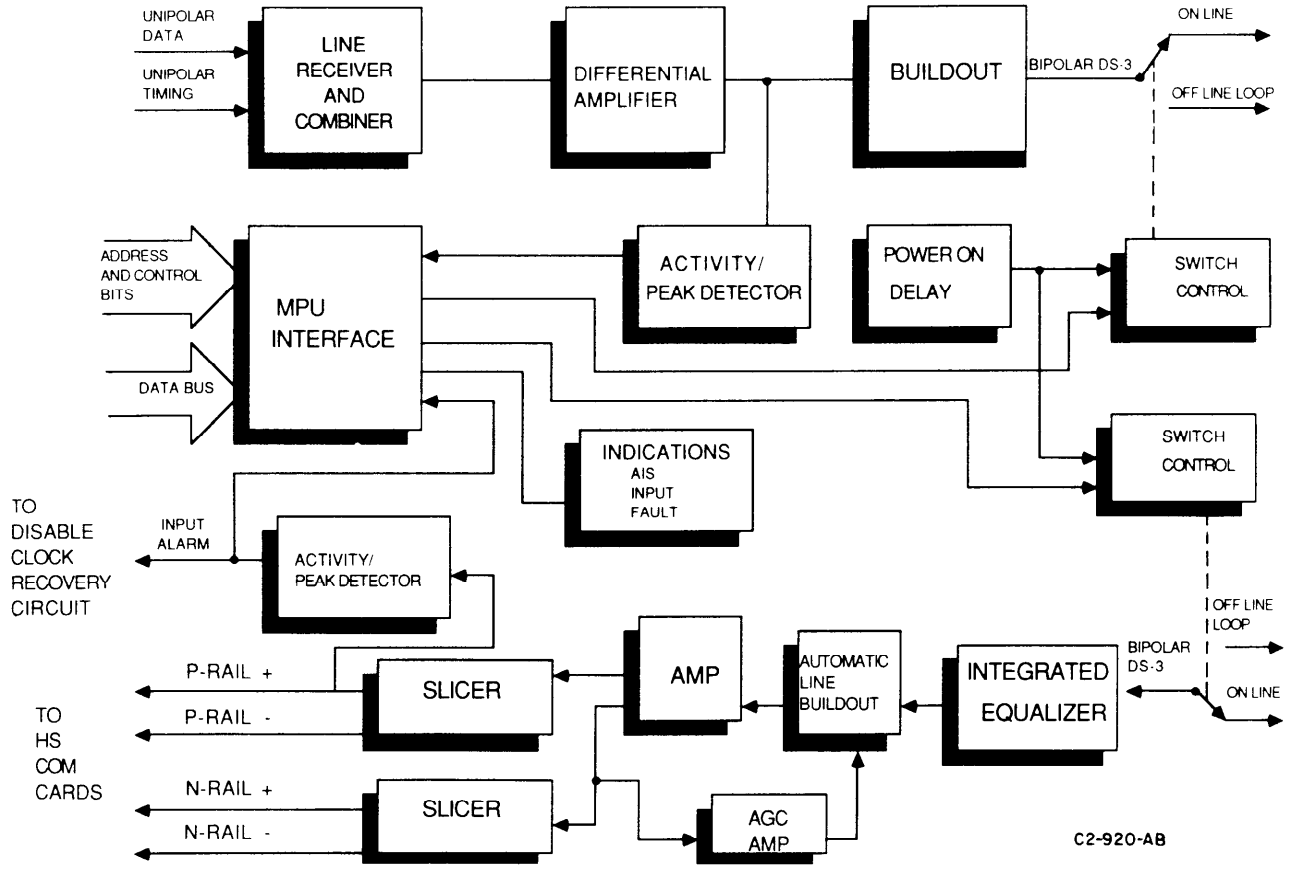


Figure 2E-2. WLEL Interfaces

B. Interfaces

2.04 The WLEL card interfaces to the HS COM card and the Control MPU (Microprocessor Unit) through the edge connector mount on the backplane. DS-3 B3ZS interface to external TX and RX coaxial cable is through the customer interface BNC type connector jacks, mounted on the side of the 828A cage behind the backplane near the WLEL mounting connectors (see Figure 2E-3).

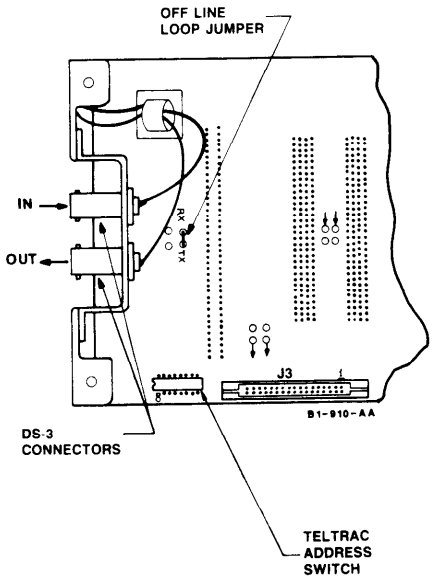


Figure 2E-3. DS-3 BNC Connectors

C. Controls and Options

2.05 The WLEL card has TX FLT (Transmit Fault) and RX FLT (Receive Fault) insertion test jacks accessible on the front of the card. The purpose of the test jacks is to enable testing of ALARM and MAIN/STBY switching operations. See Figure 2E-4.

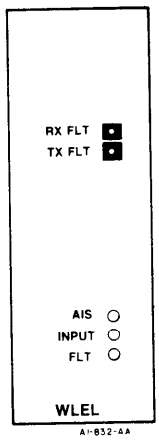


Figure 2E-4. WLEL Card (Front View)

2.06 The Build-Out Module, Z2, options the WLEL card for various lengths of cable between the 828A unit and the DSX-3 cross-connect (see Figure 2E-5). Table A lists the part numbers and characteristics of available Build-Out Modules.

TABLE A. WLEL Build-Out Module Selection

BUILD-OUT MODULE PART NUMBER	CABLE LENGTH TO DSX-3 CROSS-CONNECT FROM 828A	COLOR
1070599G1	0 - 100 ft.	red
1070599G2	101 - 200 ft.	orange
1070599G3	201 - 300 ft.	yellow
1070599G4	301 - 400 ft.	green
1070599G5	401 - 450 ft.	blue

2.07 An equalizer circuit on the CCA118G1 WLEL card compensates for coaxial line length of up to 450 feet in the B3ZS DS-3 receive signal path, eliminating need for separate equalizer modules.

D. Alarms

2.08 The LEDs on the front of the WLEL card and their functions, as well as the test jack locations, are listed in TABLE B.

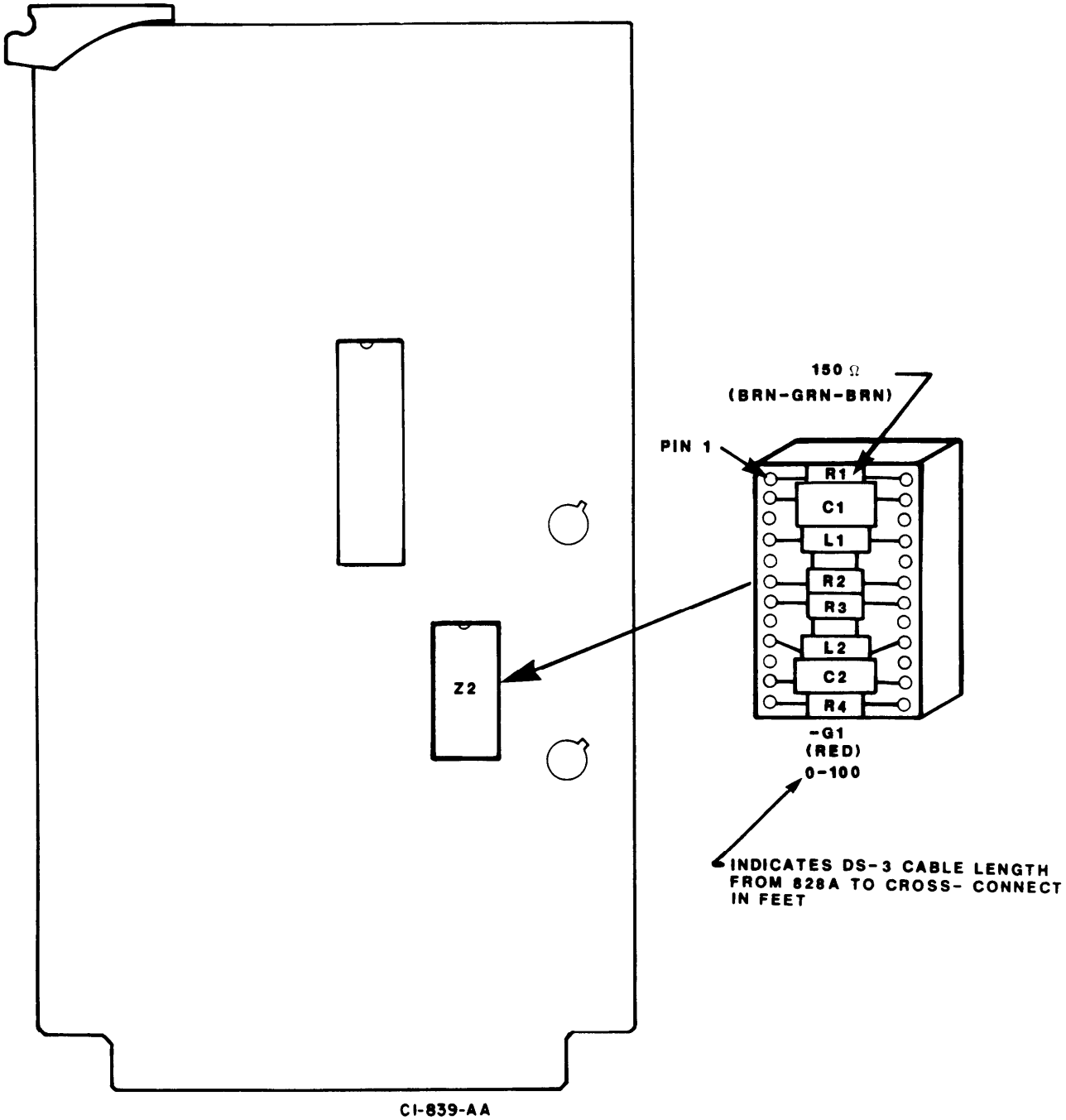
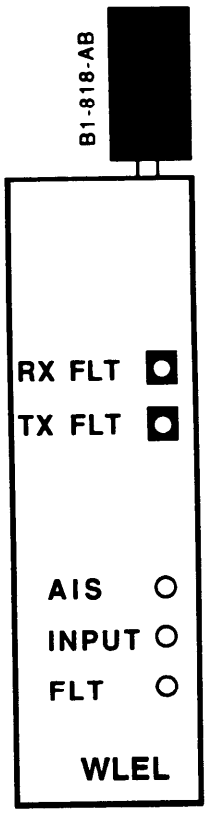


Figure 2E-5. Build-Out Module Orientation

TABLE B. WLEL Card Indicators and Test Jacks

INDICATOR	DESCRIPTION OF MONITORED POINT	ILLUSTRATION
AIS (Alarm Indication Signal) (yellow)	Illuminates when an AIS or unframed all ones is detected.	
INPUT (yellow)	Illuminates when the B3ZS input level falls below the recommended levels.	
FLT (red) (Fault)	Illuminates when the WLEL card has a failure.	
TEST POINT	FUNCTION	
RX FLT Test Jack (Receive Fault)	Used to simulate a fault in the receive circuitry.	
TX FLT Test Jack (Transmit Fault)	Used to simulate a fault in the transmit circuitry.	

3. OPERATIONAL THEORY

A. Transmit Operation

3.01 The WLEL card processes both transmit and receive DS-3 signals. See Figure 2E-6 for a functional block diagram of the WLEL card. The unipolar data and timing signals from the HS COM card are routed to a pulse generator which provides input to a differential amplifier. The differential amplifier combines the unipolar data and timing signals into a single signal. Then an amplifier amplifies the signal into an industry-standard B3ZS output. The build-out circuit compensates for various cable lengths between the 828A unit and the DSX-3 cross-connect, so that the DS-3 signal at the cross-connect will conform to industry requirements.

3.02 The bipolar signal from the differential amplifier is also sent to an activity/peak detector circuit which provides an input to the MPU interface. The MPU card monitors this signal for possible loss of activity, indicating a loss of line coding activity.

B. Receive Operation

3.03 The incoming DS-3 signal from the cross-connect is applied to an integrated equalizer circuit, which compensates for cable lengths of up to 450 feet from the DSX-3 cross-connect. The signal from the integrated equalizer circuit is amplified and then sliced to produce two unipolar signals, P-rail and N-rail, for input to the HS COM card. Demultiplexing and clock recovery are accomplished on the HS COM card.

3.04 The positive P-rail signal is also applied to an activity/peak detector which monitors the sliced DS-3 RX signal. The output from the activity/peak detector is applied to the MPU interface. The MPU monitors the output from the detector and will illuminate the INPUT LED on the WLEL card when loss of input is detected. The MPU also will illuminate the AIS LED when the HS COM card detects an AIS condition.

C. Switching

3.05 Two switches, controlled by the MPU, are used to route on-line traffic through either MAIN or STBY circuits. The TX and RX DS-3 signals can be switched independently so that either the TX or the RX signal can be individually routed through either MAIN or STBY circuitry. The DS-3 B3ZS TX and RX signals, containing both data and timing information, are routed through the on-line MAIN or STBY circuits. Off-line data is routed through the off-line loop (see Figure 2E-2.) This allows the Control MPU to monitor circuit operation in the off-line loop and to detect and report any faults that may occur in the off-line circuits prior to the circuits being switched to on-line. A power-on delay circuit ensures that the switches select the off-line loop when power is first applied.

3.06 High-speed switching of the WLEL cards can be manually controlled by the MAIN/AUTO/STBY switch on the Control MPU card, by the Manual Control Interface card, or by the TELTRAC (Telco Systems Telecommunications Remote Alarm and Control) System. When manually controlled by the MAIN/AUTO/STBY switch, both TX and RX signals are switched simultaneously to either MAIN or STBY circuits.

D. Protection

3.07 The WLEL card is 1:1 protected by a second WLEL card.

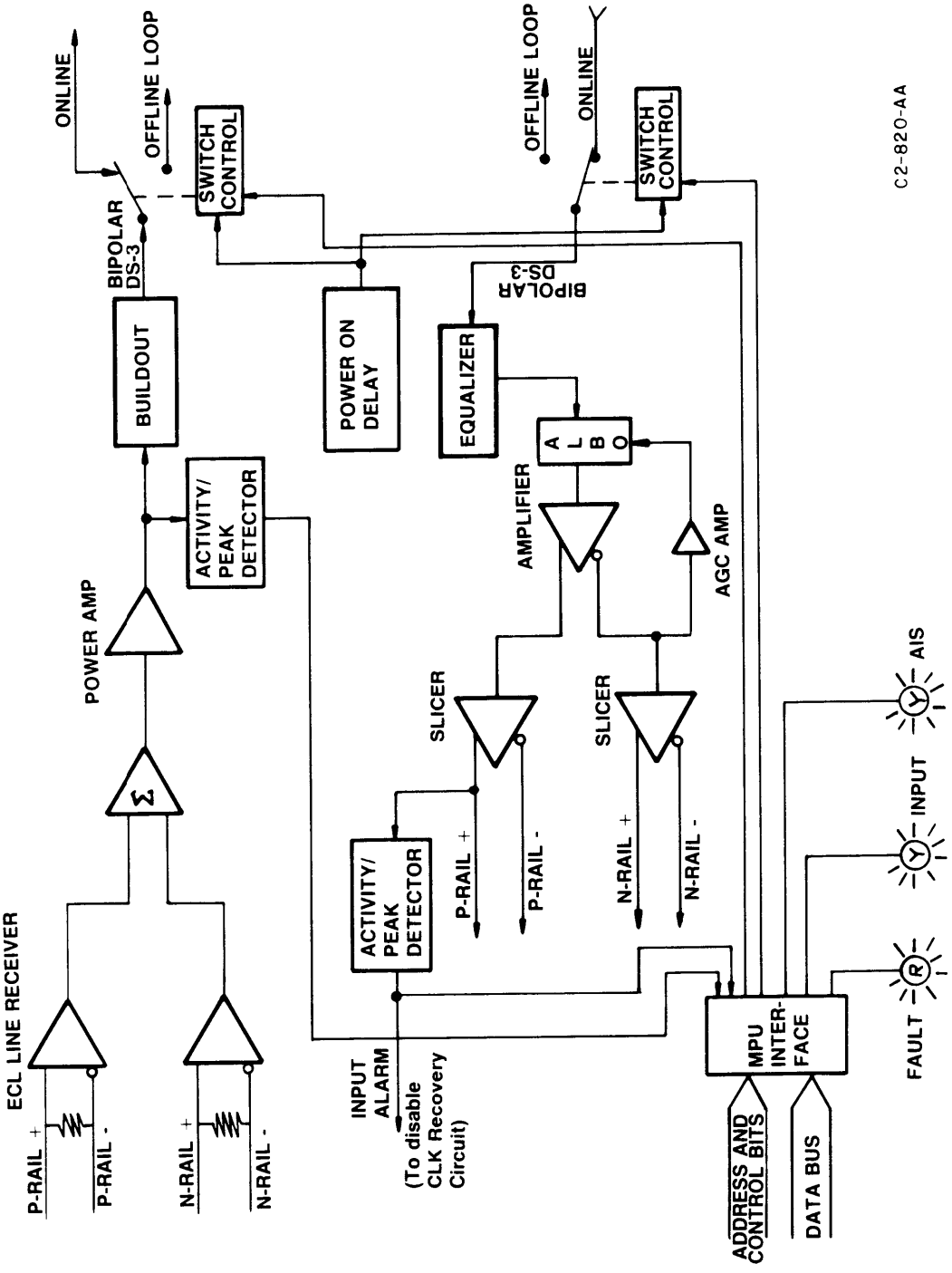


Figure 2E-6. WLEL Card Block Diagram

DIGITAL TRANSMISSION SYSTEM
828A DIGITAL MULTIPLEXER
CONTROL MICROPROCESSOR UNIT THEORY OF OPERATION
CCA137/CCA162

CONTENTS PAGE

1. SCOPE..... 2F-1

2. FUNCTIONAL DESCRIPTION..... 2F-1

A. General Description..... 2F-1
B. Interfaces..... 2F-1
C. Controls and Options..... 2F-1
D. Alarms..... 2F-4

3. OPERATIONAL DESCRIPTION..... 2F-9

1. SCOPE

1.01 This subsection presents a functional description of the Control MPU (Microprocessor Unit). Operational differences between the CCA137 MPU and the CCA162 MPU will be pointed out in the following subsections as appropriate. Figures 2F-1 and 2F-2 are pictorial representations of the two MPUs.

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 Control MPU checks various fault points within the 828A/828AF Digital Multiplexer causing alarm indicators to be illuminated as appropriate, and performs alarm lockout to prevent downline sympathetic alarms. The MPU calculates the incoming DS-3 data stream BER (Bit Error Rate) and error seconds via BPVs (Bipolar Violations) of all Low-Speed inputs, and illuminates LEDs to indicate excessive error rates. The MPU also protects traffic by switching channels, interfacing with relay alarm equipment, and communicating with remote monitoring equipment, such as TELTRAC (Telco Systems Telecommunications Remote Alarm and Control). DIP switches are provided for setting BER switching threshold at 10^{-6} to 10^{-9}, and for enabling Remote Alarm reporting, ACO (Alarm Cutoff), mux-to-mux communications, and other features. A functional block diagram of the MPU card is shown in Figure 2F-3.

B. Interfaces

2.02 The alarm inputs to the Control MPU card enter at the data bus and VIA (Versatile Interface Adapter) ports. When an alarm signal is received, the appropriate alarm LED on the front of the Control MPU card illuminates. The MPU provides contact closures for activating MAJOR and MINOR alarms for a local and remote location. The card also provides interfaces to the ACX025 Fuse and Alarm Panel for AUDIO and VISUAL, MAJOR and MINOR, and ACO.

2.03 The Control MPU card contains the firmware that controls operation of the 828A/828AF. The firmware allows the 828A/828AF to interface to a TELTRAC or TBOS (Telemetry Byte-Oriented Serial) monitoring system, and to allow the Manual Control Interface card to perform tests on the local and remote multiplexers. Refer to SPECIAL TEST CARDS (SECTION 828-102-008) for more information on the Manual Control Interface card.

C. Controls and Options

2.04 Switches for manually controlling ACO, MAIN or STBY operation of the unit, and RESET of the Control MPU card are described in TABLE A.

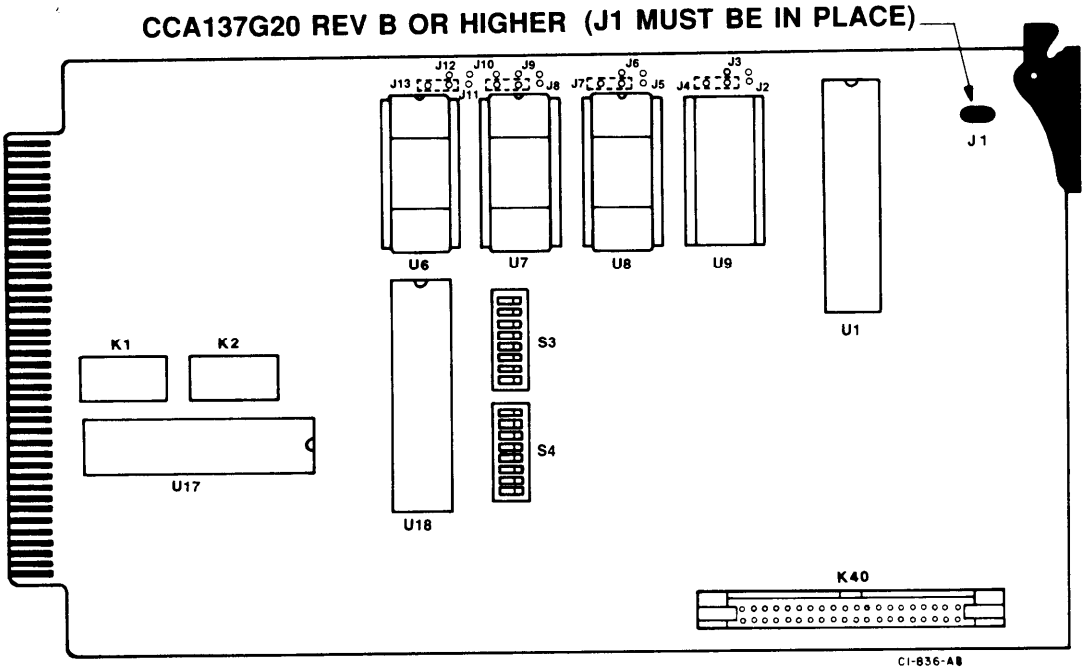


Figure 2F-1. Control MPU Card (CCA137)

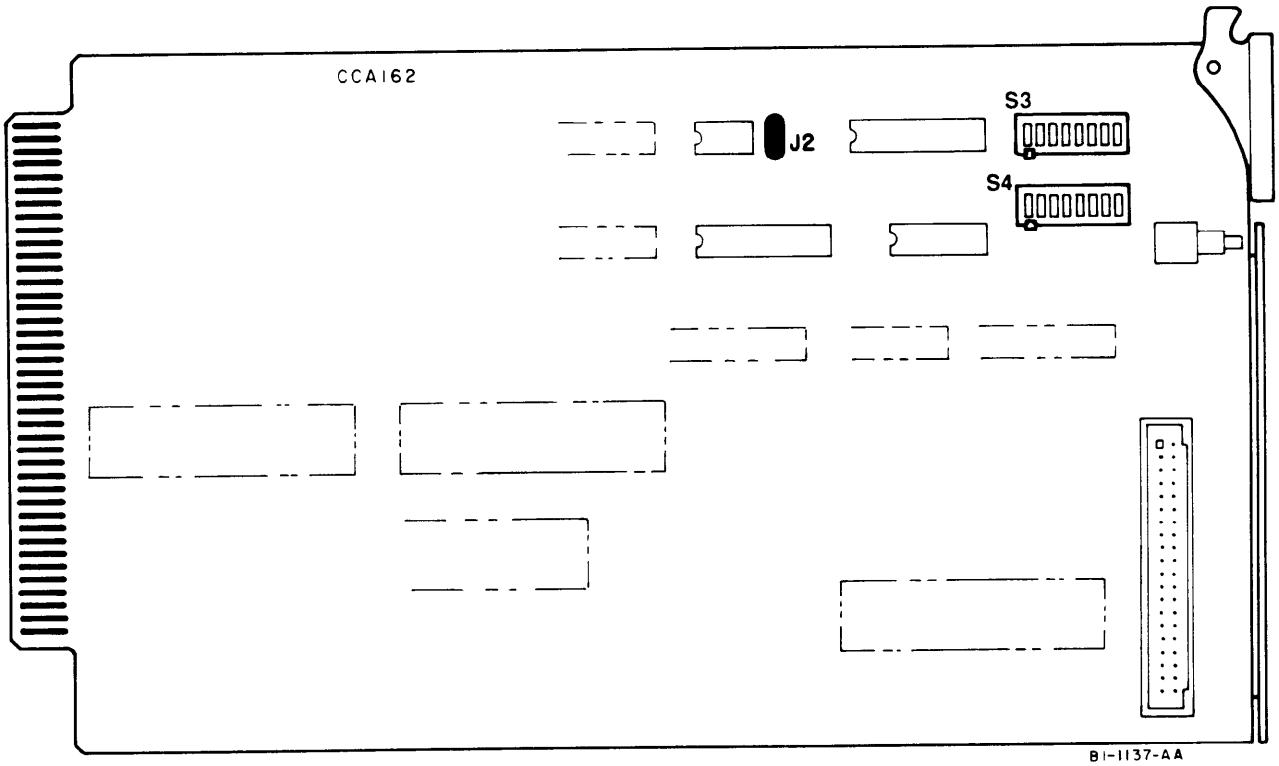
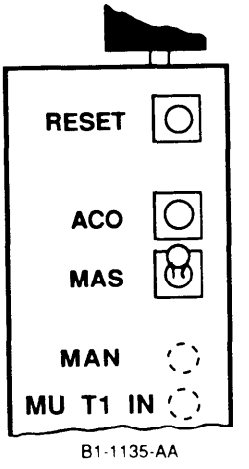


Figure 2F-2. Control MPU Card (CCA162)

TABLE A. Control MPU Card Switches (CCA137 and CCA162)

SWITCH	DESCRIPTION OF MONITORED POINT	ILLUSTRATION
RESET	Momentary-contact switch that forces the Control MPU card into initialization. Caution: Use of the RESET button while in service may result in a short error burst.	 B1-1135-AA
ACO* (Alarm Cutoff)	Momentary-contact switch that disables the current fault condition(s) from initiating local alarms. Remote audible alarms are disabled when the Remote Bay Fault enable option is ON. However, any new fault conditions are recognized.	
M/A/S (MAIN/AUTO/STBY)	In the MAIN position, traffic is locked to the MAIN HS (High-Speed) cards. In the STBY position, traffic is locked to the STBY HS cards. In the AUTO position, the Control MPU card controls switching. When in the MAIN or STBY position, HS protection switching is disabled.	

* Functional only when the ACX025 Fuse and Alarm Panel is installed in the bay.

2.05 DIP switches S3 and S4 are used for enabling and disabling various 828A/828AF unit and system options controlled by the MPU. Switch settings are given in TABLES B and C.

2.06 DIP switch S3, (see Figure 2F-1 for CCA137 or Figure 2F-2 for CCA162) is used to select various options relative to operation of the 828A/828AF unit. The switch positions are described as follows:

- Poles 1 and 2: Determine the BER switching threshold. Switching occurs only when the threshold is equalled or exceeded.

- Pole 3: When ON, ACO is permanently ON. MAJOR and MINOR audio contact closures on the ACX025 Fuse and Alarm Panel are disabled. The ACO lamp and contact closure will stay activated, and the BAY FLT lamp will stay extinguished. This switch has no affect on the ACX043 Fuse and Alarm Panel.

- Pole 4: Enables or disables the local reporting of remote BAY alarms. When Pole 4 is ON, any fault conditions occurring on the remote multiplexer will cause the illumination of the near-end (LOCAL) BAY alarm and the corresponding MAJOR or MINOR LED and relay contact closures.

  Note: Mux-to-mux communication must be enabled.

- Pole 5: Enables mux-to-mux communications. Mux-to-mux communications should be disabled if the remote multiplexer is anything other than a Telco Systems product. Also, if either multiplexer is equipped with seven T2 cards, this option should be disabled. (Only T1 and T1C cards can allow mux-to-mux communications.)

  Note: If mux-to-mux communications are disabled, REMOTE FAULT LEDs on the front of each circuit card will not illuminate. However, there is an option on the CCA161G1 T1 card that allows remote status from foreign muxes via the DS-2 X-bit from TR-TSY-000009. In addition, optional remote Manual Control Interface card interrogation, remote TELTRAC enable (which requires DS-2 X-bit communications), and RAC-II card functions will not operate.

2.07 DIP switch S4 (see Figure 2F-1 for CCA137 or Figure 2F-2 for CCA162) is also used to select various additional options. TABLE C shows the configuration of this switch.

Note: The features listed below apply to latest software revisions. For limitations of older revisions, see TABLE C for the affected MPU Part Numbers and Descriptions.

- Pole 1: Enables or disables the Delayed Alarm Reporting option. When enabled, this option will delay TELTRAC reporting and MAJOR and MINOR relay contact closures for 2- to 3-seconds after a fault is detected. It will also take 10-seconds for the alarm to clear after the fault disappears.

- Pole 2: When enabled (ON), the DS-3 X-bit will be set when a local high-speed fault occurs. The DS-3 X-bit will also be monitored for remote faults. This will allow remote monitoring of a DOX (Dual Optical Transceiver) card located in a Telco Systems M560 Multiplexer.

  Note: When this option is enabled, the RAC-II card function of bridging a Remote Monitoring RS-422 channel will be lost.

- Pole 3: Determines whether the 828A/828AF operates in a protected mode (with STBY cards) or unprotected mode (without STBY cards).

  Note: Dual power supplies are always needed.

- Pole 4: When enabled (ON), an EXT REMOTE LED illuminated on the LTU card will cause the MINOR LED on the Control MPU card and the BAY lamp on the Fuse and Alarm Panel to activate.

- Pole 5: When enabled (ON), a minor alarm will be generated when any of the Low-Speed cards receive BPV in excess of a 10^{-6}) rate.

- Pole 6: Presently unused. Place in the OFF position.

- Pole 7: Presently unused. Place in the OFF position.

- Pole 8: Presently unused. Place in the OFF position.

D. Alarms

2.08 The LED indicators on the front of the Control MPU card, and their functions, are listed in TABLE D.

TABLE B. Control MPU (CCA137 and CCA162) S3 DIP Switch Configuration

POLE	POSITION	FUNCTION
1/2 (Note 1)	1-ON; 2-ON	DS-3 BER Alarm/Switching Threshold: 10^{-6}
1/2 (Note 1)	1-OFF; 2-ON	DS-3 BER Alarm/Switching Threshold: 10^{-7}
1/2 (Note 1)	1-ON; 2-OFF	DS-3 BER Alarm/Switching Threshold: 10^{-8}
1/2 (Note 1)	1-OFF; 2-OFF	DS-3 BER Alarm/Switching Threshold: 10^{-9}
3 (Note 2)	ON	Permanently disables remote alarm reporting via audible relay contact closures and BAY fault lamp indicator. Visual contact closures are not affected by the ACO function.
3 (Note 2)	OFF	Enables the use of the front-mounted ACO push-button to cut off remote alarm reporting via audible relay contact closures and BAY fault lamp indicator, in acknowledgement of each unique alarm condition.
4 (Note 3)	ON	Remote Bay Enabled
4 (Note 3)	OFF	Remote Bay Disabled
5 (Note 4)	OFF	Mux-to-mux DS-2 X-bit communications channel disabled (non-Telco Systems far-end mux)
5 (Note 4)	ON	Mux-to-mux DS-2 X-bit communications channel enabled (Telco Systems far-end mux)
6/7/8	OFF	Not used. Set each pole to the OFF position.

Note 1: When interfacing an 828AF/828AFXT multiplexer to the DOX card of an M560 terminal, the DS-3 BER threshold is typically set to the same value as the corresponding DOX card.

Note 2: A jumper (JP1) within the Fuse and Alarm Panel (ACX025 only) allows both AUDIBLE and VISUAL relay contact closures to be ACO controllable.

Note 3: Remote Bay Enable allows BAY, MAJOR, and MINOR alarms at a far-end 828A or 828AF/828AFXT multiplexer to be mirrored at the local 828A or 828AF/828AFXT terminal. When enabled, the REMOTE LED on the Control MPU illuminates to distinguish local from remote alarms.

Note 4: When mux-to-mux communications is disabled, all REMOTE LEDs, remote TELTRAC, and Manual Control Interface card functions are disabled.

TABLE C. Control MPU (CCA137 and CCA162) S4 DIP Switch Configuration

POLE	POSITION	FUNCTION
1 (Note 1)	ON	Enables Delayed Alarm Reporting option.
1 (Note 1)	OFF	Disables Delayed Alarm Reporting option (enables immediate alarm reporting).
2 (Note 2)	ON	Enables DS-3 X-bit as a single state REMOTE fault indication to the far-end.
2 (Note 2)	OFF	Disables DS-3 X-bit as a single state REMOTE fault indication to the far-end M560 DWEL or 828A/828AF/828AFXT. Set to OFF for CCA137.
3 (Note 3)	ON	Unprotected high-speed operation (no STBY HS COM card and no STBY WLEL card).
3 (Note 3)	OFF	1:1 Protected high-speed operation (STBY HS COM and STBY WLEL cards installed).
4 (Note 4)	ON	Allows a faulted LTU card in the remote FOX-2/FOX-2R unit of a DS-2 optical span to generate local MINOR and BAY alarm conditions.
4 (Note 4)	OFF	Disables MINOR and BAY alarms resulting from remote LTU fault condition. The EXT REMOTE LED still illuminates in either mode to indicate remote FOX-2/FOX-2R failure.

Note 1: The Delay Alarm Reporting option delays TELTRAC remote alarm reporting and MAJOR/MINOR relay contact closures for 2 to 3 seconds after a fault is initially detected. Once the fault is cleared, all alarm and report functions will clear 10 seconds later.

Note 2: This option is used only on the CCA162. For the CCA137, set this pole to the OFF position. User-defined DS-3 X-bit is set to the ones state during fault condition to provide remote fault indication to a far-end M560 DWEL card (CCA170) to initiate the illumination of the REMOTE LED on the corresponding M560 DOX card. This option must be disabled (OFF) to allow DS-3 X-bit bridging of TELTRAC/TBOS with a RAC-II card. Normal RAC-II card operations work via the DS-2 X-bit.

Note 3: This option is used only on the CCA137G20 and CCA162.

Note 4: This option is used only on the CCA162.

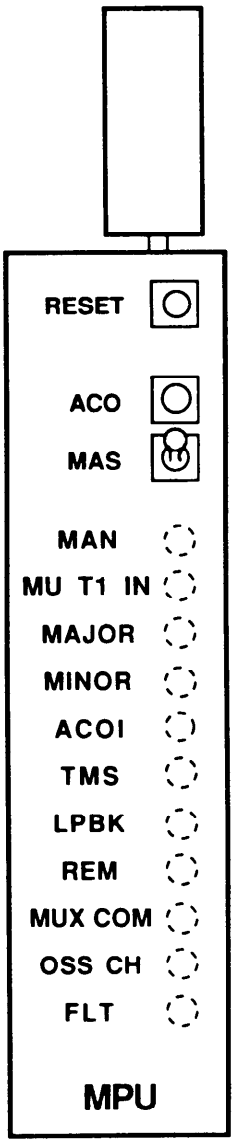
TABLE C. Control MPU (CCA137 and CCA162) S4 DIP Switch Configuration (Cont.)

POLE	POSITION	FUNCTION
5 (Notes 4,5)	ON	MINOR and BAY alarms will be generated in the presence of incoming excessive BPV (BER greater than 10^{-6}) on any Low-Speed Channel. Flashing INPUT LED on the individual Low-Speed Interface card identifies the faulted channel group.
5 (Notes 4,5)	OFF	Disables MINOR and BAY alarms resulting from excessive BPV alarm condition.
6 (Note 6)	ON	Selects a TBOS remote monitoring system to communicate with the multiplexers. SW2 on the backplane must still have pole 8 in the OFF position to enable this function.
6 (Note 6)	OFF	Allows a TELTRAC remote monitoring system to communicate with the multiplexers. SW2 on the backplane must still have pole 8 in the OFF position to enable this function. When SW2, pole 8 is in the ON position, any TELTRAC or TBOS remote communications will be disabled.
7/8	OFF	Not used. Set each pole to the OFF position.

Note 5: Excessive BPV is defined as 10 or more consecutive BPV error-seconds for T1 and T1C channels, B6ZS format error-seconds for T2 channels, and 3B6B encoding errors for DS-2 optical channels.

Note 6: This option is used only on the CCA162G2. If another MPU is used, set to the OFF position.

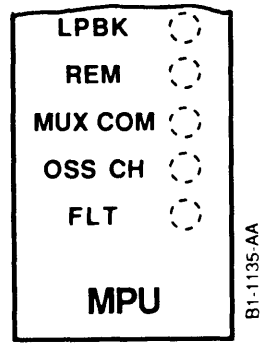
TABLE D. Control MPU Card Indicators
(CCA137 and CCA162 unless noted)

INDICATOR	DESCRIPTION OF MONITORED POINT	ILLUSTRATION
MANUAL (red)*	Illuminates when the 828A is under control of the MAIN/AUTO/STBY switch, TELTRAC (Telco Systems Telecommunications Remote Alarm and Control), or the Manual Control Interface card (both Local and Remote).	
MU T1 IN (red)*	Illuminates when more than one DS-1, or at least one DS-1C or DS-2 input is faulty. This LED will also illuminate as a result of an LTU optical input failure.	
MAJOR (red)	Illuminates when a traffic-affecting fault exists in the 828A.	
MINOR (red)*	Illuminates when a potentially traffic-affecting fault, or a mux-to-mux communications failure exists. Also illuminates when a switch condition is present.	
ACOI (red)* (Alarm Cutoff Indicator)	Illuminates when the alarm cutoff function is enabled.	
TMS (red) (Too Many Switches)	Illuminates when four or more automatic high-speed switches have occurred within a 10-minute period. The LED automatically resets within one hour.	
LPBK (CCA162 only) (yellow) (Loopback)	If there is any near-end or far-end Low-Speed cards in loopback, this LED illuminates.	
REM (CCA162 only) (yellow) (Remote)	If any far-end Remote alarms exist, this LED illuminates if Remote Bay Enable option on the Control MPU has been activated (S3, pole 4, ON).	

Note: CCA162 MPU illustrated

* Note: These LED indicators have been changed from red to amber on CCA162 cards in conformance with Bell Systems Technical Reference.

TABLE D. Control MPU Card Indicators (Cont.)
(CCA137 and CCA162 unless noted)

INDICATOR	DESCRIPTION OF MONITORED POINT	ILLUSTRATION
MUX COM (CCA162 Only) (yellow) (Multiplexer Communications)	If the mux-to-mux communication is enabled, this LED will illuminate if there is a loss of communication. A MINOR alarm will accompany the illumination of the MUX COM LED.	
OSS CH (CCA162 Only) (yellow) (Remote Monitoring channel)	For Systems connected to TELTRAC or TBOS (Telemetry Byte Oriented Serial) Remote monitoring equipment, this LED illuminates when the MPU fails to receive a poll from the Master Terminal Station.	
FAULT (red)	Illuminates when the Control MPU card has a failure.	

3. OPERATIONAL DESCRIPTION

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

Microprocessor Unit

3.02 The MPU 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 bidirectional address bus. 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, VIA, 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 24K bytes of ROM for CCA137, and 32K bytes of ROM for CCA162, 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 PTM 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 can be multiplexed into an embedded LTU overhead channel for transmission to a remote FOX-2R.

Remote Hardware Alarm Notification and Protection Switching

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. The individual latches also provide protection switching when faults or removal of cards are detected. If the 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 ms. timer, which is periodically set by software, resets and automatically initiates a hardware reset to reinitialize the MPU.

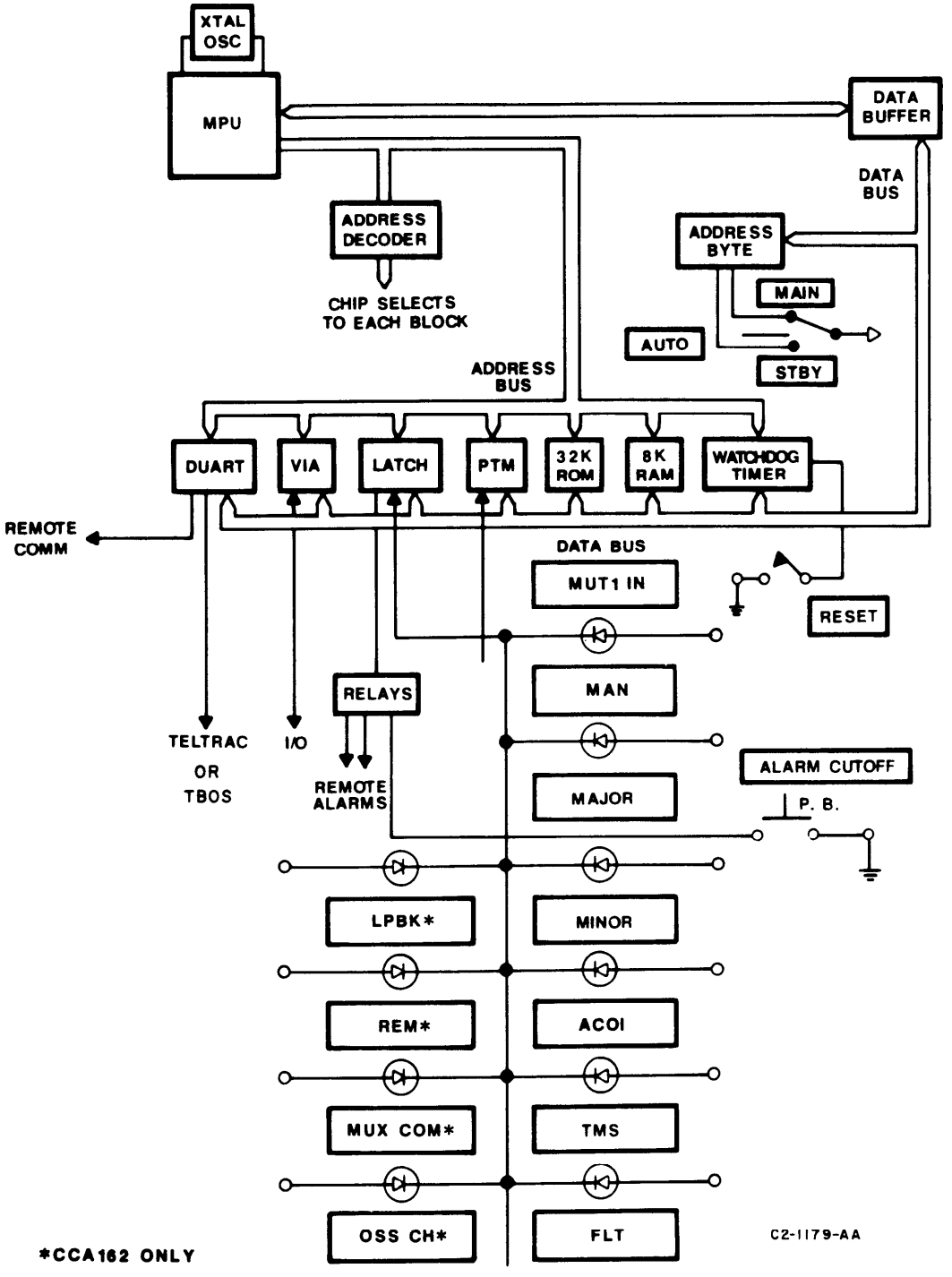


Figure 2F-3. Control MPU Card Block Diagram

DIGITAL TRANSMISSION SYSTEM
828A DIGITAL MULTIPLEXER
REMOTE ALARM CARD II CIRCUIT CARD THEORY OF OPERATION
CCA158

CONTENTS PAGE

1. SCOPE..... 2G-1

2. FUNCTIONAL DESCRIPTION..... 2G-1

A. General Description..... 2G-1
B. Interfaces..... 2G-2
C. Controls and Options..... 2G-2
D. Alarms..... 2G-2

3. OPERATIONAL THEORY..... 2G-5

1. SCOPE

1.01 This subsection presents a functional description of the RAC-II (Remote Alarm Card II) card. Figure 2G-1 illustrates the layout of the card highlighting the control switches, jumpers, 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 RAC-II card has three functions:

a. Provides remote indications of alarm status, via relay contact closures, for up to eight external alarm points

b. Allows use of a remote lamp and contact closure on the ACX025 Fuse Panel when bringing far-end MAJOR/MINOR alarms to the local end

c. Allows TELTRAC (Telco Systems Telecommunications Remote Alarm and Control) to be extended to remote sites (via DS-3 X-bit bridging) without use of a Modem, Service Channel, or other external communication facilities.

Two cards are required in a functional system, one at each end of a hop.

2.02 Each of the eight alarm inputs can be optioned individually so that an active alarm input will generate either a local MINOR alarm or only illuminate a status LED on the RAC-II card. This provides the ability to suppress local alarms if they would be undesirable for the application. If an alarm input on the RAC-II card has been optioned to generate a local MINOR alarm, and the far-end MPU (Microprocessor Unit) has been optioned to report REMOTE alarms, the local MINOR alarm will be mirrored at the far end.

2.03 Each of the eight alarm inputs can be configured individually to recognize either presence or absence of input alarm voltage as an active alarm condition.

2.04 The activity state of each of the eight output relays can be individually set so that either open or closed contacts represent an active input alarm condition.

2.05 The DS-3 X-bit bridge setting determines the function of the card, MASTER or SLAVE, when the card is being used for TELTRAC extension.

2.06 Status and fault LEDs indicate the presence of active inputs at either end of the system, and whether the card itself is faulty.

B. Interfaces

2.07 The RAC-II card contains eight opto-isolator inputs and eight sets of output relay contacts. Each input in a local RAC-II card controls a corresponding far-end output relay. An input voltage of -5 Vdc to -48 Vdc normally constitutes an alarm condition, while 0 Vdc to -1.0 Vdc constitutes no alarm. Bridge rectifier circuitry on the alarm inputs, however, ensures that voltage of either polarity can trigger an alarm. An eight-pole DIP switch, S3, provides for the inputs to be individually programmed so that either presence or absence of an applied voltage on that input will constitute an active alarm condition. The input impedance is designed for 2.7 Kohms. Through the use of DIP switch, S2, the active state of the output relays can be individually programmed so that either closed contacts or open contacts will indicate the presence of an active alarm at the corresponding input.

2.08 When used for TELTRAC extension, the RAC-II card interfaces with the DS-3 X-bit, a user-definable overhead bit in the DS-3 data stream. A regenerator circuit on the card restores the TELTRAC signal after the signal has been transported by the DS-3 X-bit.

2.09 If the remote alarm option has been enabled on the local MPU to report far-end MAJOR/MINOR alarms at the local end, the RAC-II card will interface with the REMOTE lamp relay on the ACX025 Fuse and Alarm Panel to illuminate the REMOTE lamp indicator. This identifies an alarm as having originated at the far end.

Note: The Remote Bay Fault option must be selected on the local Control MPU. See Subsection 828-102-002E on the Control MPU Card.

C. Controls and Options

2.10 The setting of DIP switch, S1, determines whether or not a MINOR alarm is generated at the local end if individually selected inputs become active. If not selected, no alarm will be generated at that multiplexer.

2.11 DIP switch, S2, selects whether open contacts or closed contacts will indicate an alarm condition for each of the eight sets of output relay contacts.

2.12 DIP switch, S3, selects whether the presence or absence of a voltage applied to each individual input will constitute an active alarm condition at that input.

2.13 The DS-3 X-bit Bridge option jumper is used when extending TELTRAC to remote sites. The bridge has three possible positions: MASTER, SLAVE, and STORAGE.

D. Alarms

2.14 TABLE A describes the RAC-II card indicators and controls. The I/P ALM status LED is used to indicate that an active input exists on the local card.

2.15 The CONTROL STATUS LED is used to indicate that relay contacts on the local card are indicating the presence of an active alarm on the corresponding input at the far end.

2.16 The FLT LED indicates that the card itself is faulty and must be replaced. When a RAC-II card is faulted or removed from a system, a MINOR alarm is generated.

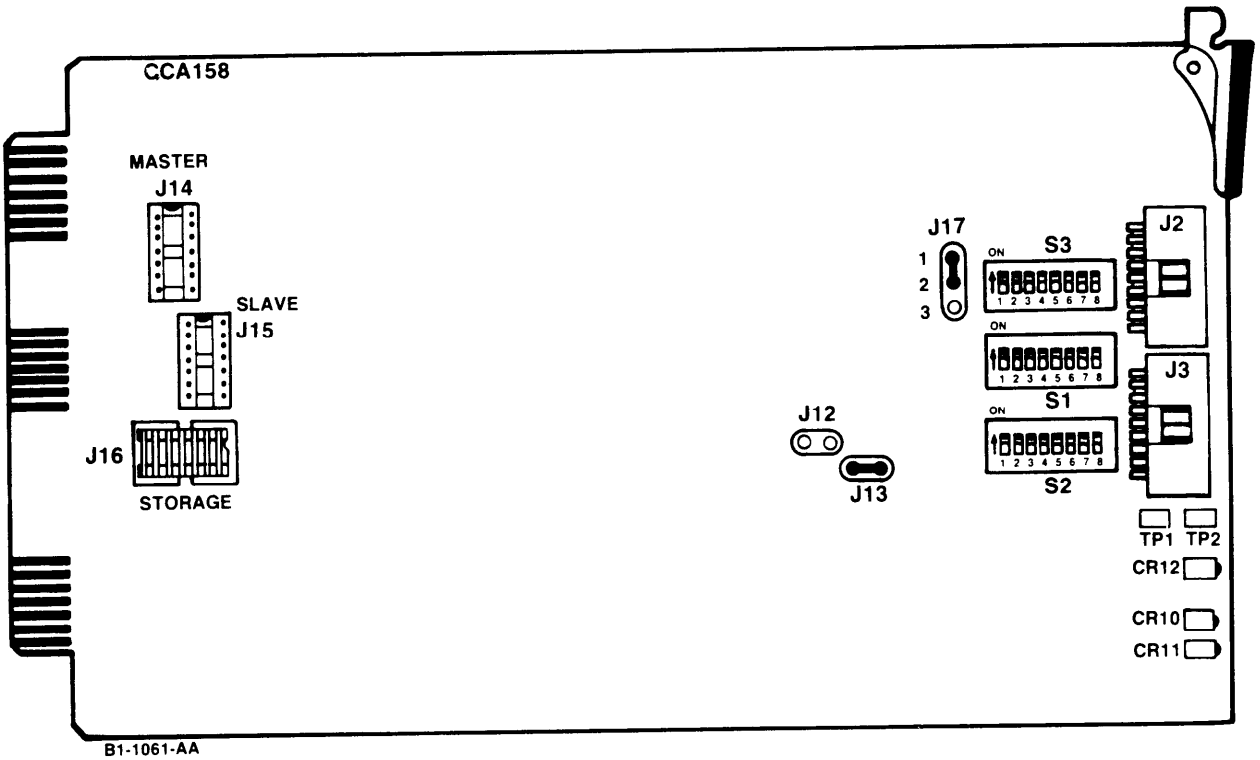


Figure 2G-1. RAC-II Card

TABLE A. RAC-II Card Indicators and Controls (See Figure 2G-1)

LED INDICATOR	DESCRIPTION OF MONITORED POINT	ILLUSTRATION
I/P ALM (yellow)	Illuminates to indicate that an active input exists on the local card. The LED will remain illuminated only while the active input exists.	[A1-1068-AA]
CONTROL STATUS (yellow)	Illuminates to indicate that an active input exists on the far-end card, and that the corresponding contact closure on the local card is activated. The LED will remain illuminated only while the active input exists.	
FLT (red)	Illuminates to indicate that the card is faulty and must be replaced.	

TABLE A. RAC-II Card Indicators and Controls (See Figure 2G-1) (Cont.)

CONTROL	CONTROL DESCRIPTION
S1	DIP switch, S1, selects whether a MINOR alarm is to be generated at the local end if individually selected inputs become active. If not selected, no local alarm will be generated. Only an input status LED will illuminate.
S2	DIP switch, S2, selects whether open contacts or closed contacts will indicate an alarm condition at the corresponding far-end input for each of the eight sets of output relay contacts. The contact closure circuits are individually fused for a maximum current of 1 A.
S3	DIP switch, S3, selects whether the presence or absence of voltage applied to each individual input constitutes an active alarm condition at that input. Normally, a voltage of -24 Vdc or -48 Vdc constitutes an active alarm, while 0 Vdc to -1.0 Vdc constitutes a no alarm condition.
DS-3 X-bit Bridge	Jumper which selects the TELTRAC briding operating mode of the RAC-II card. MASTER MODE: In the MASTER position the DS-3 X-bit bridge causes the RAC-II card to act as if it were a selective interface between TELTRAC and the DS-3 data stream. The RS-422 receiver listens to TELTRAC and bridges the TELTRAC information onto the TX DS-3 X-bit in the local 828A/828AF. The card also listens to the RX DS-3 X-bit received from the far-end RAC-II card, and when it recognizes valid TELTRAC information the card passes the information to TELTRAC. SLAVE MODE: In the SLAVE position the RAC-II card at the far-end 828A/828AF unit regenerates information received from the RX DS-3 X-bit, and transmits the information out the RS-422 TELTRAC bus to downline equipment. The RS-422 receiver listens to the downline MPUs on the TELTRAC bus and passes information from downline equipment back to the MASTER RAC-II card via the TX DS-3 X-bit from the far-end site. A jumper on the Fuse and Alarm Panel, marked MASTER/SLAVE, must be set for the SLAVE position when a bay contains a RAC-II card optioned in the SLAVE mode. This enables TELTRAC data to be transported by the RAC-II card instead of through the TELTRAC interface on the Fuse and Alarm Panel. See Section 828-102-002 on Fuse and Alarm Panel card. STORAGE: When not being used for TELTRAC extension, the DS-3 X-bit bridge must be in the STORAGE position.

3. OPERATIONAL THEORY

3.01 Consult Figure 2G-2 for a detailed block diagram of the operation of the RAC-II card.

3.02 The RAC-II card provides a remote status of alarms for up to eight external alarm points. Two cards, one at the far end and one at the local end, are needed to communicate with each other. There are eight opto-isolator inputs and eight sets of output relay contacts on each card. Each input controls a corresponding output relay at the far end. The output relays can be individually programmed so that either open contacts or closed contacts indicate an alarm condition at the corresponding input. The contact circuits are individually fused for a maximum current of 1 A. Each input can be programmed so that either the presence or absence of an applied voltage will constitute an active alarm condition at that input.

3.03 The RAC-II card controls illumination of the REMOTE lamp on the ACX025 Fuse and Alarm Panel. If the Remote Bay Fault option on the Control MPU at the local end has been selected, a MAJOR or MINOR alarm generated at the far end will be reported at the local end. The card interfaces with the REMOTE lamp relay on the local ACX025 Fuse and Alarm Panel to illuminate the REMOTE lamp, indicating that the source of the MAJOR or MINOR alarm is at the far end. This Remote Bay Fault option feature allows a local multiplexer to emulate far-end MAJOR or MINOR alarms. The ACO (Alarm Cutoff) button on the local Control MPU will act as normal, extinguishing the MAJOR and MINOR audible contact closures and BAY FLT lamp, and illuminating the ACO lamp. See Section 828-102-002E on the Control MPU, and Section 828-102-002 on the Fuse and Alarm Panel card.

3.04 When used for TELTRAC extension the RAC-II card bridges the RS-422 TELTRAC bus onto the DS-3 X-bit. Also, a regenerator circuit on the RAC-II card restores the TELTRAC signal after the signal has been transported by the DS-3 X-bit. This provides a capability for multiple hopping without degradation of the TELTRAC signal, and allows TELTRAC to be brought to remote sites without the use of a Modem, Service Channel, or other external communication facilities. The bridge can be optioned three ways: MASTER, SLAVE, or STORAGE. Refer to TABLE A for a description of these options.

Note: The 828A/828AF must be equipped with HS COM card, CCA120G2.

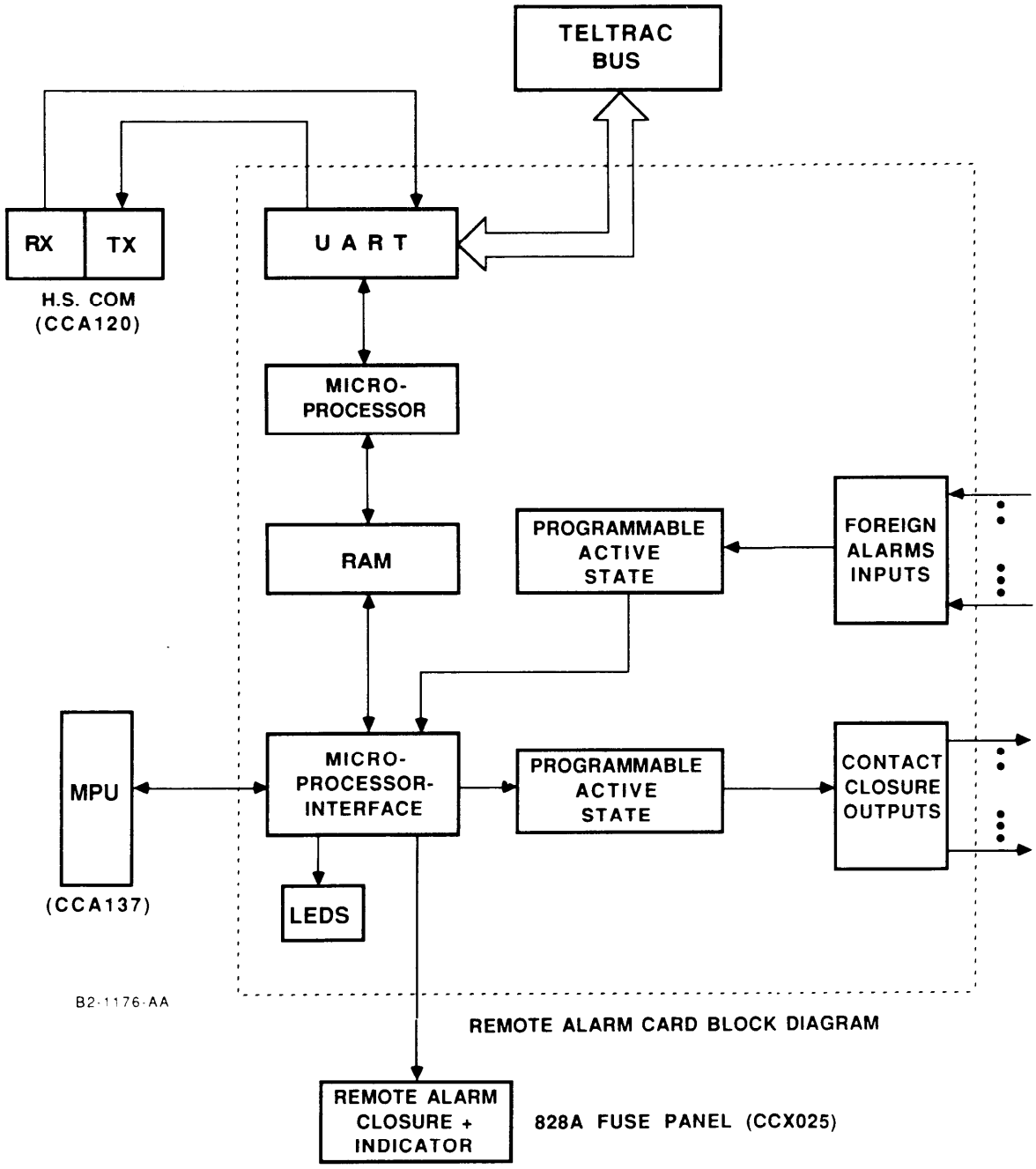


Figure 2G-2. RAC-II Card Block Diagram

DIGITAL TRANSMISSION SYSTEM
828A DIGITAL MULTIPLEXER
POWER SUPPLY MODULE THEORY OF OPERATION
PSX016-1 (-48 Vdc)/PSX016-2 (-24 Vdc)

CONTENTS PAGE

1. SCOPE..... 2H-1

2. FUNCTIONAL DESCRIPTION..... 2H-1

A. General Description..... 2H-1
B. Interfaces..... 2H-2
C. Options..... 2H-3
D. Alarms..... 2H-3

3. OPERATIONAL THEORY..... 2H-5

1. SCOPE

1.01 This subsection presents a functional description of the Power Supply (PS A or PS B) module used in the 828A and 828AF multiplexers. Figure 2H-1 illustrates the PS 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 PS module, downconverts an incoming primary office voltage to +5.1, -5.2, and +15 Vdc secondary voltage potentials required for operation of 828A/828AF circuitry. PS module PSX016-1 operates with a primary supply voltage of -48 Vdc, and PSX016-2 uses a primary supply voltage of -24 Vdc. Except for the primary supply voltage requirement, operation of both PS modules is identically the same.

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 PS A and PS B are used in the 828A/828AF 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.

B. Interfaces

2.05 Consult Figure 2H-2 for a pictorial representation of equipment interfaces to the PS module. Primary power is coupled to the 828A/828AF 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 power supplies sharing a common return line.

2.06 Primary power input to the PSX016-1 PS must be in the range of -42 to -56 Vdc as measured at TB-1 of the 828A/828AF 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	-5.6 Vdc
V2	+5.4 Vdc
V3	+15.3 Vdc
COMMON	Ground

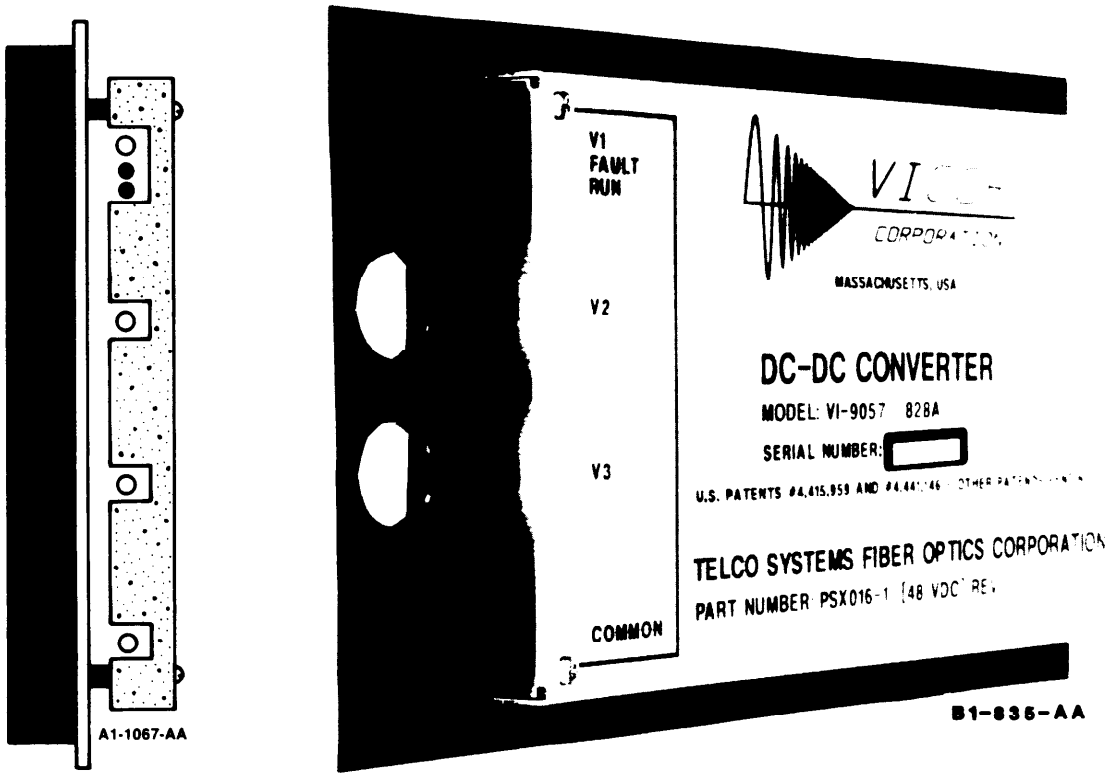


Figure 2H-1. PS Module (PSX016-1)

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 PS module.

D. Alarms

2.08 Fault detection circuitry contained in each PS 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.

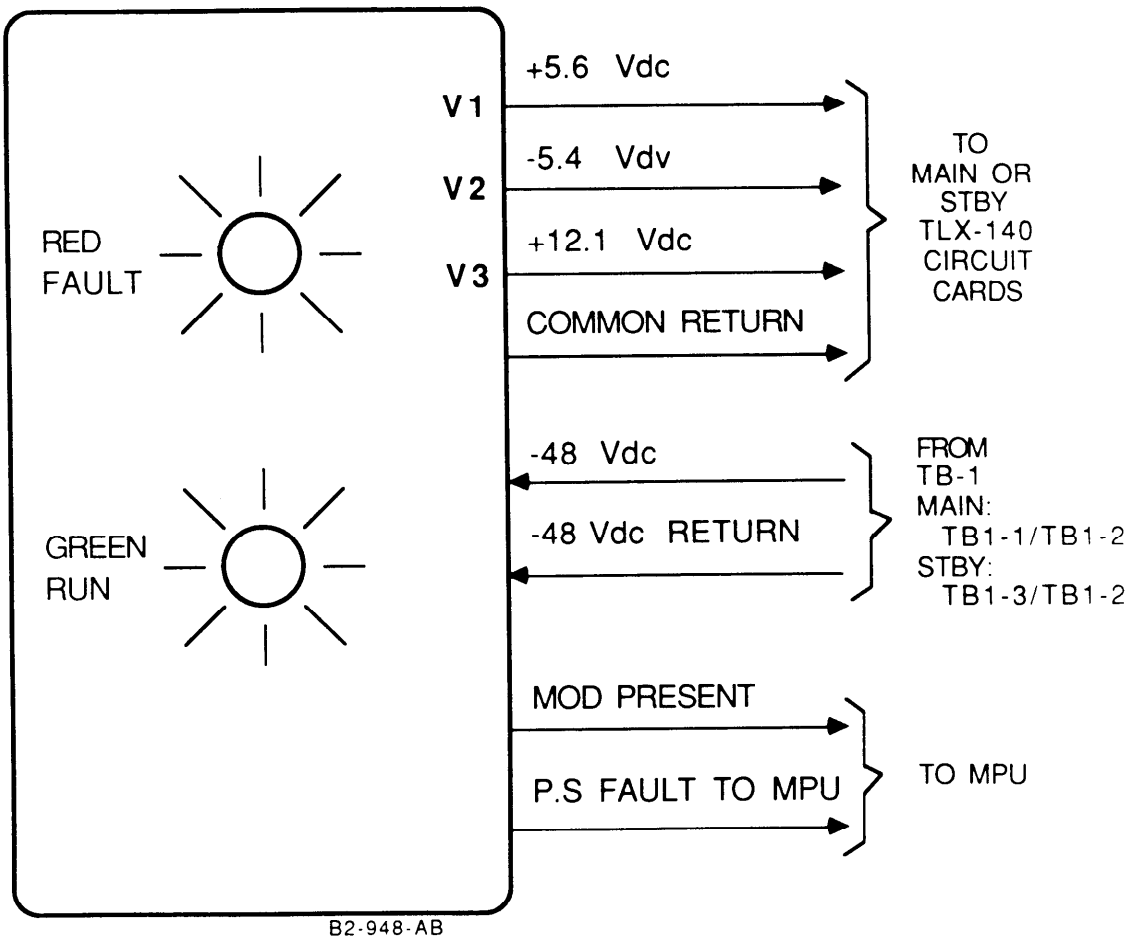


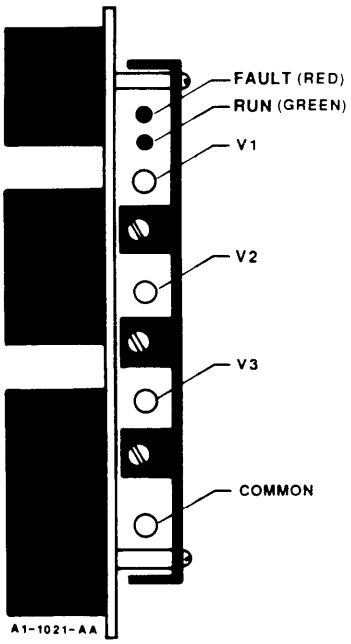
Figure 2H-2. PS Module Interfaces

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 PS module. Both the RUN and FAULT LEDs on the front of the PS 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 PS module 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 PS module fault and status LEDs and their relationship to equipment performance.

TABLE A. PS Module Indicators and Test Points

INDICATOR	DESCRIPTION OF MONITORED POINT	ILLUSTRATION
FAULT (red) RUN (green)	Illuminates when the power supply module has a failure, or there is a loss of input voltage. Illuminates during normal operation.	
TEST POINT	FUNCTION	
V1 V2 V3 COMMON	-5.6 Vdc Test Point +5.4 Vdc Test Point +15.3 Vdc Test Point Ground Test Point	

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

3. OPERATIONAL THEORY

3.01 Refer to Figure 2H-3 which illustrates the internal operation of the PS 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 PS module. 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.

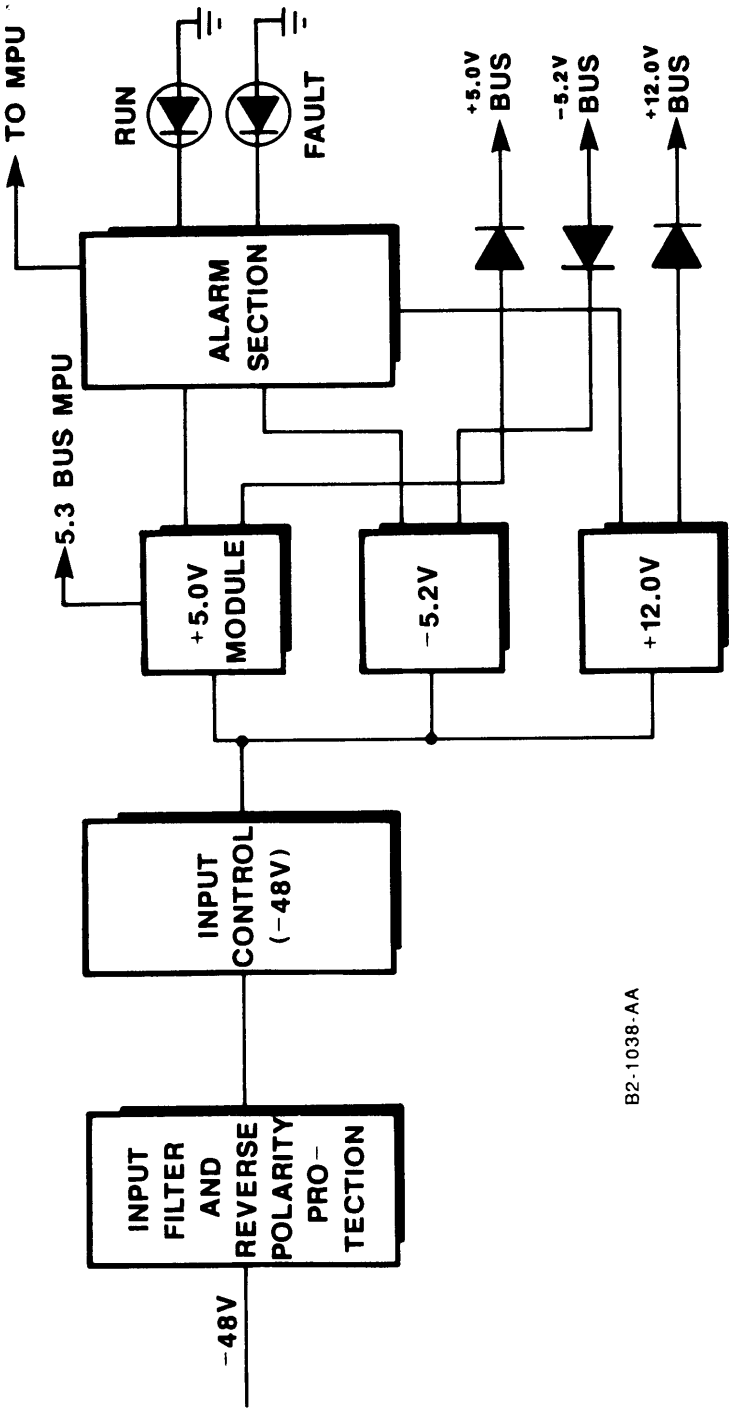


Figure 2H-3. PS Module Block Diagram

DIGITAL TRANSMISSION SYSTEM
828A DIGITAL MULTIPLEXER
OPTIONAL MICROPROCESSOR II CIRCUIT CARD THEORY OF OPERATION
CCA135G1

CONTENTS

		PAGE
1.	SCOPE	2I-1
2.	FUNCTIONAL DESCRIPTION	2I-2
	A. General Description	2I-2
	B. Interfaces	2I-2
	C. Controls and Options	2I-3
	D. Alarms	2I-3
3.	OPERATIONAL DESCRIPTION	2I-5

1. SCOPE

1.01 This subsection presents a functional description of the Optional MPU-II (Microprocessor Unit II) card. See Figure 2I-1 for a pictorial representation of the circuit card.

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

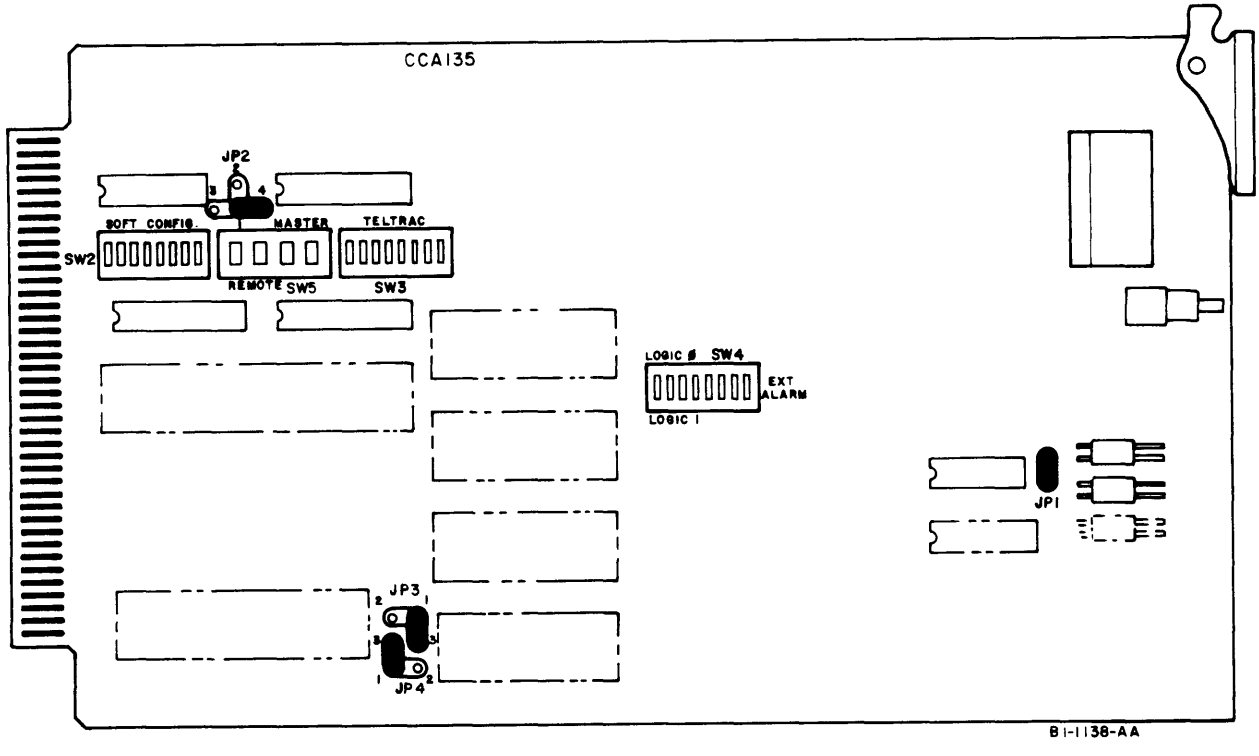


Figure 2I-1. Optional MPU-II Card (CCA135G1)

2. FUNCTIONAL DESCRIPTION

A. General Description

2.01 The Optional MPU-II card is installed in the Optional Card Slot of the 828A or 828AF, and requires a CCA162 Control MPU for proper operation. The Optional MPU-II card provides a sophisticated communications link from the Control MPU of the 828A/828AF multiplexer to the Control MPU(s) of remote FOX-2/FOX-2R units via DS-2 optical extension spans (see Figure 2I-2). The Optional MPU-II is required to provide TELTRAC (Telco Systems Telecommunications Remote Alarm and Control) or RAC-II (Remote Alarm Card II) functions to remote FOX-2/FOX-2Rs. When utilized in conjunction with remote RAC-II cards, the MPU-II card can receive active alarm inputs from externally monitored equipment at each FOX-2/FOX-2R site. These alarms are transmitted by the Control MPU card, via DS-2 X-bit, to the far-end 828A/828AF multiplexer. The Control MPU of the far-end 828A/828AF multiplexer will activate up to eight individual relay contacts, each contact corresponding to a specific input alarm. (See Figure 2I-3 for typical 828AF-to-828AF system architecture).

2.02 Additionally, the MPU-II card is capable of receiving up to eight alarm inputs which generate corresponding far-end relay contact closure. Since a total of eight relay contacts are controlled from all external alarm inputs, identically assigned external alarm inputs within the FOX-2/FOX-2R and MPU-II card of the 828A/828AF will be OR'ed together to drive a common far-end relay.

B. Interfaces

2.03 All internal interfaces with the 828A/828AF and the Optional MPU-II card are provided through motherboard interconnection.

2.04 The 16-pin male connector, J9, provides for front connection of all eight external alarms inputs. Rear access of the alarm inputs is accomplished via ribbon cable jack, J7, which can be interconnected to a separate wire-wrap block or cabled out to the integrated wire-wrap block within the ACX043 Fuse and Alarm Panel, if desired.

C. Controls and Options

2.05 The Optional MPU-II card has one momentary contact switch, SW1, and four DIP switches. Refer to TABLE A for the DIP switches and their functional description. Refer to TABLE B for information pertaining to the momentary contact switch.

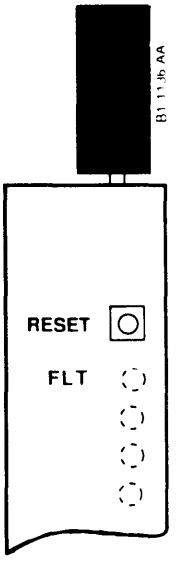
D. Alarms

2.06 TABLE B describes the alarm indicator on the Optional MPU-II card.

TABLE A. Optional MPU-II Card DIP Switches

SWITCH	FUNCTION	DESCRIPTION
SW2	Software Configuration	Selects whether or not a MINOR alarm will be generated for an active input. OFF = No alarm ON = MINOR alarm
SW3	Not Used	Set all poles to the OFF position. (Reserved for future use.)
SW4	External Alarms	Used to set the active state of external inputs. OFF = When no voltage is present at the input, the Local site RAC-II card will activate the corresponding contact closure. ON = A voltage applied to the input will activate the contact closure at the Local site RAC-II card.
SW5	Not Used	Set all poles to the OFF position. (Reserved for future use.)

TABLE B. Optional MPU-II Card Indicator and Reset Switch

INDICATOR	DESCRIPTION OF MONITORED POINT	ILLUSTRATION
FAULT (red)	Illuminates when the Optional MPU-II card has a failure and momentarily when this card is reset.	
SWITCH	FUNCTION	
RESET	Momentary pressing of this switch resets the Optional MPU-II card microprocessor and momentarily causes the LED to illuminate. Warning: Resetting this Optional MPU-II card may cause RAC-II cards to chatter any activated output contact closure, and cause temporary TELTRAC logoffs..	

3. OPERATIONAL DESCRIPTION

3.01 The Optional MPU-II Card provides a sophisticated communications link from the 828A/828AF MAIN MPU, CCA162, to individual DS-2 FOX-2/ FOX-2R Control MPUs, via an overhead embedded channel of individual DS-2 optical extension spans. LTUs (Line Terminating Units) which provide DS-2 optical span interfaces, incorporate this communications channel into the 3B6B optical line coding to/from the FOX-2/FOX-2R units. See Subsection 828-102-002C for LTU circuit card theory. This communications link will allow TELTRAC and RAC-II applications to operate with FOX-2/FOX-2R Fiber-Optic Extension Units. Refer to Figure 2I-2.

3.02 There are eight opto-isolator monitoring points on the board, each connected to both J9 on the front of the board and to J7 on the rear of the 828A/828AF motherboard. Each set of input connectors is applied to a bridge circuit so that any monitoring point can be activated by applying a 5 Vdc to 48 Vdc voltage of either polarity. The dc input is attenuated through a series resistor network to limit the current to the opto-diodes. SW4 can be set so that for each individual input, either lack of voltage or presence of voltage, can constitute an active state.

3.03 The microprocessor utilized in the MPU-II is the Motorola MC68B09, using an 8 MHz crystal from which is derived a system clock of 2 MHz. This gives an MPU cycle time of 500 ns (see Figure 2I-3). Using the bidirectional data bus, the MPU can either read or write data to any circuit addressed by the bidirectional address bus.

3.04 Through a dual-port RAM (Random Access Memory) and handshaking control lines, the microprocessor located on the Optional MPU-II card communicates with the CCA162 Control MPU in the 828A/828AF. The Optional MPU-II microprocessor polls all FOX-2/FOX-2R units and both writes data into and reads data from dual port RAM. The CCA162 Control MPU accesses the same RAM and processes the data accordingly. In this manner, communication is established between the two MPUs.

3.05 Up to eight unique monitoring points in remote FOX-2/FOX-2R units can be paralleled with the eight monitoring points on the MPU-II card, for transporting active input indications to TELTRAC and/or the RAC-II card in the local 828A/828AF via a DS-2 X-bit overhead channel. The eight output contact closures of RAC-II cards located in FOX-2R units can be independently addressed and controlled by TELTRAC. See Figure 2I-3 and RAC-II Theory of Operations Subsection (828-102-002G).

3.06 A Watchdog Timer circuit provides a guaranteed power-up reset of the MPU, and performs a RESET if software does not regularly access the circuit.

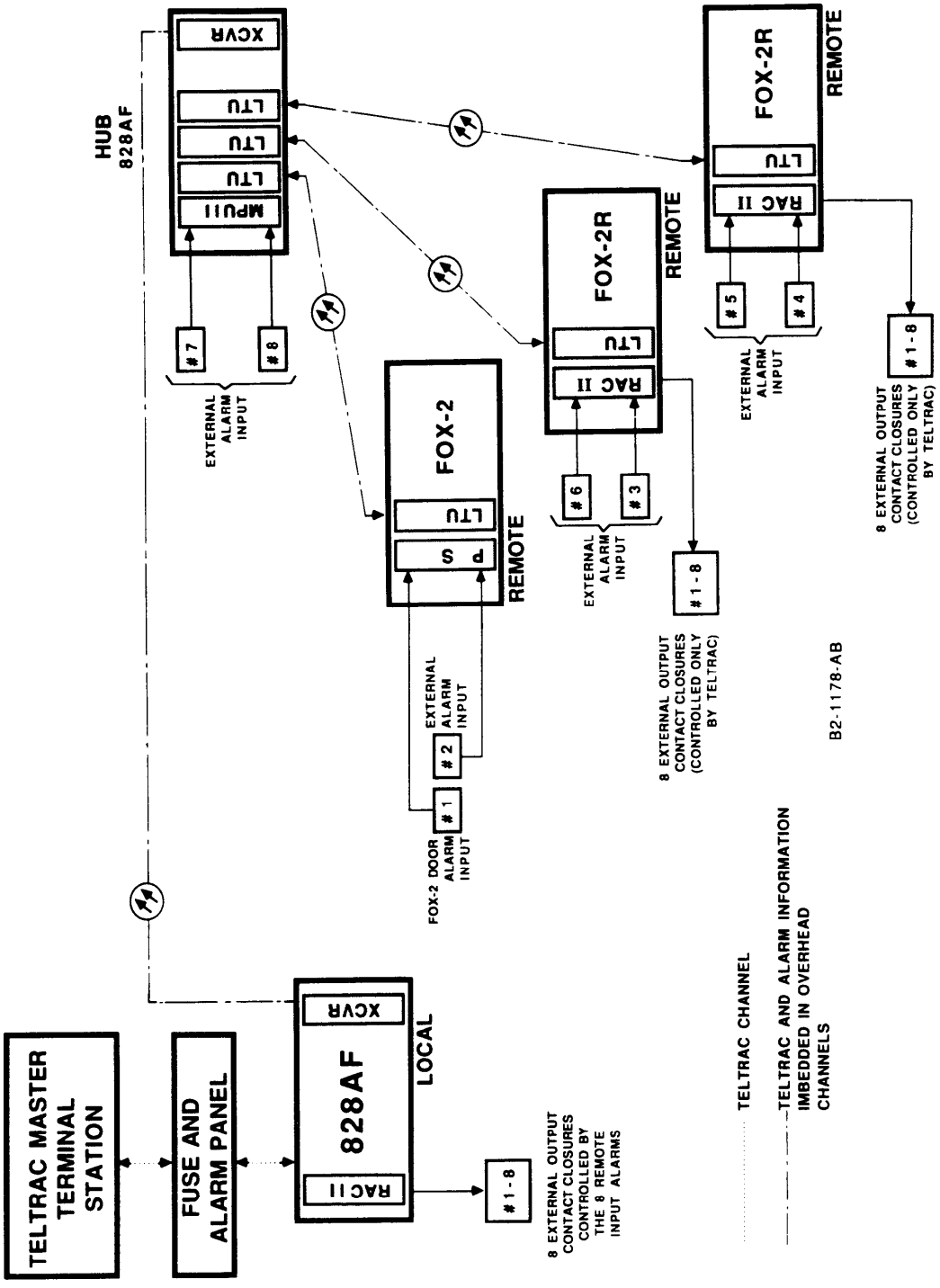


Figure 2I-2. FOX-2/FOX-2R Application of Optional MPU-II Card (CCA135G1)

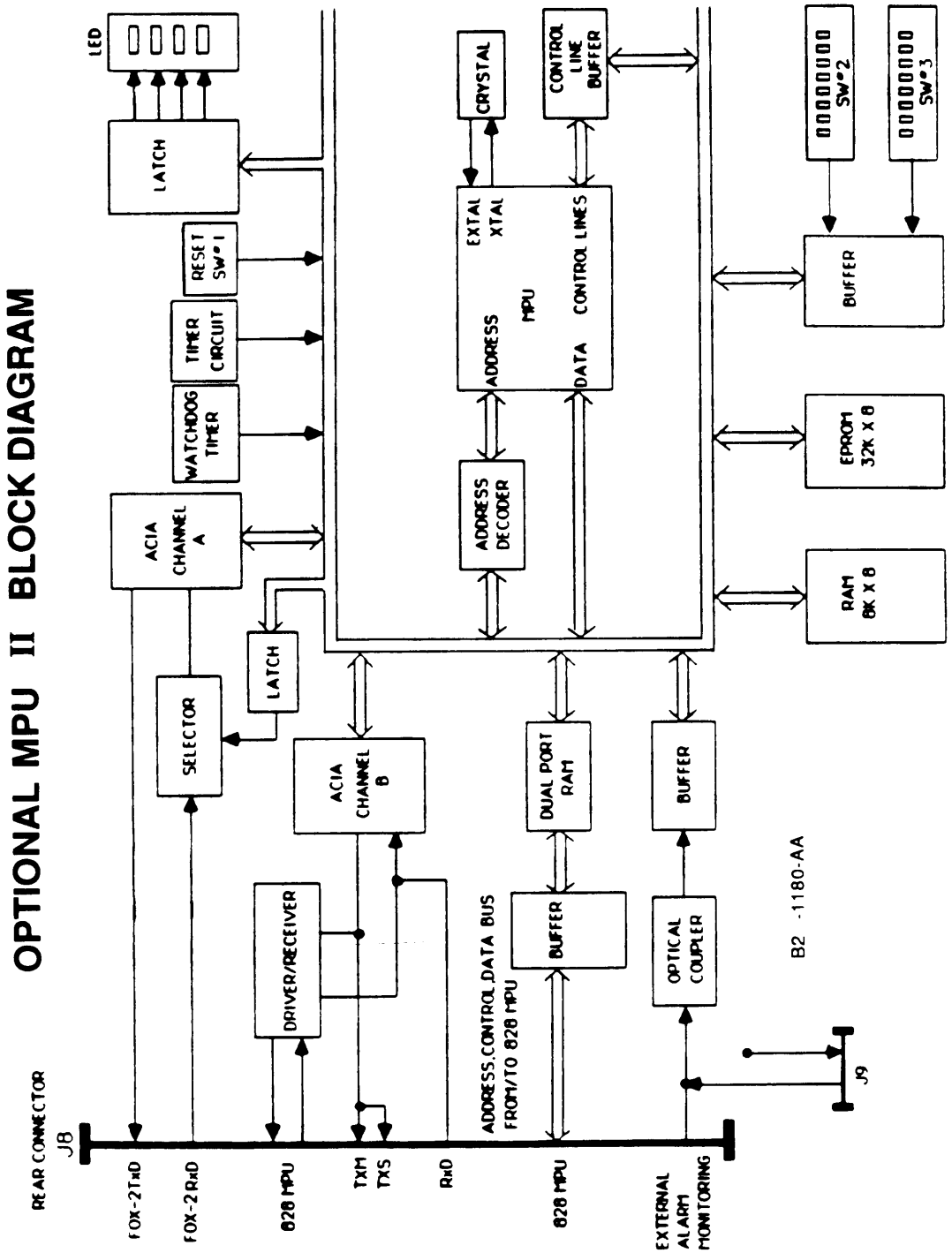


Figure 2I-3. Optional MPU-II Card Block Diagram