ML 10607
Rev. D

FIREBERD 6000
OPERATING MANUAL

This Operating Manual applies to all FIREBERD 6000 Communications Analyzers incorporating Software Revision D.

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MANUAL ABSTRACT

The FIREBERD 6000 Operating Manual contains 12 sections and several appendices. Each manual section is briefly described below.

Section 1 GENERAL INFORMATION

This section defines the scope of the operating manual and presents an overview of the FIREBERD 6000 and its capabilities.

Section 2 PREPARATION FOR USE

This section provides the instructions for unpacking and inspecting the FIREBERD as well as a list of the equipment included in each shipment, the instrument's power requirements, and important operational warnings.

Section 3 INSTRUMENT CHECKOUT

This section contains an explanation of the automatic self-test performed by the FIREBERD at power-up and step-by-step procedures for performing a more detailed manual self-test.

Section 4 INSTRUMENT DESCRIPTION

A detailed description of the FIREBERD's front panel switches, indicators, menu functions, keypad, displays, and rear panel features is presented in this section.

Section 5 FUNCTIONAL DESCRIPTION

This section discusses the FIREBERD 6000's error analysis, timing analysis, and signal analysis capabilities as well as the various modes of operation available.

Section 6 OPERATION INSTRUCTIONS

Step-by-step procedures are presented in this section for utilizing the test capabilities of the FIREBERD. Separate procedures are given for performing error analysis, timing analysis, and delay measurement.

Section 7 PRINTER/CONTROLLER INTERFACES

This section provides a description of the built-in RS-232 and the optional IEEE-488 Printer/Controller Interfaces; also discussed is their operation for both printing and remote control purposes. The various print formats are described and illustrated with sample printouts. This section also contains information on remote control operation and BERD-BASIC programming.

Section 8 DATA INTERFACES

This section contains functional descriptions, operating instructions, and the specifications for the built-in RS-232-C/V.24 Data Interface as well as for many of the other data interfaces available for use with the FIREBERD 6000.

Section 9 JITTER OPTIONS

Included in this section is information on the jitter options offered for use with the FIREBERD 6000; specifically covered are jitter measurement capabilites, available results, procedures for jitter measurement, and the jitter option specifications.

Section 10 SPECIFICATIONS

This section contains the specifications for the FIREBERD 6000.

Section 11 OPTIONS AND ACCESSORIES

This section describes the various options and many of the accessories available for use with the FIREBERD 6000. Also included is a list of the available accessories and their corresponding part numbers for ordering purposes.

Sections 12 MAINTENANCE AND SERVICE

This section contains information on routine maintenance as well as TTC's warranty and equipment return policies.

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SECTION 1

GENERAL INFORMATION

1.1 INTRODUCTION

This operating manual contains information for the operators and users of the FIREBERD 6000 Communications Analyzer manufactured by Telecommunications Techniques Corporation. This manual also covers the metal version of the instrument, the FIREBERD MC6000, and the remote-control-only version, the FIREBERD 6000R. An accompanying Remote Control Commands Handbook supplements the information in this manual. Unless otherwise stated, references to the FIREBERD or FIREBERD 6000 also refer to the FIREBERD MC6000 and FIREBERD 6000R.

Specifically included in this manual are installation procedures, functional descriptions, operating instructions, and specifications for the FIREBERD 6000 as well as for various data interfaces used with the FIREBERD. A Manual Abstract at the front of this manual gives a summary of the contents of each section.

1.2 INSTRUMENT IDENTIFICATION

An identification sticker is attached to the rear panel of each FIREBERD. The sticker bears the serial number assigned to the instrument; this serial number should be quoted on any correspondence with TTC concerning the instrument.

1.3 INSTRUMENT OVERVIEW

The FIREBERD 6000 is a powerful test instrument for analyzing, evaluating, and troubleshooting digital communications systems and equipment. Designed to operate from 50 b/s to 15 Mb/s and to use modular data interfaces, the FIREBERD combines the best of traditional bit error rate analysis with such additional features as performance analysis, signal analysis, and timing analysis.

Housed in a rectangular case approximately 6"x12"x12," the FIREBERD weighs less than 16 pounds in the plastic version and less than 20 pounds in the rugged metal version. The light weight and a sturdy handle make the FIREBERD easily portable, and a front cover is included as standard equipment for front-panel protection. To enhance flexibility of use, fold-out rear panel feet allow the FIREBERD to be operated in a stand-up position.

The FIREBERD 6000 front panel is designed to be as easy to operate for the first-time user as for the seasoned troubleshooter who, in time-critical situations, needs results readily available at the touch of a button. The FIREBERD features two alphanumeric displays, one of which can simultaneously display two sets of results. A combination of electronic slide switches, pushbutton switches, and menu formats with extensive HELP guidance further facilitate complex test configurations. Such varied indicators as labeled LEDs, panel labels with backlighting, and LED-illuminated switches keep the user constantly informed of test parameter changes and error or alarm conditions.

The FIREBERD 6000 operates in various full-duplex configurations and with synchronous, asynchronous, or recovered timing. Transmit timing may be supplied externally or from the built-in frequency synthesizer. The synthesizer allows operation at any rate from 50 b/s to 15 Mb/s with the stability and accuracy of a crystal oscillator. Other timing analysis features include: separate high-resolution transmit and receive frequency counters; an inverted clock detector; a selectable transmit clock inverter; a clock slip detector that identifies system timing problems; and a clock recovery option that permits received clock fault isolation.

The FIREBERD comes equipped with a built-in RS-232 interface, although all FIREBERD 1500A and 2000-compatible data interfaces as well as new T-Carrier data interfaces may be installed through an interface module slot in the instrument's rear panel. With the appropriate T-Carrier interface installed, the FIREBERD 6000's power and capabilities are readily apparent—in addition to logical error analysis and timing analysis, the FIREBERD can perform bipolar violation, framing error, and CRC error analysis. For T1 testing, the FIREBERD can work with D4 or Fe (ESF) framing and can generate framed or unframed loop codes with intelligent CSU response detection. In addition, bipolar violations can be inserted at variable rates, and B8ZS line coding can be automatically detected.

Among the FIREBERD 6000's signal analysis functions are the most advanced jitter generation and measurement capabilities available, such as external or precisely controlled internal jitter modulation as well as automatic frequency sweeps. The receiver features a peak-to-peak measurement and a jitter hits circuit with variable thresholds which operates continuously so that short-duration events will not be missed. Jitter spectral analysis—with multiple jitter masks—is performed using non-overlapping frequency bands to permit jitter "fingerprinting" and rapid identification of jitter sources. In addition, hard-copy graphs of the spectrum can be generated. Other important signal analysis functions include delay measurement and automatic data polarity detection.

The FIREBERD 6000 also advances the state-of-the-art in remote control, whether used with a terminal or with a computer. For terminals, the FIREBERD offers an understandable, easy-to-use, plain English format with extensive HELP prompts and screens. For computers, a condensed fixed-field format is offered. The FIREBERD also features built-in BERD-BASIC, an advance in intelligent control which allows the user to perform complex tests using only a dumb terminal.

In addition to the FIREBERD's extensive current capabilities, its flexible architecture and advanced 80186 16-bit processor are designed to easily accommodate upgrades as standards change or as new features and capabilities are added. A separate, easily accessible EPROM module permits software upgrades without disassembling the instrument. These features, as well as the 6000's compatibility with the FIREBERD 1500A and 2000, make the FIREBERD 6000 the complete data communications analyzer for present and future testing needs.

SECTION 2
PREPARATION FOR USE

2.1 INTRODUCTION

This section provides unpacking and initial inspection instructions, warnings, and power requirements.

2.2 UNPACKING AND INITIAL INSPECTION

The shipping container should be inspected for damage when it is received. If the shipping container or shipping material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. Procedures for checking electrical performance are given in Section 3. If the contents are incomplete, if there is mechanical damage or defect, or if the FIREBERD does not pass the performance tests, the customer should notify TTC. If the shipping container is damaged, notify the carrier as well as TTC, and keep the shipping container and materials for the carrier's inspection.

2.3 EQUIPMENT INCLUDED

The following equipment is supplied with each unit:

FIREBERD 6000/MC6000
- Power Cord
- Operating Manuals
- Front Cover
- Snap-On Back Pouch

FIREBERD 6000R
- Power Cord
- Operating Manuals

2.4 WARNINGS

The following precautions must be observed before and during all phases of operation of the instrument. Failure to comply with these precautions or specific warnings elsewhere in the manual may cause physical harm to the operator or to the instrument. TTC assumes no liability for the customer's failure to comply with these requirements.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis must be connected to an electrical ground. The instrument is equipped with a three-conductor AC power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adaptor with grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet.

USE PROPER LINE VOLTAGE SETTING AND FUSE SIZE

Before connecting the AC power cord, verify that the line voltage selector card is positioned for the correct operating voltage. Never operate the instrument with the incorrect fuse size.

KEEP AWAY FROM LIVE CIRCUITS

Do not remove instrument covers or insert fingers or other objects through rear panel holes while power is applied to the instrument.

TURN OFF POWER BEFORE INSERTING AND REMOVING INTERFACE MODULES

DO NOT OPERATE IN AN AMBIENT TEMPERATURE ABOVE 50° C

2.5 POWER REQUIREMENTS

The instrument requires a power source of 90-135 or 195-250 volts ac, single phase, 48 to 66 Hz that can deliver 120 volt-amperes (maximum). The instrument is normally shipped from the factory set to operate from a 120-volt power source. To operate the instrument from a different source voltage, proceed as follows:

(1) Remove the input power cord.

(2) Slide the plastic door on the AC input connector to the left.

(3) Remove the fuse.

(4) Pull the voltage select card straight out.

(5) Change the orientation of the voltage select card and reinsert so the appropriate operating voltage is visible on the card after it has been installed.

(6) Install the appropriate size fuse (See Table 2-1).

(7) Slide the plastic door to the right and reinsert power cord.

Table 2-1
Fuse Size

Operating Voltage	Fuse Size
90-135	3 amp 125 V Slow Blow
195-250	1.5 amp 250 V Slow Blow

2.6 GROUND JUMPER

The FIREBERD 6000/MC6000/6000R is equipped with a pluggable ground jumper. When the FIREBERD is shipped from the factory, signal ground is connected to chassis ground through a 100-ohm, ½ watt resistor. Signal ground may be directly connected to chassis ground by repositioning the pluggable jumper on a PC board. To reposition the jumper, use either of the following procedures, as applicable.

2.6.1 FIREBERD 6000/6000R (Plastic Case)

(1) Remove the power cord from the back of the FIREBERD.

(2) Turn the unit upside down and remove the four screws from the bottom of the FIREBERD case.

(3) Turn unit right side up, and remove the top cover by simultaneously pressing in on both sides and pulling up.

(4) Locate PC board #40442 immediately behind the front panel. The pluggable ground jumper is located on the upper left-hand corner of the component side of the board. (See Figure 2-1.)

(5) Lift the jumper (JW1) from the three-position header (B position) and press it into place one position to the right. (A position.)

(6) Put the top cover back on, turn the FIREBERD upside down, and fasten the cover back in place by replacing the four screws on the bottom of the FIREBERD case.

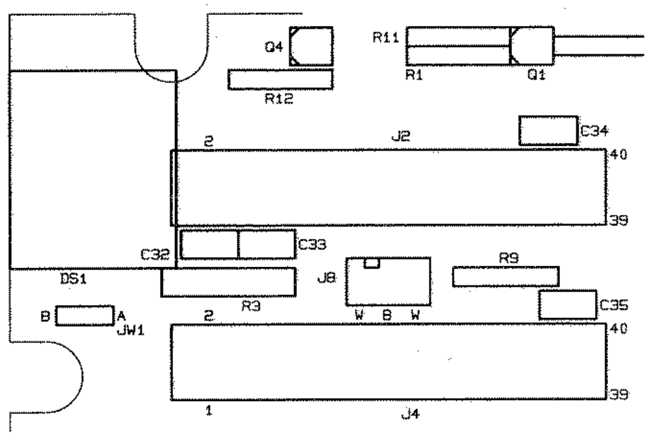


Figure 2-1
Component Side PC Board #40442
View of Upper Left Corner
and Pluggable Jumper Position

2.6.2 FIREBERD MC6000 (Metal Case)

(1) Remove the power cord from the back of the FIREBERD.

(2) Locate and remove the two screws (one on each side of the case) which hold the front bezel in place.

NOTE: If the case is equipped with a handle, press the buttons on each side of the handle and rotate the handle downward to expose the front bezel screws (one on each side of the case).

(3) Remove front bezel by pulling forward.

(4) Slide the top cover forward and lift out.

(5) Locate PC board #40442 immediately behind the front panel. The pluggable ground jumper is located on the upper left-hand corner of the component side of the board. (See Figure 2-1.)

(6) Remove the pluggable jumper (JW1) from the three position header (B position) and install it one position to the right (A position).

(7) Replace the top cover by sliding it through the guides on each side of the case, and ensure that the cover is seated properly in the rear of the FIREBERD.

(8) Press the front bezel back into place and replace the two screws.

SECTION 3
INSTRUMENT CHECKOUT

3.1 INTRODUCTION

This section describes the automatic self-test that the FIREBERD 6000 performs at power-up. Also included is a manual self-test which can be used to verify proper operation of the FIREBERD. The following procedures assume that the user is familiar with the operation of the FIREBERD 6000; unfamiliar users should refer to Section 5.

3.2 AUTOMATIC SELF-TEST

The automatic self-test is actually a series of diagnostic tests that are performed at power-up by the FIREBERD 6000 to ensure that it is functioning correctly. If one of these tests fail, the FIREBERD 6000 will display an error message specifying what part of the instrument failed.

The automatic self-test also performs the following functions.

- All of the discrete LED indicators (except the MK and SP indicators), switches containing LEDs, and panel labels with backlighting will be illuminated for approximately 1 second.

- Switches are checked for proper position. If a switch is found to be depressed (stuck) at power-up, an error message is displayed specifying the key that is stuck. For example, holding down the DATA switch during power-up causes the message KEY STUCK DATA to be displayed for approximately 1 second.

- Non-volatile RAM (NOVRAM) is checked because, at power-up, the FIREBERD 6000 restores the instrument to the settings that were selected before the last power-down. If any changes are found, a message is displayed for approximately 1 second specifying what general portion of NOVRAM failed. The original factory settings are automatically restored for each portion of NOVRAM. The FIREBERD 6000 may still be fully functional even though switch settings may not be saved during a power cycle.

- All of the RAM and the EPROMS are tested. If an error is found, a message is displayed. In the case of an EPROM error, the instrument may not be able to operate, and TTC should then be called for service.

3.3 MANUAL SELF-TEST

The manual self-test is performed in the Self-Loop mode. The FIREBERD's operation in this mode is directly related to the interface selected. TTC recommends that the built-in RS-232/V.24 data interface be used for this test. If the built-in RS-232 is suspected of malfunctioning, an external interface may be used for the test. Remember that power to the FIREBERD must be turned OFF before inserting or removing an interface. If the interface used has clock invert switches, they should be placed in the NORMAL position for this test. Other interface switches should be set appropriately. (Refer to Section 8 for information on interface switch settings; if an interface is not included in Section 8, refer to the individual operating manual.)

If the self-test leads to a determination that servicing of the FIREBERD is required, it is helpful to note the areas of the test in which the FIREBERD failed.

3.3.1 Preparation

(1) Verify that the ac line voltage card is set appropriately for the existing line voltage. Set the POWER switch to the ON position.

(2) Verify that the automatic self-test does not display any error messages. Also verify that all of the discrete LED indicators, switches containing LEDs, and panel labels with backlighting are illuminated for approximately 1 second after power-up.

(3) If the AUX FUNC IN USE label (to the left of the MENU switch) is illuminated, press the MENU switch to select the AUXILIARY position. Using the keypad, enter the number 99 and complete the entry by pressing ENTER. The message CLEAR FUNC IN USE? will appear on the top line of the display, and the answers YES and NO will appear on the line below. Press the YES soft key to clear all in-use auxiliary functions.

(4) The SELF LOOP switch must be illuminated throughout the entire test unless otherwise specified.

3.3.2 Frequency Synthesizer and Frequency Counter

To set the FIREBERD 6000 for testing the frequency synthesizer and the frequency counter, use the following procedure.

(1) Verify that the SELF LOOP switch is illuminated.

(2) Set the DATA switch to the 2^{23}-1 position.

(3) Set the GEN CLK switch to the SYNTH position.

(4) Set the TIMING MODE switch to the SYNC position.

(5) Press the MENU pushbutton switch to select the INTF SETUP function.

(6) An interface selection menu will appear in the left display (immediately above keypad). Press the soft key beneath the INT 232 selection.

(7) Press the EMLATE soft key.

(8) Press the DTE soft key. Interface setup is now complete.

(9) Press the MENU pushbutton switch to select the SYNTH FREQ function.

(10) When a selection menu appears in the display, press the illuminated MORE pushbutton switch below the display to scroll to additional menu selections.

(11) Press the MORE key again; then press the soft key beneath the 64 selection. The synthesizer frequency is now set.

(12) Press the left and then the right CATEGORY switches to select the SIGNAL category. (The indicators to the left and the right of SIGNAL will illuminate.)

(13) Press the right RESULT switch until RCV FREQ appears in the right portion of the display.

(14) Press the left RESULT switch until GEN FREQ appears in the left portion of the display.

(15) Set the ANALYSIS MODE switch to the CONTINUOUS position.

(16) Verify that the display above the ANALYSIS RESULTS block shows:

GEN FREQ	RCV FREQ
64000.0	64000.0

3.3.3 Synchronous Transmit and Receive

To set the FIREBERD 6000 for testing synchronous transmit and receive, use the following procedure.

(1) Verify that the 10^{-3} indicator is NOT illuminated. If it is illuminated, press the ERROR INSERT switch to turn it off.

(2) Press the right CATEGORY switch to select the ERROR category.

(3) Press the right RESULT switch until BIT ERRS appears in the right portion of the display.

(4) Press the RESTART switch and verify that the SYNC indicator is illuminated and that a zero is displayed for bit errors in the right-most display. The SYNC LOST, DATA INV, CLK INV, and NO CLK indicators should be off.

3.3.4 Error Counter and Error Insert

To set the FIREBERD for testing the error counter and the error insert function, use the following procedure.

(1) Use the setup procedure in Section 3.3.3.

(2) Press the ERROR INSERT switch once and observe the right-most display (BIT ERRS) increment by one count.

(3) Adjust the volume control until a beep is heard every time the ERROR INSERT switch is pressed.

(4) Hold down the ERROR INSERT switch until the 10^{-3} indicator illuminates and observe the right-most display count incrementing rapidly. A beep should be heard for every second which contains an error.

(5) Press the MENU switch to select the TEST INTERVAL function. Press the soft key beneath the 10^{6} selection.

(6) Press the right RESULT switch until the BER result appears in the display and reads 1.00E-03 after approximately 15 seconds.

3.3.5 Seconds and Blocks

To set the FIREBERD 6000 for testing seconds and block measurement functions, use the setup procedure in Section 3.3.3, but with the following changes.

(1) Press the MENU switch to select the SYNTH FREQ function. Using the keypad, type the number 1 and press ENTER.

(2) Press the left CATEGORY switch to select the TIME category.

(3) Press the left RESULT switch until E F EAS appears in the left portion of the display.

(4) If the 10^{-3} indicator is illuminated, press the ERROR INSERT switch once to turn the indicator off.

(5) Press the MENU switch to select the AUXILIARY function. Using the keypad, type the number 30 and press ENTER. Then type the number 1000 and press ENTER.

(6) Press the RESTART switch and verify that the count in the left side of the display above the ANALYSIS RESULTS block is incrementing one count per second.

(7) Press the right CATEGORY switch to select the TIME category. Press the right RESULT switch until E A SEC appears in the right portion of the display. Verify that the counting is identical to that for E F EAS.

(8) Press the right CATEGORY switch to select the ERROR category. Using the right RESULT switch, scroll through the right portion of the display to verify that the results listed below are being measured correctly.

BLK ERRS	Count of Zero
BLKS	Counting identical to E F EAS and E A SEC

3.3.6 Data Generator

To test the operation of the data generator, use the following procedure.

(1) Set the DATA switch to the MARK position.

(2) Press the MENU switch to select the SYNTH FREQ function. Using the keypad, type the number .05 and press ENTER.

(3) Verify that the MK indicator is illuminated.

(4) Press the ERROR INSERT switch a few times and verify that the SP indicator is briefly illuminated.

(5) Set the DATA switch to the 1:1 position and verify that the MK and SP indicators are both flashing.

(6) Change the synthesizer frequency to 5 kHz by typing the number 5 and pressing ENTER.

(7) Sequence the DATA switch through all of its pattern positions and verify that the SYNC indicator is illuminated for each position except FOX and USER.

3.3.7 Time

To verify that the FIREBERD is recording the correct time and date, press the left RESULT switch until TIME and then DATE appear in the left portion of the display. Verify that the correct time and date are shown.

If the time and date shown are not correct, set both functions using Auxiliary Function 60 (see Section 4.3.2.3).

SECTION 4
INSTRUMENT DESCRIPTION

4.1 INTRODUCTION

This section describes the FIREBERD 6000's front panel switches, indicators, menu functions, keypad, and displays. It also describes the connectors and test points on the rear panel and other pertinent FIREBERD features.

Figure 4-1 shows the FIREBERD front panel. The numbers for each item in the figure correspond to the numbered descriptions in the following sections.

4.2 CONTROLS AND INDICATORS

This section describes the FIREBERD's discrete switches and indicators. There are two types of switches: electronic slide switches and single-function pushbutton switches. An electronic slide switch consists of a column of labeled indicators above a pushbutton switch. Pressing and releasing the pushbutton switch turns off the illuminated indicator and turns on the next indicator. When the switch is pressed and held down, the sequence continues until the switch is released.

Several of the switches contain LED indicators. The LED indicators served varied purposes and are described along with their corresponding switches.

The FIREBERD features two types of indicators: discrete LED indicators with adjacent labels, and panel labels with backlighting. Both types of indicators are described in the following sections.

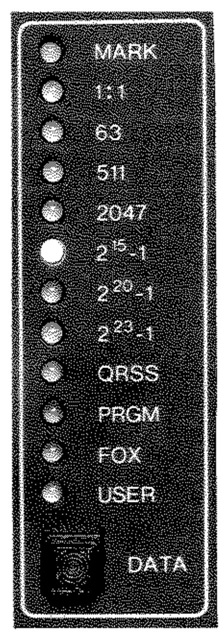
4.2.1 Controls

Listed below are descriptions of the FIREBERD front panel controls. The numbers preceding each description correspond to the numbers in Figure 4-1.

---

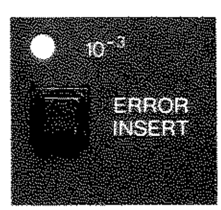
1. DATA Switch

The DATA switch selects the pattern or message to be used for testing. The data generator transmits the selection and the data receiver expects to receive this selection to synchronize. The programmable pattern (PRGM) and user-programmable message (USER) are defined via Auxiliary Functions 33 and 41, respectively. Note that the FOX and USER messages are not available with synchronous or recovered timing and that the PRGM, 2^{20}-1, 2^{23}-1, and QRSS patterns are not available with asynchronous timing.



2. ERROR INSERT Switch and 10^{-3} Indicator

The ERROR INSERT pushbutton switch causes errors to be placed in the generator data stream. Each time the switch is momentarily pressed and released, a single error is inserted. If the switch is held down for longer than 1 second, a continuous error rate of 1 error in 1000 bits is inserted in the generator data stream, and the 10^{-3} indicator directly above the switch is illuminated. Momentarily pressing the switch while the 10^{-3} indicator is illuminated returns the switch to the off (error-free) position.



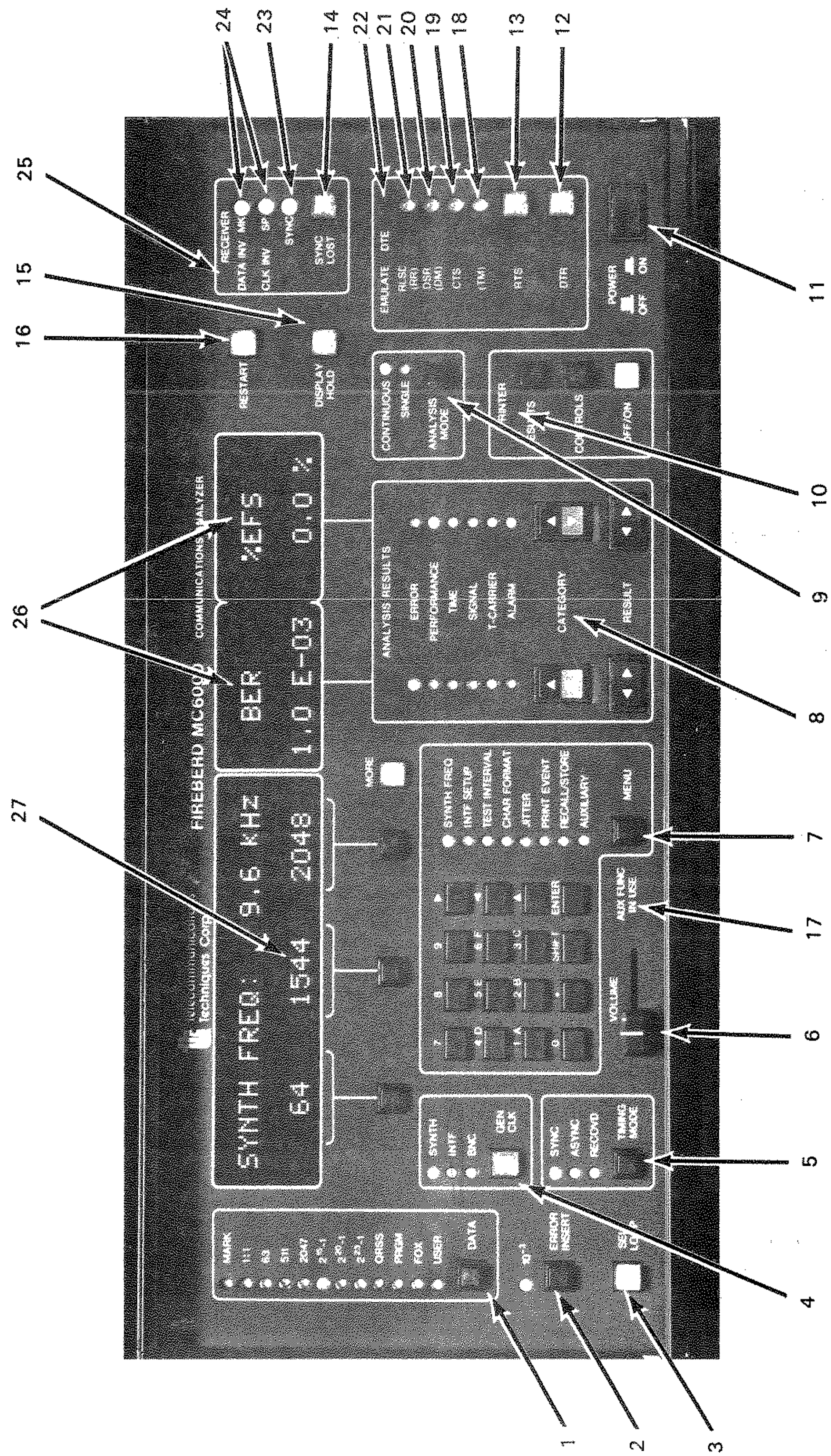
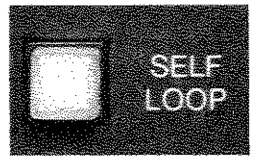
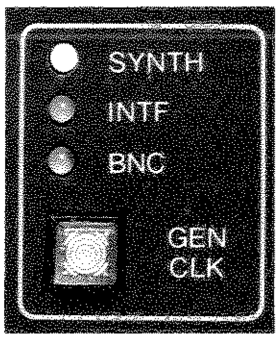


Figure 4-1
FIREBERD 6000 Front Panel

3. SELF LOOP Switch



The SELF LOOP pushbutton switch changes FIREBERD operation from normal Full-Duplex mode to Self-Loop mode or vice versa. When in self-loop operation, a red LED within the SELF LOOP switch is illuminated to indicate that the generator and receiver data and clock lines are disconnected from the system or connector under test.

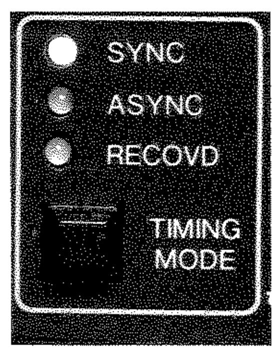


4. GEN CLK Switch

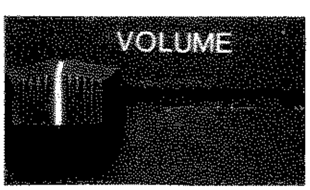
The GEN CLK switch is used to select the source of generator timing for the instrument. The SYNTH position selects the built-in frequency synthesizer; the synthesizer can generate frequencies from 50 Hz to 15 MHz. The BNC position selects an external timing source connected to the rear panel BNC connector. The INTF position selects a clock derived from the selected data interface. Some restrictions apply to the BNC and INTF positions; see Section 5.6 for further information.

If no clock signal is detected at the selected source, a red LED within the GEN CLK switch will be illuminated. In asynchronous timing operation, this LED will be illuminated regardless of clock activity when the GEN CLK switch is set to either the BNC or INTF position.

5. TIMING MODE Switch



The TIMING MODE switch selects between synchronous, asynchronous, and recovered timing operation. If the Clock Recovery option is not installed, the RECOVD position of the TIMING MODE switch will be skipped when scrolling through the switch positions. The TIMING MODE switch is not applicable with some data interfaces; when such an interface is in use, the TIMING MODE switch positions will not be illuminated, and the switch will be inoperative.



6. VOLUME Control

The VOLUME control determines the audio level of the tone generator.

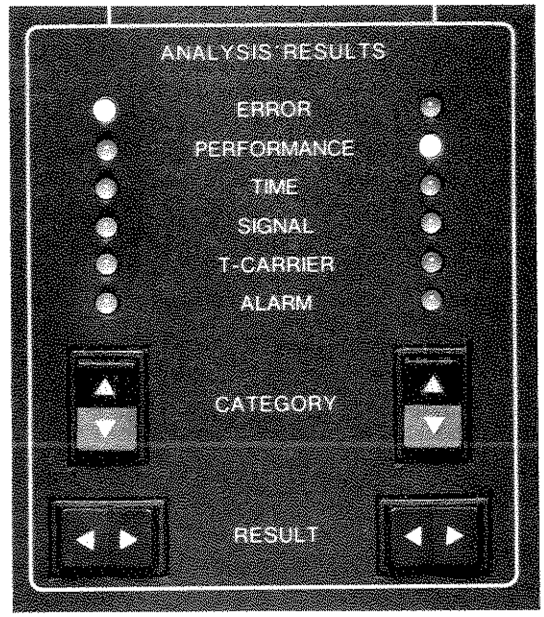
7. MENU Switch, Keypad, and Soft Keys

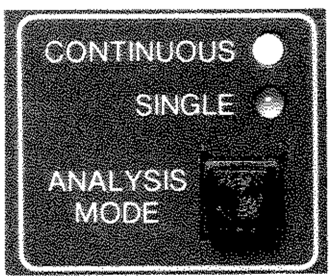
The MENU switch, keypad, and soft keys are described in Section 4.3.2.

8. ANALYSIS RESULTS Functional Block

The CATEGORY and RESULT switches are used to determine which of the available analysis results are shown in the two results displays. The left and right CATEGORY and RESULT switches operate identically and independently: the left pair of switches selects what is presented in the left results display; the right pair selects what is presented in the right results display.

The FIREBERD 6000's analysis results are divided into result categories. Within each result category, several individual analysis results are typically available. A particular analysis result may be displayed by first setting the CATEGORY switch to the appropriate result category and then pressing the RESULT switch until the desired result is presented in the display. The analysis results included in each category are listed in Section 4.4.





9. ANALYSIS MODE Switch

This switch determines whether a test will run continuously or whether it will run only for a selected interval and then stop. This switch is closely tied to the TEST INTERVAL function of the MENU switch. In continuous operation, results are accumulated indefinitely; in single analysis operation, results are accumulated for the length of the test interval. Data transmission continues but the FIREBERD will not accumulate results past the end of the test interval.

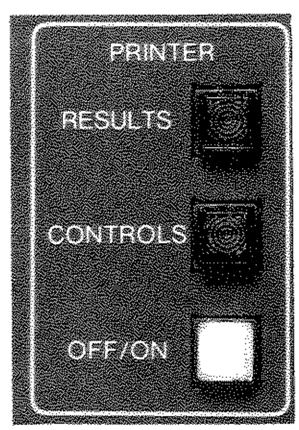
10. PRINTER Functional Block

The PRINTER control block contains three switches which can be used to turn on and off an external printer or to initiate certain printouts.

The RESULTS pushbutton switch takes a snapshot of the results currently available and queues them for printing. The most recent results are used regardless of whether the DISPLAY HOLD switch is in the ON position.

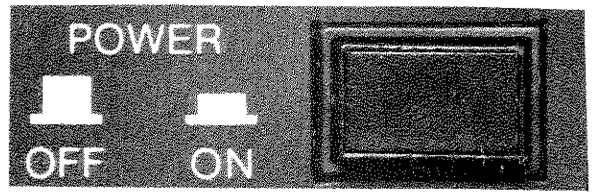
The CONTROLS pushbutton switch initiates a controls printout. This printout contains the current setting of each switch.

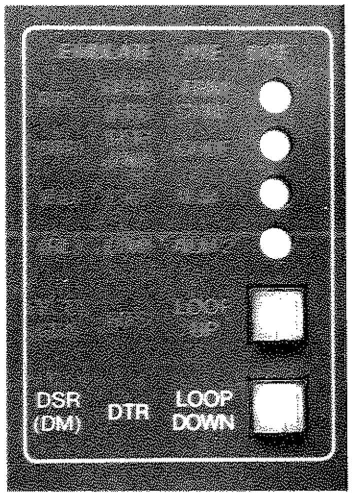
The OFF/ON pushbutton switch enables or disables the printer. The green LED within the switch illuminates in the ON position. Whenever the OFF/ON switch is switched off, the print buffer is cleared. This switch applies to all printouts except those initiated via the RESULTS or CONTROLS switches; results prints and controls printouts are printed regardless of the position of the OFF/ON switch.



11. POWER Switch

The POWER pushbutton switch turns the power to the FIREBERD on and off. The ON and OFF positions are illustrated to the left of the switch.



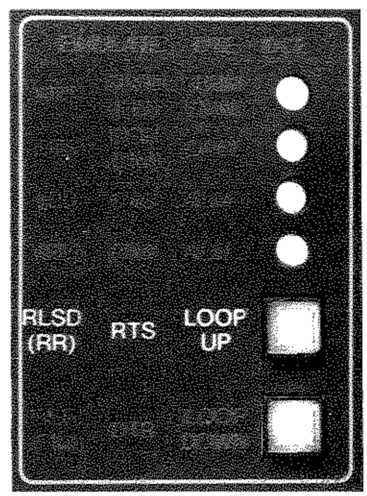


12. DSR (DM)/DTR/LOOP DOWN Switch

The DSR(DM)/DTR/LOOP DOWN pushbutton switch controls the state of the DTR (Data Terminal Ready) line in DTE emulation and DSR(DM) (Data Set Ready) line in DCE emulation. The switch toggles between ON and OFF each time that it is pressed; a yellow LED within the switch is illuminated in the ON position. With an appropriate T-Carrier interface, a loop-down code is transmitted each time the switch is pressed. The LED is illuminated while the loop-down code is being transmitted.

13. RLSD (RR)/RTS/LOOP UP Switch

The RLSD (RR)/RTS/LOOP UP pushbutton switch controls the state of the RTS (Request to Send) line in DTE emulation and the RR (Receiver Ready) line in DCE emulation. The switch toggles between ON and OFF each time that it is pressed; a yellow LED within the switch is illuminated in the ON position. With an appropriate T-carrier interface, a loop-up code will be transmitted when the switch is pressed. The LED is illuminated while the loop-up code is being transmitted.

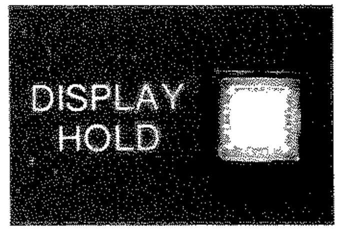


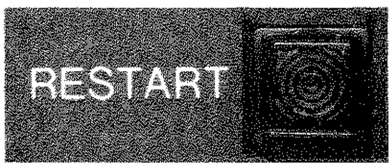
14. SYNC LOST Switch

The red LED indicator within the SYNC LOST switch is illuminated immediately upon the detection of a receiver synchronization loss and remains illuminated until the switch is pressed or the test is restarted.

15. DISPLAY HOLD Switch

When the DISPLAY HOLD switch is pressed, all analysis results selectable by the CATEGORY and RESULT switches are frozen, so that the values of these results at the time the switch was pressed may be examined. This display hold feature does not affect a test in process; while the display may be frozen, curent analysis results continue to accumulate. When the display hold feature is selected, a red LED within the switch is illuminated to warn that the results presented in the display are not the current results. Pressing the DISPLAY HOLD switch again will return the displays to their normal mode of operation.





16. RESTART Switch

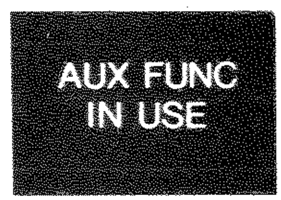
When the RESTART switch is pressed, all accumulated analysis results are cleared and all tests and measurements are restarted. Pressing the RESTART switch also initiates data transmission in the Single Transmit mode, which is selectable through Auxiliary Function 04.

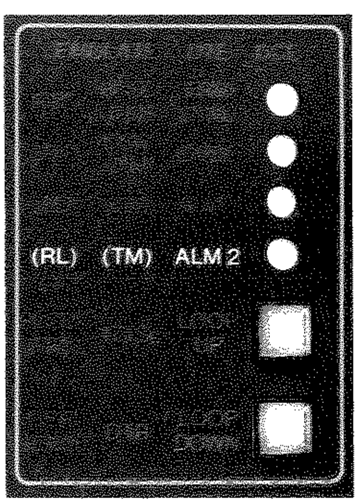
4.2.2 Indicators

Listed below are descriptions of the FIREBERD front panel indicators. The numbers preceding each description correspond to the numbers in Figure 4-1.

17. AUX FUNC IN USE Panel Label

The yellow AUX FUNC IN USE panel label is illuminated when a status-select auxiliary function is in a state other than its default state. Status-select auxiliary functions alter the standard operation of the FIREBERD; they are described in Section 4.3.2.3 and listed in Table 4-1 in that section.



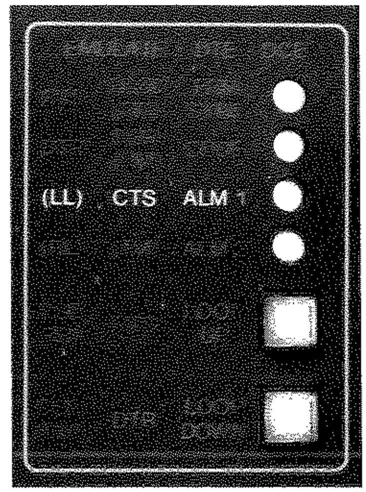


18. (RL)/(TM)/ALM 2 Indicator

The yellow (RL)/(TM)/ALM2 indicator is illuminated when the FIREBERD is in the Emulate DTE mode and the TM (Test Mode) signaling line is ON. The indicator is also illuminated when the FIREBERD is in the Emulate DCE mode and the RL (Remote Loopback) line is ON. When operating with pseudoternary interfaces, the indicator is illuminated on particular alarm conditions. See the specific interface sections for detailed information regarding these alarm conditions.

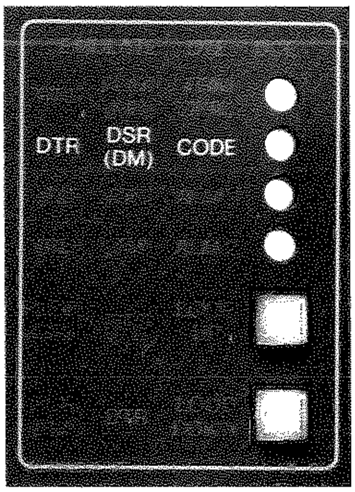
19. (LL)/CTS/ALM1 Indicator

The yellow (LL)/CTS/ALM1 indicator is illuminated when the FIREBERD is in the Emulate DTE mode and the CTS (Clear to Send) signaling line is ON. The indicator is also illuminated when the FIREBERD is in the Emulate DCE mode and the LL (Local Loopback) signaling line is ON. When operating with pseudoternary interfaces, the indicator is illuminated on particular alarm conditions. See the specific interface sections for detailed information regarding these alarm conditions.



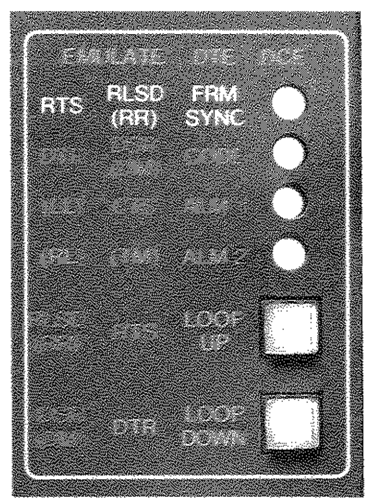
20. DTR/DSR (DM)/CODE Indicator

The yellow DTR/DSR (DM)/CODE indicator is illuminated when the FIREBERD is in the Emulate DTE mode and the DSR (Data Set Ready) signaling line is ON. The indicator is also illuminated when the FIREBERD is in the Emulate DCE mode and the DTR (Data Terminal Ready) signaling line is ON. When operating with pseudoternary interfaces, the indicator is illuminated when a specific code, such as B8ZS, is being received.



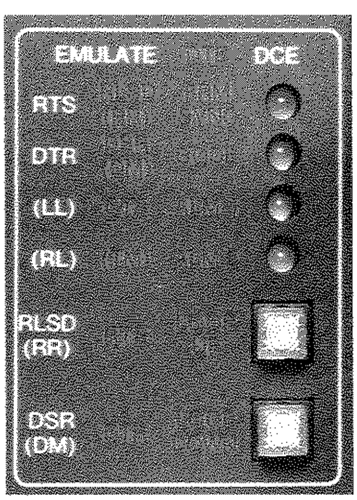
21. RTS/RLSD (RR)/FRM SYNC Indicator

The yellow RTS/RLSD (RR)/FRM SYNC indicator is illuminated when the FIREBERD is in the Emulate DTE mode and the RLSD (Receive Line Signal Detector) signaling line is ON. The indicator is also illuminated when the FIREBERD is in the Emulate DCE mode and the RTS (Request to Send) signaling line is ON. When operating with pseudoternary interfaces, the indicator is illuminated when synchronization to a specific framing pattern has been achieved.

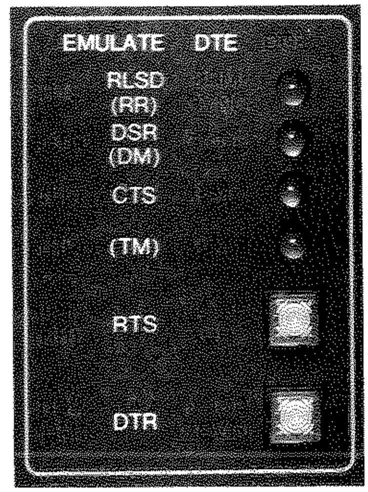


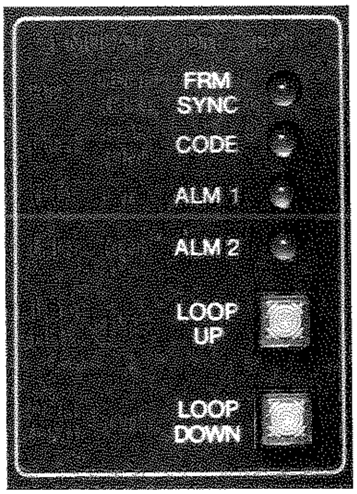
22. EMULATE DTE and EMULATE DCE Panel Labels

The yellow EMULATE DCE panel label is illuminated when the FIREBERD is in the Emulate DCE mode. In addition, the FIREBERD will backlight the DCE signaling lead labels as shown to the left; these labels use RS-232 notation with RS-449 notation in parentheses.



The yellow EMULATE DTE panel label is illuminated when the FIREBERD is in the Emulate DTE mode. In addition, the FIREBERD will backlight the DTE signaling lead labels as shown to the right; these labels use RS-232 notation with RS-449 notation in parentheses.

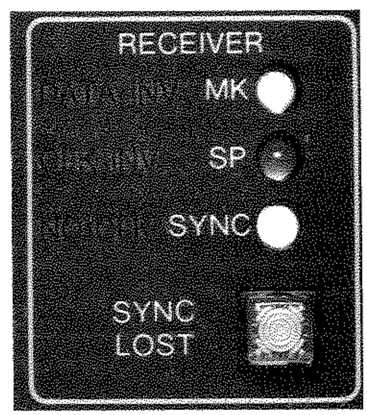


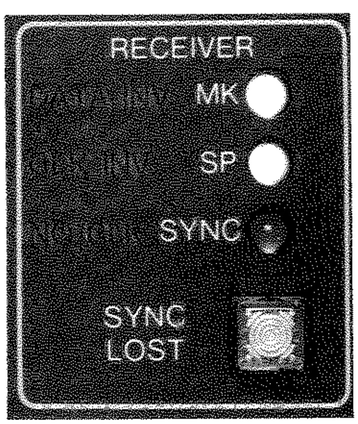


When a pseudoternary interface is selected, the FIREBERD will backlight the right column of labels as shown to the left. All or only part of the column of labels will be illuminated depending on their applicability to the selected interface.

23. SYNC Indicator

The green SYNC indicator is illuminated when pattern synchronization is achieved. The SYNC indicator is controlled based on the receiver synchronization criteria described in Section 5. In Live analysis mode, the SYNC indicator is used to indicate the presence of the signal being monitored.



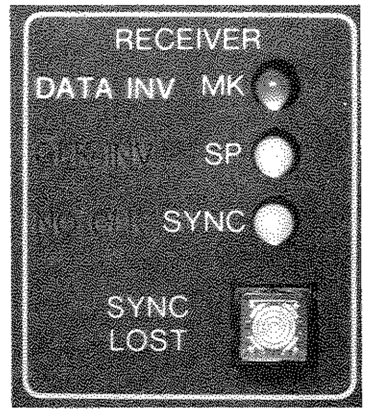


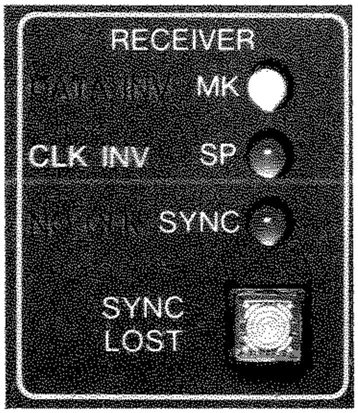
24. MK and SP Indicators

The yellow MK and SP indicators are illuminated when a Mark or a Space is detected in the received data. The Mark and Space detection is performed prior to polarity correction (if required). The MK and SP indicators are mutually exclusive – the MK indicator is on and the SP indicator is off for the duration of a Mark, and the SP indicator is on and the MK indicator is off for the duration of a Space.

25. RECEIVER Block Panel Indicators

The red DATA INV panel label is illuminated when the data received by the FIREBERD has been found to be the logical inversion of what was expected, and the auto-polarity circuit has re-inverted the data to permit error analysis.





The red CLK INV panel label is illuminated when the clock-data phasing at the input to the FIREBERD's data interface has been found to be the opposite of that specified by the applicable interface standard.

The red NO CLK panel label is illuminated when the selected timing mode requires a clock and there has been no receiver clock activity for 50 milliseconds. Note that a clock loss will force a synchronization loss.

4.3 DISPLAY AND MENU FUNCTIONS

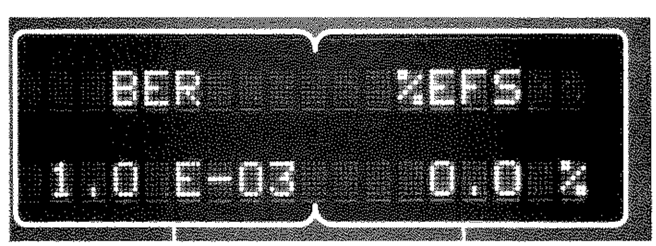
4.3.1. Display

The display is divided into three sections with an upper and a lower line for each section. The display sections and their use are described below. The numbers preceding the descriptions correspond to the numbers in Figure 4-1.

26. Results Display

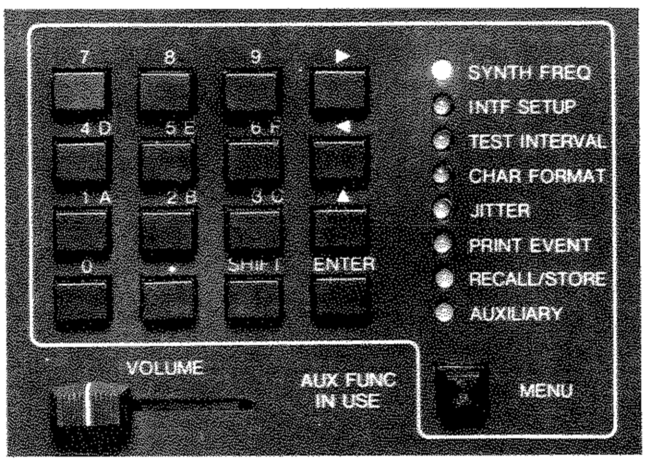
The two sections of the results display are used for displaying test results. The right section corresponds to the CATEGORY and RESULT switches on the right side of the ANALYSIS RESULTS block below the display; the left section of the display corresponds to the switches on the left side of the ANALYSIS RESULTS block. The right and left displays are identical in function. The upper line of each section is used for the result name, while the lower line contains the result itself. If a result is not yet available (e.g., when the FIREBERD is not yet synchronized to incoming data.), the lower line of the display remains blank. When a result is not applicable in the operating mode, "N/A" is displayed. If a result has overflowed the 8-digit display, the visible portion of the result will flash. If a result has overflowed its internal storage capacity so that it has become meaningless, the lower line will display the message OVERFLOW.

The FIREBERD also provides the user with error and status messages. These messages appear on the upper line of the display, alternating with the result names. For detailed information on the messages, see Section 5.5.4.



27. Menu Display

The menu section of the display accomodates the functions selected by using the MENU switch, the soft keys below the display, the MORE switch, and the keypad. The menu functions are described in Section 4.3.2.



4.3.2. MENU Switch, Keypad, and Soft Keys

The MENU switch is used to select a menu to display; menus are used to set up the various functions of the FIREBERD. Menus are provided for functions which have a large number of configurable parameters, functions with selections that change with data interfaces or options, and functions requiring numeric or hexadecimal entries.

The soft keys are used to move through the menu and to make selections. There are three soft keys below the menu display; the labels for these keys appear on the lower line of the display within the bracket above each key. If a soft key is not used, its label will be blank.

The MORE switch (below the menu display) is illuminated when more than three soft-key selections are available for a given menu. This switch can then be used to display the labels for the next set of three soft-key selections.

Each menu is designed using a hierarchical or "tree" structure. Each menu tree is presented graphically in Section 4.3.2.2. For illustration purposes, the PRINT EVENT menu is presented in Figure 4-2. In this figure and all other menu tree figures, the top of the tree is a single line representing the switch position. All of the other boxes signify soft-key labels.

To access a menu, the MENU switch is used to select the desired function. When a function is selected, the display will show the top level of the menu. The current setting of the present level of the menu is displayed on the upper line; the soft-key labels are displayed on the lower line. Pressing a soft key will either (1) display the next level of the menu, or (2) configure the FIREBERD to the setting specified by the soft key.

If the TIME soft key is pressed, the menu will move down yet another level and the labels OFF and HELP will appear in the display. The HELP soft key is displayed whenever keypad entry is required for a menu selection. Pressing the HELP soft key will display information regarding the nature and range of the parameters to be entered. This message will remain in the display for approximately 2 seconds, or as long as the soft key is held down.

At this point in the PRINT EVENT menu, the user is at the third level of the menu. The ▲ key on the keypad can be pressed to move back to the previous level in the menu; the ENTER key will move the user back to the top level. A detailed description of each keypad function is contained in Section 4.3.2.1.

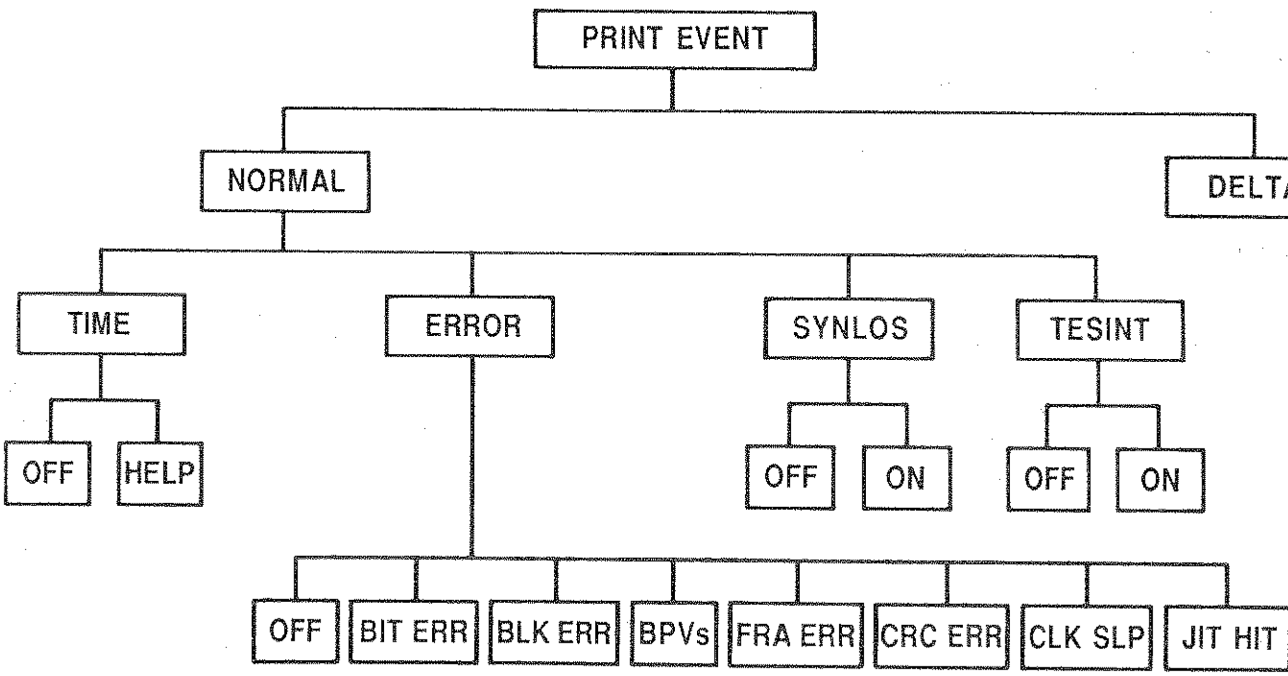


Figure 4-2
PRINT EVENT Menu Tree

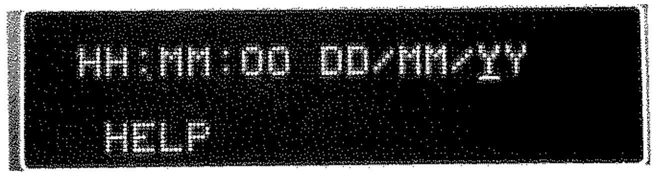
4.3.2.1 Keypad

Key	Function
0 – 9	Used for numeric entry
. key	Used for floating decimal point entry, such as synthesizer frequency.
SHIFT	This key is labled in blue and provides access to the hexadecimal digits A – F, also labeled in blue. For example, to enter an A, press and release the SHIFT key, and then press the key labeled A. It is not necessary to hold down the SHIFT key while the A key is pressed.
ENTER	This key is used to terminate and implement keypad-entered data. If no data has been entered, this key will return the user to the top level of the particular menu in use.
▲ key	This key is used to move to the previous level of the menu in use.
▶, ◀ keys	Some menus have a cursor to allow the operator to change all or part of a setting. These keys are used to position the cursor under the field to be changed. When no cursor is used, the ◀ key also functions as a rub-out (delete left character) key.

When a function uses a large range of values that cannot be represented with soft-key labels, the keypad is used to enter the desired values. After the digits are entered, the ENTER key must be used to complete the entry.

Menu functions that have fields of data will display a cursor. For example, the time and date setting (Auxiliary Function 60) will display:

Here the cursor is under the first minute digit. The cursor can then be moved with the ▶ and ◀ keys. If the user wants only to change the year, the cursor should be positioned under the YY field by using the ▶ key:



Changing only one field will leave the other fields unaffected. The current year is entered using the keypad:

The ENTER key must then be pressed to implement the new setting.

Some functions do not have fields and, therefore, do not require the cursor. For example, the SYNTH FREQ function display appears as:

To enter 1544.1 kHz as the new frequency, enter the number 1544.1 using the keypad. As soon as the first digit is pressed, the previous display is blanked and replaced with the new number as it is entered. The old setting (9.6) is still implemented at this point. After all digits are entered, the ENTER key must be pressed to implement the new frequency. The display will then read:

4.3.2.2 Main Menus

SYNTH FREQ: Selects the synthesizer frequency.

This menu is used to select the synthesizer frequency. The frequency can be selected from the set provided by using the soft keys (see Figure 4-3) or can be entered by using the keypad. All frequencies are entered in kHz and must be between .05 kHz and 15000 kHz. If the user attempts to enter an out-of-range frequency from the keypad, the FIREBERD will beep and restore the previous setting without disturbing the test in progress.

A frequency may have four or five significant digits. If the first two digits are 16 through 99, four digits may be entered. If the first two digits are 10 through 15, five digits may be entered.

The soft-key labels for frequency may be changed so that the user will have the most commonly used frequencies available at the touch of a button. Auxiliary Function 32 enables the user to program the soft keys to the desired frequencies. The frequencies in Figure 4-3 are the factory settings.

In asynchronous operation, when the synthesizer is the generator clock source, the frequency must be no more than 20 kHz. In recovered clock operation, it must be no more than 520 kHz. If the synthesizer exceeds these frequency ceilings, the FIREBERD will indicate a contention.

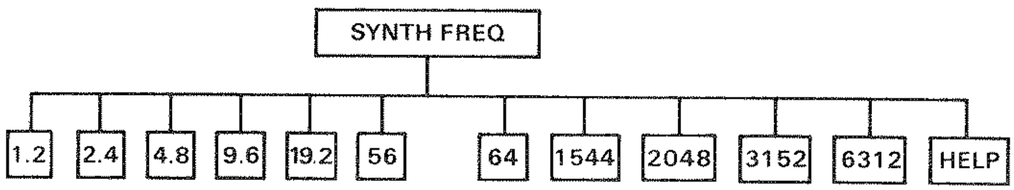


Figure 4-3
SYNTH FREQ Menu Tree

INTF SETUP: Selects and configures the data interface.

This menu is used to select either the internal RS-232 interface or the external interface installed in the rear panel opening. The menu is shown in Figure 4-4. The soft-key label <EXTERNAL> will actually be labeled with the name of the interface installed. When this soft key is pressed, the external interface will be selected. If there are configuration menus for that interface, they will then be displayed. The menu diagrams for the interfaces that have them are given in the individual interface sections of Section 8.

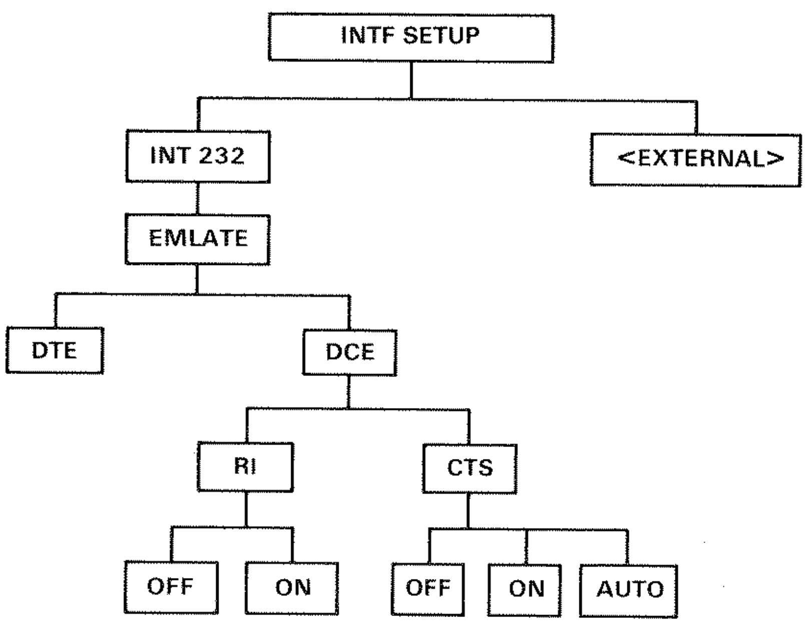


Figure 4-4
INTF SETUP Menu Tree

TEST INTERVAL: Selects a test interval.

The test interval can be set to be a fixed interval of time, or it can be determined by the number of data bits received (see Figure 4-5). In continuous analysis operation, the test interval determines the length of cyclic measurements (e.g., BER or BPV Rate); non-cyclic results are accumulated indefinitely. In single analysis operation, the FIREBERD accumulates all results until the test interval is complete and stops; no further result accumulations occur.

When the TIMED soft key is pressed, the cursor will appear and the interval can be changed within the range of 1 second to 24 hours. The FIREBERD will beep for an illegal entry and will restore the previous time without disturbing the test in progress. Once data has been entered, but before the ENTER key is pressed, the display changes from TEST INTVL to SET INTVL to indicate that the ENTER key must be pressed to implement the setting.

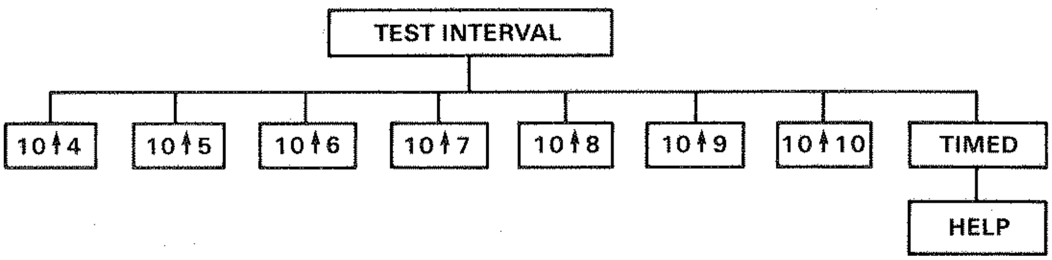


Figure 4-5
TEST INTERVAL Menu Tree

CHAR FORMAT: Selects the asynchronous character format.

This menu is used to set up the asynchronous character format for the interfaces (see Figure 4-6). The settings shown in the menu diagram are applicable when the TIMING MODE switch is set to the ASYNC position. The number of data bits, stop bits, and parity bits can be configured. All selections can be made using soft keys, although the number of data bits can be entered by using either a soft key or the keypad.

JITTER: Configures the jitter parameters and displays spectral analysis.

This function is described in detail in Section 9 (Jitter Options).

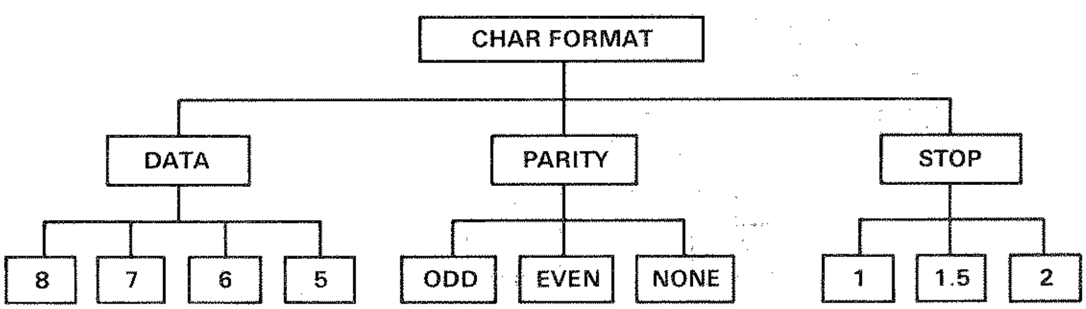


Figure 4-6
CHAR FORMAT Menu Tree

PRINT EVENT: enables results printouts based on particular events.

The PRINT EVENT menu can be set in two basic modes: DELTA and NORMAL (see Figure 4-7). Note that the printer must be on for selected events to cause printouts.

If the DELTA soft key is pressed, a Delta print is generated at the end of each test interval. A Delta print is a printout of those results accumulated only during the most recent test interval, as opposed to being accumulated since testing began.

If the NORMAL soft key is pressed, several event categories may be selected to cause a cumulative results print: TIME, ERROR, SYNLOS, and TESINT. Any time that one of the selected events occurs, a results print will be generated.

When TESINT is selected, a printout will occur at the end of each test interval. With SYNLOS, a printout will be generated when a loss of synchronization occurs; the printout results will be from 2 to 4 seconds preceding the synchronization loss. The ERROR selection accesses the error printout menu. A printout may be generated on the occurrence of bit errored seconds, block error seconds, BPV seconds, frame error seconds, CRC error seconds, clock slip seconds, or jitter hits seconds. Each error printout will be printed at the end of an error analysis second (E A SEC); therefore, AUX 03 receiver action on sync loss may affect error prints.

The TIME selection is used to specify a time interval for results prints. The user may enter from 1 to 1440 minutes (24 hours) by using the keypad.

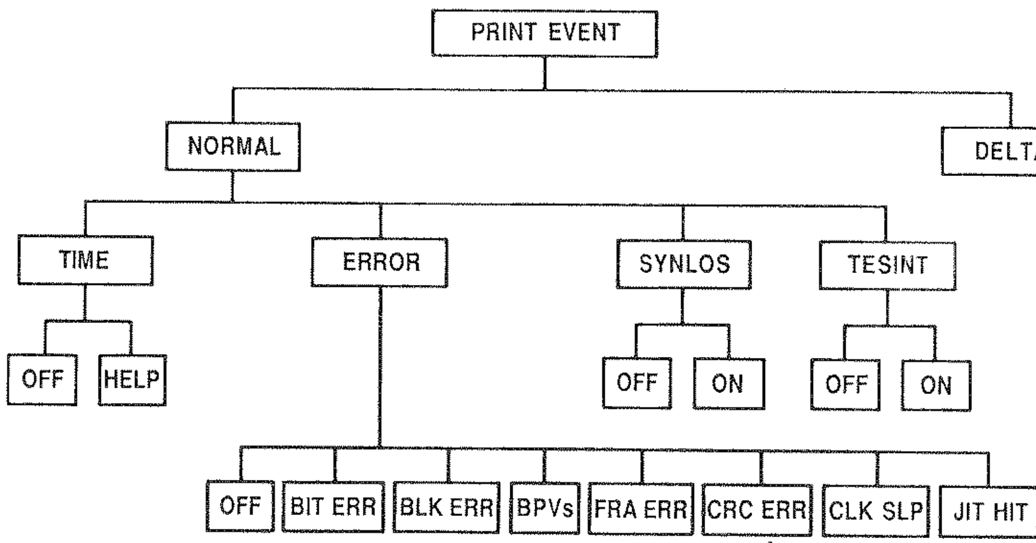


Figure 4-7
PRINT EVENT Menu Tree

RECALL/STORE: FIREBERD setup for store or recall.

The FIREBERD can store up to 10 different configurations (see Figure 4-8). The current configuration may be saved by pressing the STORE soft key and then pressing the soft key for the program's ID number. A program may be recalled by pressing the RECALL soft key and, again, the soft key for the program's ID number. The program's ID number may also be entered by using the keypad.

Once a program has been stored or recalled, the menu will display "CURRENT PROGRAM: n" where "n" is the program's ID number. When the setting of a major switch is changed, the display will indicate "LAST PROGRAM".

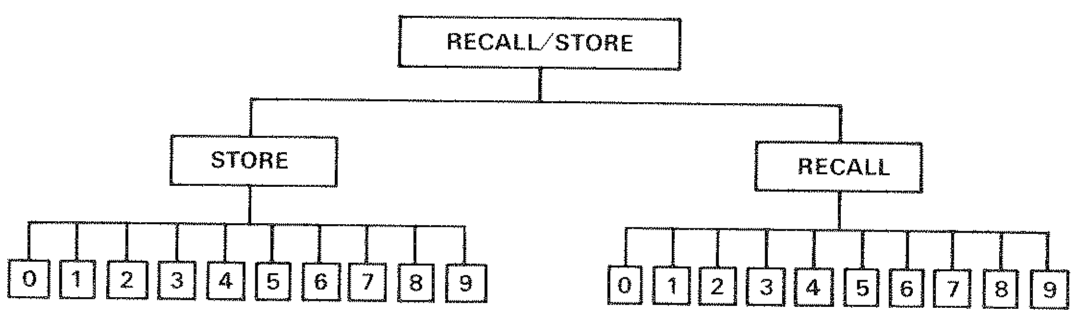


Figure 4-8
RECALL/STORE Menu Tree

4.3.2.3 Auxiliary Functions

The FIREBERD has several other configurable functions that are obtained via the AUXILIARY position of the MENU switch. The auxiliary function access menu is shown in Figure 4-9. The LIST soft key enables the operator to display the name and number of each function. The FWD soft key moves through increasing numbers; RVRS moves through decreasing numbers. The SELECT soft key enters the menu for the displayed function. The desired menu may also be obtained by entering the function number from the keypad rather than using the LIST soft-key menu.

A subset of the auxiliary functions is a group of status-select auxiliary functions. The status-select auxiliary functions are shown in Table 4-1. The status settings are the actual soft-key labels; the setting listed first is the default setting. A status-select auxiliary function is "in use" when it is set to any other setting other than the default. When one or more status-select auxiliary functions are in use, the AUX FUNC IN USE panel label will be illuminated.

The IN USE soft key in Figure 4-9 displays those status-select auxiliary functions that are not in their default settings.

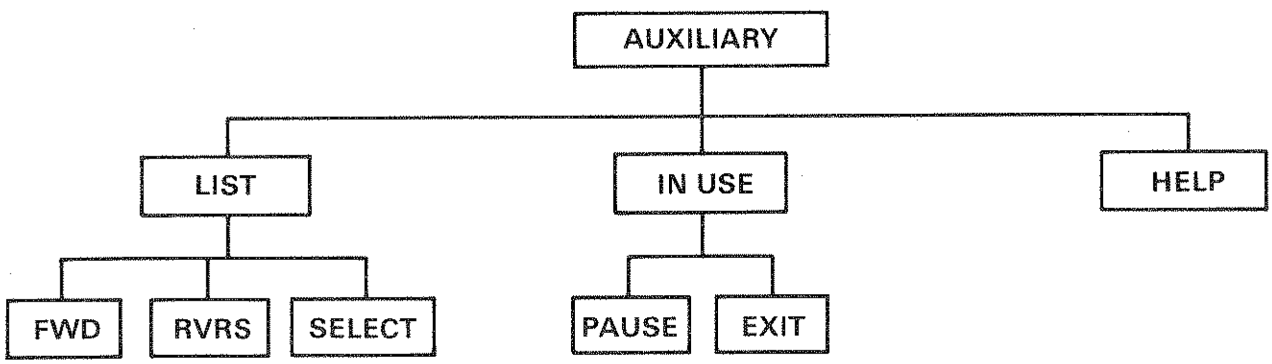


Figure 4-9
AUXILIARY Menu Tree

Table 4-1

Status-Select Auxiliary Functions

FUNCTION	NUMBER	NAME	STATUS SETTING ABBREVIATION AND DESCRIPTION
Generator Clock Polarity	01	GEN CLK POL	NORMAL – Clock data phasing is per interface standard. INVERT – Clock data phasing is the inverse of the interface standard.
Receiver Clock Polarity	02	RCVR CLK POL	AUTO – Receiver clock data phasing is automatically detected, corrected, and maintained while error analysis is in process. NORMAL – Clock data phasing is per interface standard. INVERT – Clock data phasing is the inverse of the interface standard.
Receiver Action Upon Sync Loss	03	ACT SYN LOSS	CLEAR – Clear all results counters and restart test as soon as sync is reacquired. HALT – Freeze all results counters for duration of sync loss. Test continues as soon as sync is reacquired. CONT – Continue to accumulate error analysis results while receiver is trying to resynchronize. (Synchronous and Recovered mode only.) AUTDIS – Auto sync disable. Continue to accumulate error analysis results but do not try to resynchronize.
Single Transmit	04	SINGLE TRANS	OFF – Transmit data continuously. ON – Transmit one pattern or message only each time restart switch is depressed.
Interface	05	INTF CONTROL	F-BERD – The data interface is controlled through the FIREBERD front panel or through remote control. INTF – the data interface is controlled through switches on the interface. This function applies only to interfaces which are able to be controlled both through the FIREBERD front panel as well as by the interface's own switches
Generator Data Inverter	06	GEN DATA INV	OFF – Transmitted data not inverted. ON – Transmitted data inverted.
Receiver Clock Select (Emulate DCE Only)	07	RCVR CLK SEL	AUTO – ST (a DCE output) automatically chosen if TT (a DCE input) is not present at the interface TT – TT chosen. ST – ST chosen.

Table 4-1 (Cont.)

Status-Select Auxiliary Functions

FUNCTION	NUMBER	NAME	STATUS SETTING ABBREVIATION AND DESCRIPTION
Out-of-Band Flow Control	08	OUT-BAND FLOW	OFF – Data transmission occurs regardless of the status of signaling leads. ON—Data transmission can be conditioned upon the reception of TR, DM, RS, CS, and RR signals.
In-Band Flow Control (Asynchronous Messages Only)	09	IN-BAND FLOW	OFF – Test does not respond to XON and XOFF characters in the data received, and data transmission is not affected. ON – Test set scans the incoming data for XON and XOFF characters and responds accordingly. Defaults XON to 11H and XOFF to 13H.
Sync Loss Threshold	10	SYNC LOSS THR	MED – Declare sync loss when 250 bit errors are counted in less than 1000 bits. LOW – Declare sync loss when 100 bit errors are counted in less than 1000 bits. HIGH – Declare sync loss when 20,000 bit errors are counted in less than 100,000 bits.
Printer Select	11	PRINTER SEL	AUTO – Select RS-232 first, if no device connected (no DTR) then send data to IEEE-488. RS-232 – Select RS-232 only. 488 – Select IEEE-488 only.

The following descriptions are for the auxiliary functions other than the status-select auxiliary functions.

FUNCTION	NUMBER	NAME	DESCRIPTION
Block Length	30	BLK LEN	Selects the block length. The allowable range is 100 – 1,000,000 bits.
Signal Delay	31	DELAY	Sets up the FIREBERD for signal delay timing. The start timing and stop timing signals and edges are selected here. See Section 6.4 for detailed information on setting up for delay timing.
Program Common Frequencies	32	COMMON FREQ	Used to program the most commonly used frequencies into the soft-key settings for the SYNTH FREQ function of the MENU switch.
Programmable Pattern	33	PATTERN	Allows the user to program and edit a 3- to 24-bit pattern. This is the pattern used for the PRGM position of the DTA switch. The order of data bits transmitted is left to right on the display. When this function is entered, the pattern editor is in "exchange" mode. Any binary digits entered will write over the digit at the cursor. Use the INSERT soft key to toggle in/out of insert mode. In insert mode, digits are inserted at the cursor without overwriting any others. Digits may be entered at the end of the pattern in either mode. The DELETE soft key deletes the digit at the cursor. The ▶ and ◀ keys are used to position the cursor. The ENTER key is used to save and implement all changes made to the pattern.
Site Identification	34	SITE ID	Used to enter a site ID. This ID is included on printouts and can be used to identify a site when the FIREBERD is used in a network. The site ID is displayed and printed in ASCII characters; however, it must be entered using the hexadecimal codes for ASCII characters. A hex conversion table is included in Appendix C.
Results Print Content Selection	35	RESULTS PRINT	Used to determine the content of results printouts. STD selects the standard printout. Table 4-2 shows the standard printout for each operating mode. The LONG print includes all applicable results. The CUSTOM print allows each result to be included (ON) or excluded (OFF). Note that each result is included in the printout only as long as it is applicable to the operating mode in use at the time of the printout.
Status Print Selection	36	STATUS PRINT	Each of the status messages can be enabled (ON) or disabled (OFF). When enabled, the status message will be printed each time the status changes (if the printer is on). The status message will not be printed when this function is disabled.

Table 4-2

Standard Printouts for Operating Modes

Asynchronous

SITE ID
Bit Errors
Average BER
BER
Blocks
Block Errors
Character Errors
Error-Free Error Analysis Seconds
Error Analysis Seconds
Time/Date
GEN FREQ
Interface

Synchronous and Recovered

SITE ID
Bit Errors
Average BER
BER
Blocks
Block Errors
Error-Free Error Analysis Seconds
% Error-Free Seconds
Error Analysis Seconds
Time/Date
RCV FREQ
GEN FREQ
Interface

Pseudoternary Standard

SITE ID
Bit Errors
Average BER
BER
Error-Free Error Analysis Seconds
% Error-Free Seconds
Error Analysis Seconds
Time/Date
Violations
Average Violation Rate
Violation Rate
Frame Errors
Average Frame Error Rate
Frame Error Rate
CRC Errors
Average CRC Error Rate
CRC Error Rate
Frame Word Errors
Average Frame Word Error Rate
Frame Word Error Rate
RCV FREQ
GEN FREQ
Interface

Pseudoternary Live

SITE ID
Bit Errors
Error Analysis Seconds
Time/Date
Violations
Average Violation Rate
Violation Rate
Violation-Free Error Analysis Seconds
Frame Errors
Average Frame Error Rate
Frame Error Rate
CRC Errors
Average CRC Error Rate
CRC Error Rate
Frame Word Errors
Average Frame Word Error Rate
Frame Word Error Rate
RCV FREQ
GEN FREQ
Interface

Printout Format	37	PRNT FRMT	Used to change the format of the printouts. The COLUMN soft key is used to change between 20, 40, and 80 columns. The MODE soft key is used to change between COND (condensed) and NORM (normal). LAYOUT selects between FWD (forward) and BACKWD (backward). BACKWD should be selected with the PR-2000 20-column printer. FWD should be used for CRTs and the PR-85 80-column printer. Further descriptions of the settings can be found in Section 7.
RS-232 Printer/ Controller Setup	38	232	Used to configure the RS-232 printer/remote controller mote controller interface. The display for this function appears as: 232: bbbb,d,pppp,tttt,x where bbbb is the baud rate: 110, 300, 600, 1200, 2400, 4800, 9600. d is the number of data bits: 7, 8. pppp is the parity: ODD, EVEN, NONE. tttt is the line terminator: CR (carriage return), LF (line feed), or CR LF (both). x is the print speed: S (slow) – print no more than 20 characters per second. F (fast) – print at full baud rate. The S (slow) setting is recommended for the PR-2000 printer.
IEEE-488 Printer/ Controller Setup	39	488	Used to configure the IEEE-488 printer/remote control interface. The display for this function is: 488: aaaa,sss,tttt,x where aaaa is the address or TALK (this shows the current setting of the DIP switch on the IEEE-488 option and is not configurable from the front panel). sss is the service request setting: ERR (error), DAT (data). tttt is the line terminator: CR (carriage return), LF (line feed), CR LF (both). x is the print speed: S (slow) – print no more than 20 characters per second. F (fast) – print at the full transfer rate.
User Message Selection	41	USER MESSAGE	Allows the selection of one of three user-defined messages for the USER position of the DATA switch. The selected message can then be edited. The characters are entered in hex from the keypad. The ► and ◄ keys position the cursor. Note that in hex, 2 digits are required to define a character; therefore, the cursor is 2 digits wide. The INSERT key is used to toggle in/out of insert mode. When not in insert mode (when in exchange mode), the character entered overwrites the character at the cursor. In insert mode, the character is inserted without overwriting any others.

			Characters may be added at the end of the message in either mode. The DELETE soft key deletes the character at the cursor. After editing, the ENTER key must be used to save and implement the message. Messages may be from 1 to 225 characters long.
Recall Pre-Sync Loss Results	42	PRE SYNC LOSS	Accessing this function will cause the results from 2 to 4 seconds preceding the most recent sync or power loss to be transferred to the results display buffer. An automatic display hold will be performed. If the printer is on, these results will also be printed out. If no sync or power loss has occurred since the test started, the message "No sync losses" will be displayed.
Clear Non-Volatile RAM Settings	43	CLEAR NOVRAM	Used to clear the configuration of the FIREBERD and all stored programs, patterns, and user messages. The FIREBERD will prompt the user to verify this operation twice before it is performed. All of the settings will be reset to the factory preset values.
Histogram Setup	44	HISTOGRAM	Used to select the resuts to be graphed and the scale to be used for histogram plots. See Section 7 for details on the histogram printout.
Time/Date Set	60	TIME/DATE	Used to set the FIREBERD's clock/calendar. The display will show: HH:MM:00 DD/MM/YY The cursor should be positioned under the field to be changed and the digits entered from the keypad. All or part of time/date may be modified. The hours are in 24-hour format and range from 00 to 24. ENTER is used to implement the setting. Setting the minutes will automatically set the seconds to 00.
Clear Status Select Functions in Use	99	CLEAR FUNC IN USE	Used to reset all of the status-select auxiliary functions (Table 4-1) to their default states. This will extinguish the AUX FUNC IN USE panel label.

4.4 RESULT CATEGORIES

These are the categories and results available by using the ANALYSIS RESULTS switches. This listing shows the result abbreviation and the full name of the result. A detailed description of each result is included in Section 5.5.

CATEGORY	ABBREVIATED RESULT NAME	FULL RESULT NAME
ERROR	BIT ERRS	Bit Errors
	AVG BER	Average Bit Error Rate
	BER	Bit Error Rate
	BLOCKS	Blocks
	BLK ERRS	Block Errors
	AVG BLER	Average Block Error Rate
	CHAR ERR	Character Errors
	CLK SLIP	Clock Slip

CATEGORY	ABBREVIATED RESULT NAME	FULL RESULT NAME
PERFORMANCE	% ACT SEC	% Active Seconds
	% AVL SEC	% Available Seconds
	% DEG MIN	% Degraded Minutes
	% EFS	% Error-Free Seconds
	% SES	% Severely Errored Seconds
	% SVS	% Severely Violated Seconds
	% SYN SEC	% Sync Seconds
	% VFS	% Violation-Free Seconds
	AVL SEC	Available Seconds
	DEG MIN	Degraded Minutes
	EFS	Error-Free Seconds
	ERR SEC	Errored Seconds
	SES	Severely Errored Seconds
	SIGL SEC	Signal Loss Seconds
	SVS	Severely Violated Seconds
	SYNL SEC	Sync Loss Seconds
	UNA SEC	Unavailable Seconds
	VFS	Violation-Free Seconds
TIME	ERR EAS	Errored Error Analysis Seconds
	E A SEC	Error Analysis Seconds
	E F EAS	Error-Free Error Analysis Seconds
	ELAP SEC	Elapsed Seconds
	TIME	Time
	DATE	Date
T-CARRIER	BPVs	Bipolar Violations
	AVG BPVR	Average Bipolar Violation Rate
	BPV RATE	Bipolar Violation Rate
	V F EAS	Violation-Free Error Analysis Seconds
	% V F EAS	% Violation-Free Error Analysis Seconds
	RCV CODE	Received Code
	FRA ERR	Frame Errors
	AVG FER	Average Frame Error Rate
	F E Rate	Frame Error Rate
	FRA LOSS	Frame Sync Losses
	CRC ERR	CRC Errors
	AVG CRC	Average CRC Error Rate
	CRC E Rt	CRC Error Rate
	FW ERR	Frame Word Error
	AVG FWER	Average Frame Word Error Rate
	FW E Rate	Frame Word Error Rate
	1SEC CRC	One Second CRC Errors
SIGNAL	DELAY	Delay
	MAX JTR	Maximum Jitter
	1SEC JTR	1 Second Jitter
	JTR HITS	Jitter Hits
	% MASK	Maximum % of Mask
	RCV FREQ	Receiver Clock Frequency
	GEN FREQ	Generator Clock Frequency
ALARM	SYN LOSS	Sync Losses
	DAT LOSS	Receiver Data Losses
	CLK LOSS	Receiver Clock Losses
	SIG LOSS	Receiver Signal Loss
	YEL SEC	Yellow Alarm Seconds

XS0 SEC	Excess Zero Seconds
C-D CHA	Receiver Clock-Data Phase Changes
PWR LOSS	Power Losses
AIS SEC	AIS Seconds

4.5 REAR PANEL

All connections to the FIREBERD 6000 are made on the rear panel: data interface modules are also installed in a slot in the rear panel. In addition to the test points and BNC connectors which provide access to signals and are discussed in the following sections, several other features are accessed through the rear panel. Figure 4-10 shows the FIREBERD 6000 rear panel.

Remote Control or Printer

A standard feature of the FIREBERD 6000 is remote control via the built-in RS-232 interface. This connector is a female 25-pin D connector configured as DCE. Communication is asynchronous at a rate set using Auxiliary Function 38. This RS-232 port is also used for connection to a printer for obtaining hard copy of results and messages. Remote control via the optional IEEE-488 (GPIB) interface is possible by installing the IEEE-488 module in the slot below the data interface module slot on the rear panel. Auxiliary Function 39 is used to configure the IEEE-488 Printer/Controller interface.

Fuse and Voltage Selector

The voltage selector is a small card near the power plug that is removed, rotated, and then replaced with the appropriate voltage showing. Any time that the voltage is changed, the fuse must be replaced with another fuse of the proper style and rating. See Section 2.5 for detailed information on voltage selection and fuse replacement.

Fan

A fan mounted on the rear panel allows proper cooling and ventilation of the internal components. The fan is always in operation when the FIREBERD itself is on; the fan cannot be operated independently. The fan is protected by a screen which should be checked periodically for dirt or blockage. See Section 12 for instructions on fan screen maintenance.

4.5.1 BNC Connectors

Up to four BNC connectors are mounted on the rear panel. These connectors are GEN CLK OUT, GEN CLK IN, JITTER MOD IN, and DEMOD JITTER OUT. Each of these connectors is described below.

GEN CLK OUT

This connector provides a buffered version of the generator clock signal. This output is a TTL signal capable of driving a 50-ohm load.

GEN CLK IN

An external clock source may be used by connecting the clock source to the GEN CLK IN connector and setting the FIREBERD front panel GEN CLK switch to the BNC position. The FIREBERD accepts a sine- or square-wave signal of at least 1.5 volts peak-to-peak from 50 Hz to 15 MHz. This BNC input has a built-in 50-ohm termination.

JITTER MOD IN

This connector is used only when the DS1 Jitter Generation option is installed in the FIREBERD and the DS1/D4/Fe Data Interface is used. Any signal presented to this connector may be selected to jitter the transmitted T1 signal correspondingly. See Section 9 for further information on the jitter options.

DEMOD JITTER OUT

This connector is active only when the DS1 Wideband Jitter Measurement option is installed in the FIREBERD and the DS1/D4/Fe Data Interface is selected. The jitter on the received T1 signal is extracted and is provided at this connector for monitoring. This output can drive a 50-ohm load, and is calibrated at 10 unit intervals per volt.

4.5.2 Test Points

A variety of test points are provided for measurement and synchronization purposes. Test point inputs and outputs are at TTL level, where a logic low is less than or equal to 0.4 volts, and a logic high is greater than or equal to 2.4 volts.

RCVR CLK

This TTL-level output is a buffered version of the clock used by the receiver section of the instrument. Under normal circumstances, the data of the RCVR DATA test point is valid on the rising edge of the RCVR CLK signal. This output is not valid with asynchronous timing.

RCVR DATA

This TTL-level output is a buffered version of the data being sent to the FIREBERD's receiver. A logic high represents a received Mark; a logic low represents a received Space.

GEN CLK

This TTL-level output is a buffered version of the clock used by the generator section of the instrument. Under normal circumstances, the data at the GEN DATA test point is valid on the rising edge of the GEN CLK signal. This output is not valid with asynchronous timing.

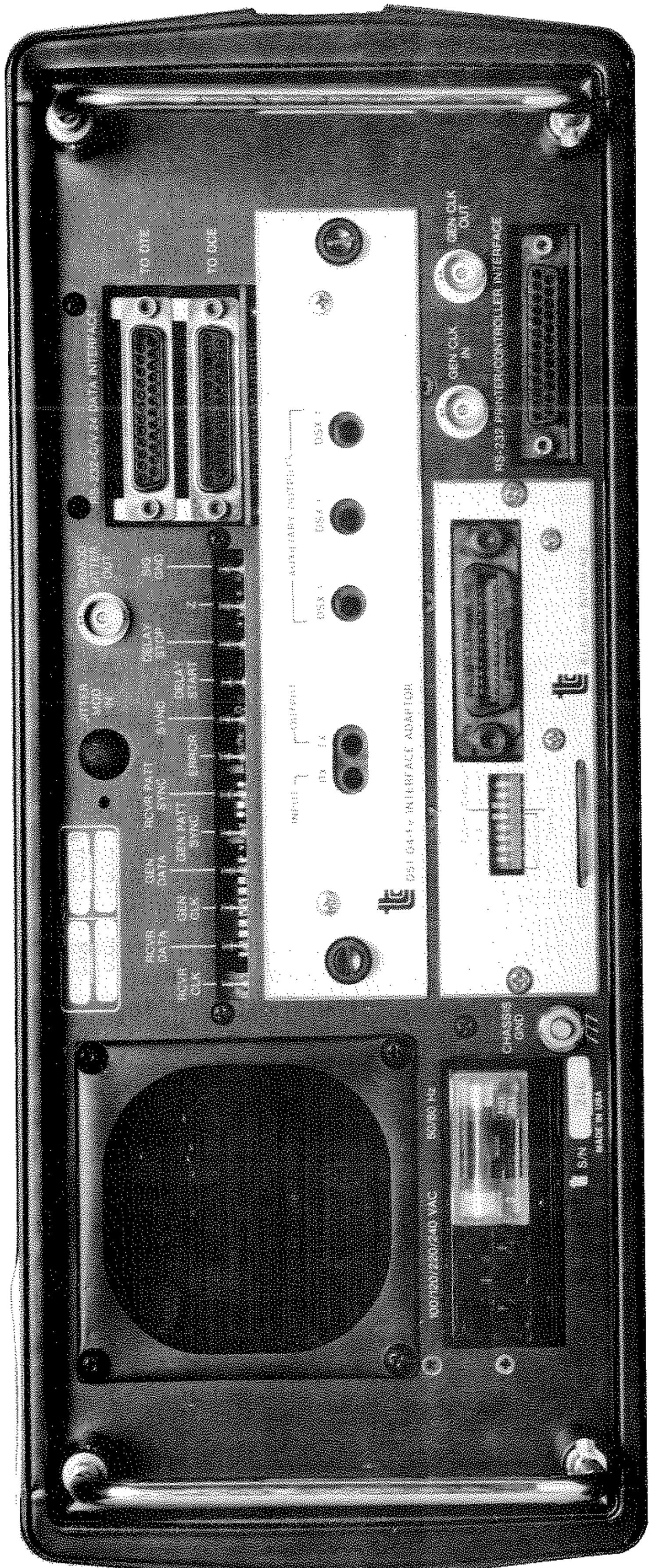


Figure 4-10
FIREBERD 6000 Rear Panel

GEN DATA

This TTL-level output is a buffered version of the generator data being sent to the data interface. A logic high represents a transmitted Mark; a logic low represents a transmitted Space.

GEN PATT SYNC

This TTL-level output provides a one-bit-wide, high-going pulse once per generated pseudorandom pattern. For example, if the DATA switch is set to the 511 position, one GEN PATT SYNC pulse will occur every 511 generator data bits. If the DATA switch is set to the PRGM postion, one pulse is provided for every repetition of the 3- to 24-bit pattern. If the DATA switch is set to the MK or 1:1 positions, one pulse is provided every 24 generator data bits. This output is not valid with asynchronous timing.

RCVR PATT SYNC

This TTL-level output provides a one-bit-high, high-going pulse once per received pseudorandom pattern after the receiver has achieved synchronization. If synchronization is achieved to a PRGM pattern, one pulse is provided for each repetition of the 3- to 24-bit pattern. If synchronization is achieved to a Mark or 1:1 pattern, one pulse is provided every 24 received data bits. This output is not valid with asynchronous timing.

ERROR

This TTL-level output provides a half-bit-wide pulse each time an error is detected in the received data. This output is not valid with asynchronous timing.

SYNC

This TTL-level output will be at a logic low whenever the receiver is not in synchronization with the received pattern, and will be at a logic high when receiver synchronization has been achieved. This output is not valid with asynchronous timing.

DELAY START

This TTL-level input can be selected via Auxiliary Function 31 (using the TP soft key) as the delay start-of-measurement signal. Either the rising or falling edge of the signal may be selected.

DELAY STOP

This TTL-level input can be selected via Auxiliary Function 31 (using the TP soft key) as the delay end-of-measurement signal. Either the rising or falling edge of the signal may be selected.

Z

This output is reserved for future use.

SIG GND

This test point is connected to signal ground.

4.6 BUILT-IN RS-232 INTERFACE

The built-in RS-232 data interface has two female 25-pin D connectors for separate DTE and DCE operation. The top connector is a DCE connection and therefore connects to a DTE unit under test. The lower connector is a DTE connection and connects to a DCE unit under test. Either synchronous or asynchronous tests, as well as recovered tests (if the Clock Recovery option is installed), may be performed.

The built-in RS-232 Data Interface is described in detail in Section 8.2.

4.7 TONE GENERATOR

The FIREBERD presents three distinct audible signals: they are listed below with the events that trigger them. The audio level of the tones can be adjusted with the VOLUME control.

Short single-tone beep
- Invalid keypad entry
- Errored second when ERR EAS or BIT ERRS is displayed.

Two-tone beep
- Loss of synchronization

Three-tone beep
- Completion of a test interval when BER is displayed.

SECTION 5
FUNCTIONAL DESCRIPTION

5.1 INTRODUCTION

This section describes the FIREBERD 6000's error analysis, timing analysis, and signal analysis capabilities as well as the various modes of operation available. The error analysis section specifically includes a description of methods of operation, data generation, and receiver functions. The discussion of timing analysis includes a description of the clock detectors, the FIREBERD's synthesizer, and frequency measurement; the segment on signal analysis discusses delay measurement. Section 5 also includes a description of the analysis results available, in what modes and with which interfaces specific results are obtained, and the methods in which results may be accumulated. The final part of the section describes the timing modes available for use with the FIREBERD 6000.

5.2 ERROR ANALYSIS

As used in this manual, the term "error analysis" refers to the FIREBERD 6000's ability to recognize various incoming data patterns and to analyze these patterns for incorrect data polarity, bit errors, data losses and, in certain cases, clock losses, clock slips, character errors, T-Carrier framing errors, and bipolar violations. Most of these results are counted and available to the user through the front panel display and/or optional printer. Some of the results are correlated with time and position in the incoming data stream to yield more refined information such as bit error rate and counts of block errors and error-free seconds.

In contrast to timing analysis (Section 5.3) and signal analysis (Section 5.4), most of the error analysis functions can only be performed when the incoming data pattern is one of the patterns recognized by the FIREBERD; most of the error analysis results are not available when the FIREBERD is monitoring "live" data traffic. Timing and signal analysis results are not restricted in this way.

5.2.1 Methods of Operation

During normal system testing, clock and data outputs from the FIREBERD 6000's generator drive the system under test, and clock and data signals from the system under test are supplied to the FIREBERD's receiver inputs. Transmission and reception of data occur continuously and independently. This method of operation is referred to as full duplex. Full-duplex operation is available in all timing modes and at all FIREBERD bit rates.

Full-duplex operation of the test set provides for transmission to be temporarily halted through the use of in-band or out-of-band flow control. Whenever transmission is resumed after a flow control initiated halt, the outgoing data pattern continues from the precise point at which it was halted.

In-band flow control, available only for use with asynchronous messages, makes use of user-programmable XON and XOFF characters imbedded in the received data stream. The FIREBERD will not respond to in-band flow control characters unless specifically instructed to do so by activation of Auxiliary Function 09.

Out-of-band flow control makes use of interface signaling leads to control data transmission and may be used regardless of data type or timing. It is normally disabled so that the FIREBERD will transmit unconditionally, but Auxiliary Function 08 allows the user to specify that certain signaling lines must be in the ON state for transmission to take place. In either DTE or DCE emulation, data transmission may be conditioned upon the ON state of any or all of the following signaling leads: DTR (TR), DSR (DM), RTS (RS), CTS (CS), and RLSD (RR).

Auxiliary Function 04 (Single Transmit) also affects data transmission in full-duplex operation. This auxiliary function allows transmission to be automatically halted after one complete pattern or message is sent. When this single transmission function is enabled, one complete pseudorandom pattern or message is sent each time the FIREBERD's front panel RESTART switch is pressed. Pattern lengths for Mark and 1:1 data are considered to be 24 bits for synchronous operation and approximately 1000 bits (see section 5.2.2.5) for asynchronous operation. This auxiliary function is available in all timing modes and at all FIREBERD 6000 bit rates.

As an alternative to full-duplex operation, the FIREBERD's SELF LOOP switch may be used to select self-loop operation, in which the outputs of the clock and data line drivers are looped back to the inputs of the clock and data receivers on the installed data interface or the built-in RS-232 interface. This method of operation completely isolates the clock and data drivers and receivers from the interface connector, allowing self-loop testing to be performed without disconnecting the FIREBERD from the system under test. Self-loop operation is useful for verifying proper instrument setup and operation as well as for checking operation of the installed data interface at the selected data rate. Data is continuously transmitted and received in self-loop operation regardless of the status of any interface signaling leads or whether the Single Transmit auxiliary function is selected. Both in-band and out-of-band flow control are disabled during self-loop operation so that data generation is performed unconditionally. Note that selection of self-loop operation does not cause interface signaling leads to be looped. Both incoming and outgoing signaling lines remain active and connected to the system under test. In self-loop operation all available error analysis results are exactly the same as for full-duplex operation.

5.2.2 Data Generation

The FIREBERD 6000's data generator provides fixed patterns, pseudorandom patterns, and messages. These patterns and messages, as well as a detailed discussion of the FIREBERD's data generation capabilities, are discussed in the following sections.

5.2.2.1 Fixed Patterns

Three types of fixed patterns may be selected for use with the FIREBERD 6000:

- continuous Mark
- alternate Mark and Space
- 3to 24-bit, user-programmable, repeating pattern (This pattern is entered using Auxiliary Function 33 and is further described in Section 4.3.2.3)

5.2.2.2 Pseudorandom Patterns

Seven different pseudorandom patterns may be selected for use with the FIREBERD 6000:

- 63 (2^6-1)
- 511 (2^9-1)
- 2047 (2^{11}-1)
- 2^{15}-1
- 2^{20}-1
- 2^{23}-1
- QRSS

Each pseudorandom pattern is a maximal length sequence generated from a feedback shift register of length "n" (n = 6, 9, 11, 15, 20 or 23). The generated sequence repeats every 2^n-1 bit periods, and has the property that no more than "n" sequential ones (Marks) or "n-1" sequential zeros (Spaces) will ever occur.

A Quasi-Random Signal Source (QRSS) pattern is also provided. This pattern is derived from a 2^{20}-1 pseudorandom pattern and is modified to have no more than 14 consecutive zeros. This allows the FIREBERD 6000 to be compatible with and operate with test sets used exclusively for T1 testing.

5.2.2.3 Messages

Four different messages are provided by the FIREBERD 6000: a FOX message and three user-programmable messages.

A FOX message is available for asynchronous transmission only in four different code levels. The specific code used by the test set in generating the FOX message is determined by the number of data bits as follows:

Number of Data Bits	Code
5	Baudot
6	BCDIC
7	ASCII
8	EBCDIC

The FOX message takes this form: THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 1234567890 (CR) (LF).

The user-programmable messages, which are provided when the DATA switch is in the USER position, are selected via Auxiliary Function 41. These messages may be programmed through the FIREBERD 6000's keypad and may have a maximum length of 255 characters each. (See Section 4.3.2.3 for further information on Auxiliary Function 41.) For message entry purposes, each message character is represented by two hexadecimal digits. Messages may also be entered in ASCII through a dumb terminal or other remote controller.

When a user-programmable message is entered into the test set's memory, only the data bits of each character are stored. This leaves the user free to select the code level, parity, and number of stop bits each time a user-programmable message is chosen for transmission. When the code level is set to 5, 6, or 7, the 5, 6, or 7 least significant bits of each hex character pair are transmitted. The hex character pair is transmitted in its entirety when an 8-level code is chosen.

5.2.2.4 Data Generation With Synchronous and Recovered Timing

All of the fixed patterns and pseudorandom patterns are available with synchronous timing as well as with recovered timing (if the Clock Recovery option is installed; see Section 5.6 for more information on the option). Messages are not available with synchronous or recovered timing. The data generator's output may be inverted through the use of Auxiliary Function 06. With synchronous timing, the maximum data rate is restricted by the interface selected by the user. With recovered timing, the maximum data rate is restricted to the lesser of (1) the interface selected by the user or (2) 520 kb/s.

5.2.2.5 Data Generation With Asynchronous Timing

All of the fixed patterns, messages, and pseudorandom patterns, with the exception of the 2^{20}-1, 2^{23}-1 and QRSS patterns, are available with asynchronous timing. Data generation and reception rates are restricted to a maximum of 20 kb/s with asynchronous timing.

In asynchronous operation, all transmitted data is framed with start and stop bits to put it into character format. The user may select each of the following parameters to determine the specific format of each character; this selection is made using the CHAR FORMAT function of the MENU switch.

Parameter	Selection
Number of Data Bits	5, 6, 7, 8
Number of Stop Bits	1, 1.5, 2
Parity	Odd, Even, None

Each asynchronous character is transmitted in the following order: start bit, data bits, parity (optional), stop bit(s). The start bit is normally a Space, and the stop bits are normally Marks. When pseudorandom or fixed pattern data is sent, the transmitted order of the data bits is exactly the same as when synchronous or recovered timing is chosen. With asynchronous messages, the data bits of each character are sent in order of increasing significance, the least significant bit immediately following the start bit. In all cases in which a parity bit is sent, this bit immediately follows the most significant information bit and immediately precedes the stop bit(s).

As discussed in Section 5.2.2.3, the FOX message and the user-programmable messages are available for asynchronous transmission. When operating in Asynchronous Single Transmit mode, generated pattern lengths are adjusted to facilitate transmission of character formatted data. (Messages are not affected since they are entered in character format. One full message is always transmitted in Single Transmit mode. No more, no less.) The pattern length for Mark and 1:1 patterns varies with the selected character size as follows:

Data Bits/ Character	Characters Transmitted	# Bits Transmitted
5	200	1000
6	167	1002
7	143	1001
8	125	1000

Pseudorandom patterns are transmitted completely. Characters are filled with the pattern data consecutively. If there are not enough pattern bits remaining to fill the last character, bits are added from the beginning of the pattern to fill the character.

With all timing modes, the data generator's output may be inverted through the use of Auxiliary Function 06. With asynchronous timing, start, stop, and parity bits are inverted along with the data bits.

5.2.3 Receiver Functions

The FIREBERD 6000's receiver is that portion of circuitry and software responsible for recognizing and synchronizing to incoming data patterns. The receiver provides information such as data polarity and indications of synchronization and data losses. Two types of results—standard results and live results—are also available; these results are further discussed in Section 5.5. The receiver accepts all of the data patterns and messages listed in Section 5.2.2 with the same timing and speed restrictions as the data generator.

5.2.3.1 Standard Results Mode

Once the receiver has successfully synchronized to the received data, the front panel SYNC indicator is illuminated and error analysis begins. When using pseudoternary interfaces, the Standard results mode accommodates the measurement of bipolar violations (BPVs) and other code-specific results on incoming data that is of the type selected by the DATA switch. The following sections discuss how these results are affected by a loss of synchronization.

Sync Acquisition

The FIREBERD attempts to acquire synchronization automatically, using its autopolarity and receiver circuits. The autopolarity circuit is used to automatically correct any data inversion occurring in the system under test, and the receiver circuits synchronize to and detect any errors occurring in the received data stream.

The setting of the FIREBERD's front panel DATA switch determines what data pattern is expected by the FIREBERD's receiver. Under normal operating circumstances, the receiver will not even momentarily declare synchronization to any pattern other than that selected by the DATA switch, even in a high bit-error-rate environment.

In synchronous and recovered timing operation, the FIREBERD's receiver will declare synchronization to fixed pattern data (Mark; 1:1; and 3-to 24-bit, user-programmable, repeating) when it has received 30 consecutive bits without any errors. For pseudorandom patterns, synchronization is declared upon the reception of 30 + n consecutive error-free bits for a pattern length of 2^n-1 (for the QRSS pattern, n = 20). The receiver will declare synchronization to asynchronous fixed patterns and message data when it has received 10 consecutive characters without any errors.

Synchronization Loss

The FIREBERD 6000's receiver will declare a loss of synchronization upon the occurrence of any one of the following events:

1. High error rate in received data. In synchronous and recovered timing operation, synchronization will normally be lost when 250 bit errors are counted in less than 1000 bits of data. Auxiliary Function 10 (Sync Loss Threshold) may be used to decrease this threshold to 100 errors in less than 1000 bits or to increase it to 20,000 errors in less than 100,000 bits. Auto sync disable is also offered for applications where this high sync loss threshold is still not high enough (see section labeled Resynchronization). In asynchronous operation, sync will be lost when 30 errored characters are received in 60 or fewer characters of data.

2. Loss of received data. With synchronous and recovered timing, a data loss will be declared when data being clocked into the receiver does not change state for 61 bit periods. (The data loss detector is automatically disabled upon the selection of Mark data, as well as for fixed patterns which are all Mark or all Space.) In the Asynchronous timing mode, a loss of received data will be declared when no characters have been received for 10 seconds. Whenever the FIREBERD 6000 loses synchronization as a direct result of a data loss, the DAT LOSS count is incremented and "DATA LOSS XXX" will immediately precede the SYNC LOSS printout whenever an enabled printer is connected, where XXX represents the count of data losses since the beginning of the test.

3. Loss of received clock. With synchronous timing, the absence of high-to-low state transitions on the received clock line for a period longer than 50 milliseconds will cause a clock loss to be declared. Whenever the FIREBERD loses synchronization as a direct result of a clock loss, the CLK LOSS count will be incremented and "CLOCK LOSS XXX" will immediately precede the SYNC LOSS printout whenever an enabled printer is connected, where XXX represents the count of clock losses since the beginning of the test.

Whenever a sync loss occurs, the FIREBERD's front panel SYNC indicator goes out and the red SYNC LOST indicator is illuminated. After it is illuminated once, the SYNC LOST indicator remains illuminated regardless of sync status until it is manually reset or until the test is manually restarted. The purpose of this indicator is to inform the user that receiver synchronization has been lost at some time since the start of the test.

Whenever a printer or controller is connected to the FIREBERD, "SYNC LOSS XXX" will be printed on the occurrence of each sync loss (provided that the front panel PRINTER switch is set to ON and the SYNC LOSS status message is enabled through Auxiliary Function 36), where XXX represents the count of sync losses since the start of the test. Note that data losses, clock losses, and sync losses are numbered independently on the printout even though data losses and clock losses always cause a sync loss to be declared.

Pre-Synchronization-Loss Results

The FIREBERD allows the user to recall the set of test results immediately preceding the most recent sync loss in the Standard results mode with any type of data interface (regardless of the setting of Auxiliary Function 03; see section labeled Resynchronization). In the Live Traffic mode, the test results immediately preceding the most recent line signal loss are available instead. For either mode, this results recall is effected by activating Auxiliary Function 42 (Pre-Sync Loss Results), which will cause a complete set of results preceding the most recent sync loss to be presented in the display. Auxiliary Function 42 also initiates an automatic display hold, allowing the user to scroll through the pre-sync loss results using the CATEGORY and RESULT switches. The current results may be returned to the display at any time by pressing the DISPLAY HOLD switch. Activating Auxiliary Function 42 will also initiate a titled printout of these results; this printout will include the time at which the printed results were stored.

Auxiliary Function 42 also allows access to the test results immediately preceding a loss of ac line power to the FIREBERD. Since a common results buffer is shared between pre-sync-loss results and pre-power-loss results, the auxiliary function gives the user access only to the results preceding the most recent sync loss or the most recent power loss, whichever occurred last. Printouts initiated by activation of the auxiliary function will indicate whether the printed results preceded a sync loss or a line power failure. The pre-sync-loss results are always cleared upon a manual test restart of any kind. Activation of the auxiliary function before a sync loss or power failure occurs will cause the message "No sync losses" to appear in the menu display.

In addition to manual recall of the results preceding the most recent sync loss or power failure, the FIREBERD may be instructed to automatically print these results after each such event if a printer is connected to the test set. This may be done through the PRINT EVENT function of the MENU switch. See Section 4.3.2.2 for more information on the PRINT EVENT function.

Resynchronization

Under normal circumstances, as soon as the FIREBERD's receiver loses synchronization to the incoming data it immediately begins trying to resynchronize. Auxiliary Function 03 (Receiver Action Upon Sync Loss) allows the user to decide what happens to the various error analysis counts and results provided by the receiver when a sync loss occurs. When this auxiliary function is set to CLEAR (the "normal" setting), a sync loss causes all accumulated error analysis results to be cleared and the test to be automatically restarted.

NOTE: Performance analysis results will not be cleared in CLEAR mode.

Setting Auxiliary Function 03 to HALT causes error analysis results accumulation to be suspended for the full duration of the sync loss and resumed upon reacquisition of sync. When this auxiliary function is set to HALT, sync losses will affect the real-time duration of the specific test interval in which they occur if the test interval is specified in terms of the number of bits. This is because in the Halt mode the accumulation of all error analysis results, including the count of bits, is suspended during a sync loss. In effect, the test interval is specified in terms of the number of bits of received data on which error analysis was actually performed. Test intervals specified in terms of time are not affected by sync losses except in the Clear mode, in which a sync loss/sync acquisition cycle causes the test interval timer to be restarted along with the counts of all error analysis results.

As a third alternative, results accumulations may be allowed to continue while the receiver is in the process of resynchronizing to the incoming data by setting the auxiliary function to CONTINUE. In this mode, errors will be counted at a BER of approximately 0.5 while the receiver is trying to resynchronize. The Continue mode is not available in asynchronous timing.

Finally, the receiver may be prevented from resynchronizing by setting the auxiliary function to AUTDIS (Auto Sync Disable). This allows the results accumulations to continue after sync loss declaration and prevents the receiver from attempting to resynchronize to incoming data. This mode is particularly useful in a high bit-error-rate environment. Auto Sync Disable mode is not available in asynchronous timing.

5.2.3.2 Live Results Mode

As an alternative to the Standard results mode, certain code-specific information may be obtained on any data pattern (including "live" data) by selection of the Live Traffic results mode, which is accessed through the INTF SETUP function of the MENU switch. The FIREBERD's receiver is disabled in this mode and only those results that do not require receiver synchronization to the incoming data are provided. All available results begin accumulating as soon as signal presence is detected at the receiver's input. Results accumulation is suspended during subsequent periods of line-signal loss and resumed when signal presence is again detected. In Live Traffic mode, the SYNC and SYNC LOST indicators are used to indicate signal presence and signal loss, respectively.

5.3 TIMING ANALYSIS

5.3.1 Inverted Clock Detector

The inverted clock detector determines if the phase relationship between the receive clock and data is correct. If the clock is inverted with respect to what is specified for the data interface, the front panel CLK INV indicator will light. This detection only takes place when the unit is in synchronous timing operation. Auxiliary Function 02 (Receiver Clock Polarity) does not affect the operation of the inverted clock detector.

5.3.2 Clock Activity Detectors

Clock activity detectors operate on both the transmitter and receiver clocks to indicate when transitions are not present. If there is no transmitter clock detected, a red LED inside the GEN CLK switch will be illuminated to warn the user. If there is no receiver clock detected, the NO CLK indicator on the front panel will be illuminated.

5.3.3 Receiver Clock Slip Detector

A clock slip occurs when the received data has "moved" forward or backward with respect to the accompanying clock signal. To avoid counting bit errors directly resulting from a clock slip, bit errors occuring in the 80 bits surrounding the clock slip are not counted. This scheme leaves 80-bit holes in all of the test results surrounding the occurrence of each clock slip.

5.3.4 Frequency Synthesizer

The FIREBERD 6000 contains a user-programmable frequency synthesizer that allows the FIREBERD to operate at any data rate from 50.00 Hz to 15.000 MHz. This advanced feature provides the flexibility to test at non-standard data rates and also to stress system performance by running at frequencies that are offset from the nominal. Section 4.3.2.2 describes how the synthesizer is controlled.

5.3.5 Frequency Measurements

Frequency measurements are performed on both the generator and receiver clocks and are displayed in the SIGNAL category of the ANALYSIS RESULTS block. The measurements are made over a 1-second interval and have an accuracy to within ±5 ppm ±1 count (optionally ±1 ppm ±1 count) of the reading. The displayed frequency is given in hertz (Hz) with a resolution as shown in Table 5-1. With asynchronous timing, only the generator clock (or baud rate) is measured. There is no receiver baud rate measurement provided.

Table 5-1
Frequency Range and Corresponding Resolution

Frequency Range	Resolution
greater than 99.9999 kHz	1 Hz
10.0000 kHz to 99.9999 kHz	0.1 kHz
1.00000 kHz to 9.99999 kHz	.01 kHz
less than 1.00000 kHz	.001 kHz

5.4 SIGNAL ANALYSIS

Signal analysis includes delay measurement and jitter measurement. Delay measurement is discussed below; jitter measurement is discussed in Section 9.

A delay measurement can be performed that measures the time interval between two user-selectable events. These events include rising or falling edges of signaling leads (DSR, CTS, RTS, etc.), the transmitted or received data, pattern sync signals, or user-supplied signals from rear panel test points.

The start-of-measurement and end-of-measurement signals can be set independently using Auxiliary Function 31. See Section 6.4 for a list of the signals and instructions for using the auxiliary function. The range of measurement is from 0 to 9999.9 milliseconds, with a resolution of 0.1 millisecond.

By looping back the remote end of a test channel and measuring the delay between the generator pattern sync and the receiver pattern sync, the round-trip delay can be obtained. One delay measurement is set up, or "armed," by pressing the RESTART switch, whereupon the result display is blanked. After the measurement takes place, the result is displayed and the RESTART switch must be pressed again to re-arm for another measurement.

5.5 ANALYSIS RESULTS

The FIREBERD 6000 offers a range of error analysis results in various measurement configurations. Results may be obtained in two modes, Standard and Live, depending on the data interface in use. The Standard mode of results is available for both pseudoternary and non-pseudoternary interfaces while, in general, only pseudoternary interfaces specifically designed for use with the FIREBERD 6000 can obtain results in the Live mode.

5.5.1 Standard Analysis Results

Measurements in the Standard results mode require receiver synchronization to obtain meaningful results. Synchronization is achieved when the data pattern selected by the DATA switch is the same as the incoming data pattern. All available results for any given configuration are accumulated from the instant that receiver synchronization is achieved.

5.5.2 Live Analysis Results

As an alternative to the Standard results mode, certain code-specific information may be obtained on any data pattern, including "live" data. This Live Traffic results mode is selected through the INTF SETUP function of the MENU switch. The FIREBERD's receiver is disabled in this mode, and only those results that do not require synchronization to the incoming data are provided. All available results begin accumulating as soon as signal presence is detected at the receiver's input. The Live results mode monitors signal characteristics, other than bit errors, in a known pattern. Most of the results are concerned with code violations, known as BPVs; CRC errors and framing errors are also measured if applicable.

5.5.3 Result Categories

ERROR Category

Results in this category depend on having the FIREBERD's receiver synchronize to the incoming data pattern. Once synchronization has been achieved, the received data is examined for bit errors and clock slips, and the ERROR category results are calculated.

Bit Errors (BIT ERRS)	The number of errored data bits counted since the beginning of the test.
Average Bit Error Rate (AVG BER)	The ratio of the number of bit errors counted to the number of data bits examined since the beginning of the test.
Bit Error Rate (BER)	The ratio of the number of bit errors counted over the last test interval to the number of data bits examined in the last test interval.
Blocks (BLOCKS)	The number of complete blocks received since the beginning of the test. The length of a block is set through Auxiliary Function 30.
Block Errors (BLK ERRS)	The number of complete blocks received since the beginning of the test that contain one or more bit errors.
Average Block Error Rate (AVG BLER)	The ratio of the number of block errors counted to the number of blocks examined since the beginning of the test.
Character Errors (CHAR ERR)	In asynchronous timing only, the number of characters received since the beginning of the test that contain one or more data errors.

Clock Slips (CLK SLIP) — The number of occurrences since the beginning of the test where data bits have been added to or deleted from the received pattern.

PERFORMANCE Category

CCITT Recommendation G.821 compatible performance analysis results provide statistical information about the performance of the equipment or system under test. These results are derived by observing the received bit error counts and received bit counts at 1-second intervals, and classifying each 1-second interval as either available, unavailable, severely errored, error free, or as a sync loss second.

This division of test time is illustrated in Figure 5-1. Further calculations yield the number and percentage of degraded minutes, and percentages of available, severely errored, error free, and pattern synchronization seconds.

In live analysis mode, the received bipolar violations count and bipolar violations rate calculations are used to classify each 1-second interval, and signal presence replaces pattern synchronization for performance analysis purposes.

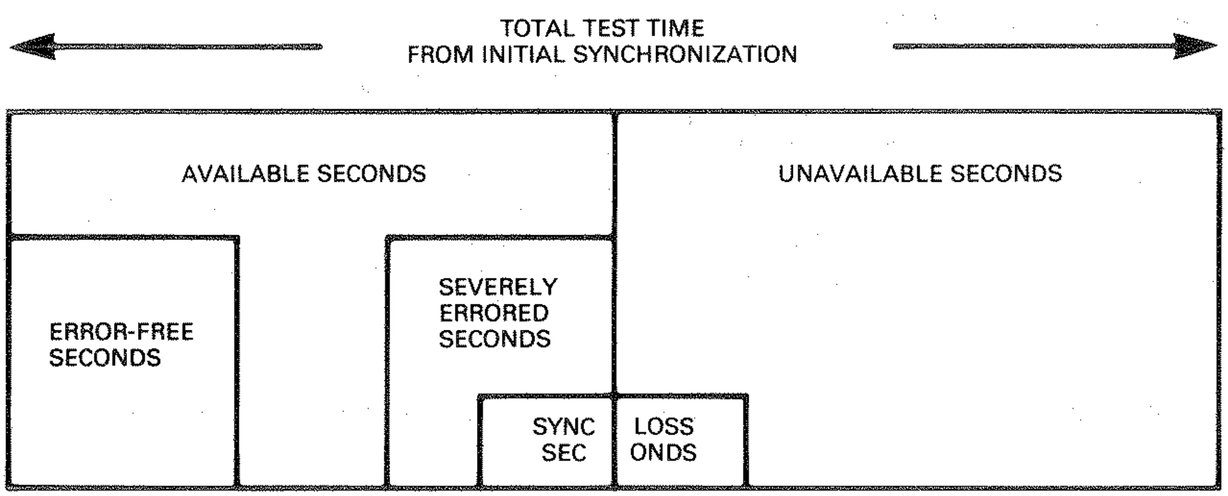


Figure 5-1
Division of Test Seconds for Performance Analysis

Errored Seconds (ERR SEC) — The number of available seconds in which at least one bit error occurred.

Error-Free Seconds (EFS) — The number of available seconds in which no bit errors occurred.

%Error-Free Seconds (%EFS) — The ratio, expressed as a percentage, of the number of available seconds in which no errors were detected to the total number of available seconds.

Severely Errored Seconds (SES) — The number of available seconds during which the BER is worse than 10^{-3}.

%Severely Errored Seconds (%SES)	The ratio, expressed as a percentage, of the number of severely errored seconds to the number of available seconds.
Unavailable Seconds (UNA SEC)	The number of seconds judged unavailable by CCITT Recommendation G.821 criteria (see Appendix D).
Available Seconds (AVL SEC)	The number of seconds judged available by CCITT Recommendation G.821 criteria (see Appendix D).
% Available Seconds (%AVL SEC)	The ratio, expressed as a percentage, of the number of available seconds to the number of test seconds since initial pattern synchronization.
Sync Loss Seconds (SYNL SEC)	The number of seconds during which the receiver was not in continuous pattern synchronization.
% Sync Seconds (%SYN SEC)	The ratio, expressed as a percentage, of the number of seconds in which pattern synchronization had been achieved and there were no synchronization losses to the total number of seconds since the initial pattern synchronization.
Degraded Minutes (DEG MIN)	The number of blocks of 60 non-severely errored available seconds in which the average BER over the 60 seconds was worse than 10^{-6} (see Appendix D). Note that CCITT Recommendation G.821 relaxes this requirement somewhat at 64kHz (see CCITT Recommendation G.821, Table 1 Note 4), so that when the average bit rate over 60 seconds is 64kHz, and four bit errors are counted, corresponding to an average BER of 1.042×10^{-6}, the minute is not considered to be degraded.
% Degraded Minutes (%DEG MIN)	The ratio, expressed as a percentage, of the number of degraded minutes to the number of minutes made up from available, non-severely errored seconds.
Signal Loss Seconds (SIGL SEC)	The number of seconds during which the signal was not present for any part of the second.
% Active Seconds (%ACT SEC)	The ratio, expressed as a percentage, of the number of seconds during which the signal was present (active) for the entire second to the total number of seconds since the initial signal presence.
Severely Violated Seconds (SVS)	The number of available seconds during which the BPV rate was worse than 10^{-3}.
% Severely Violated Seconds (%SVS)	The ratio, expressed as a percentage, of the number of severely violated seconds to the number of available seconds.
Violation-Free Seconds (VFS)	The number of available seconds in which no bipolar violations were detected.
% Violation-Free Seconds (%VFS)	The ratio, expressed as a percentage, of the number of available seconds in which no violations were detected to the total number of available seconds.

TIME Category

This category contains not only the time of day and the date, but also results based on time.

Time of Day (TIME)	The time of day in hours, minutes, and seconds. Hours are given in a 24-hour format.
Calendar Date (DATE)	The calendar date given in day of the month, month, and year. Both the time of day and the date may be set through Auxiliary Function 60.
Elapsed Seconds (ELAP SEC)	The number of seconds, based on the time-of-day clock, since the last major switch change or test restart.
Error Analysis Seconds (E A SEC)	The amount of time, given in seconds, during which error analysis has been performed. The time error analysis has been performed depends on receiver pattern synchronization and the setting of Auxiliary Function 03 (Receiver Action Upon Sync Loss).
Errored Error Analysis Seconds (ERR EAS)	The number of error analysis seconds during which one or more bit errors were detected. Errored error analysis seconds are of the asynchronous type.
Error-Free Error Analysis Seconds (E F EAS)	The number of error analysis seconds during which no bit errors were detected.

SIGNAL Category

The results in this category describe signal characteristics such as receiver clock frequency or the delay between two events. Included in this category are the jitter results available with the jitter measurement options.

Time Delay (DELAY)	The most recently measured time interval between a start and a stop event. The start and stop events are selected through Auxiliary Function 31.
Receiver Frequency (RCV FREQ)	The current measurement of the receiver clock frequency.
Generator Frequency (GEN FREQ)	The current measurement of the generator clock frequency.
1 Second Jitter (1SEC JTR)	The maximum amount of timing jittter measured over the last 1-second test interval, expressed in Unit Intervals peak-to-peak.
Maximum Jitter (MAX JTR)	The largest value of 1-Second Jitter measured since the beginning of the test, expressed in Unit Intervals peak-to-peak.

Jitter Hits (JTR HITS)	A count of the number of times the jitter has exceeded the selected jitter hits threshold since the beginning of the test.
Spectrum Analyzer (S/A)	The present spectrum analyzer frequency in Hertz or, if noted, kHz. Also the measured jitter amplitude at that frequency is displayed in unit intervals peak-to-peak. If the spectrum analyzer is sweeping, the amplitude is the largest yet measured at this frequency; if the spectrum analyzer is not sweeping, the amplitude is the last measured at this frequency.
Maximum % of Mask (%MASK)	Each time the jitter spectrum analyzer takes a reading, the ratio of the measured jitter amplitude to the reference jitter mask's value at this point is calculated. If the spectrum analyzer is sweeping, then the maximum value of that ratio encountered since the beginning of the test is displayed as a percentage, and a value less than 100% indicates that during the test no spectrum analyzer reading exceeded the reference mask. If the spectrum analyzer is not sweeping, then the ratio of the last spectrum analyzer reading to the reference mask at that frequency is displayed as a percentage.

T-CARRIER Category

This category contains analysis results available only with pseudoternary interfaces. Included in this category are results based on framing analysis and line coding analysis.

Bipolar Violations (BPVs)	The number of bipolar coding violations detected in the received signal.
Average Bipolar Violation Rate (AVG BPVR)	The ratio of the number of bipolar violations counted to the number of data bits examined since the beginning of the test.
Bipolar Violation Rate (BPV Rate)	The ratio of the number of bipolar violations counted over the last test interval to the number of data bits examined over the last test interval.
Received Code (RCV CODE)	The type of line-coding detected, e.g., B8ZS, AMI, etc.
Violation-Free Error Analysis Seconds (V F EAS)	The number of error analysis seconds during which no bipolar violations were detected.
% Violation-Free Error Analysis Seconds	The ratio, expressed as a percentage, of violation-free error analysis seconds to the number of error analysis seconds since the beginning of the test.
Frame Errors (FRA ERR)	The number of errored framing bits received since the beginning of the test.
Average Frame Error Rate (AVG FER)	The ratio of the number of frame errors counted to the number of framing bits examined since the beginning of the test.
Frame Error Rate (F E Rate)	The ratio of the number of frame errors counted over the last test interval to the number of framing bits examined in the last test interval.

Frame Sync Losses (FRA LOSS)	The number of times that frame synchronization had been lost since the beginning of the test.
CRC Errors (CRC ERR)	The number of CRC errors counted since the beginning of the test.
Average CRC Error Rate (AVG CRC)	The ratio of the number of CRC errors counted to the number of CRCs examined since the beginning of the test.
CRC Error Rate (CRC E Rt)	The ratio of the number of CRC errors counted over the last test interval to the number of CRCs examined in the last test interval.
Frame Word Errors (FW ERR)	The number of frame word errors counted since the beginning of the test.
Average Frame Word Error Rate	The ratio of the number of frame (AVG FWER) word errors counted to the number of frame words examined since the beginning of the test.
Frame Word Error Rate (FW E Rate)	The ratio of the number of frame word errors counted over the last test interval to the number of frame words examined in the last test interval.
One Second CRC Errors (1SEC CRC)	The number of CRC errors counted in the last test second.

ALARM Category

Several alarm conditions are monitored by the FIREBERD 6000, and occurrence of each alarm are accumulated.

Some alarms—such as signal, sync, data, clock, or power loss—indicate conditions that affect the test underway. Other alarms note such occurrences as clock-data phase changes or the detection of a yellow alarm or excess zeros.

Sync Losses (SYN LOSS)	The number of times a synchronization loss is detected.
Data Losses (DAT LOSS)	The number of times a receiver sync loss results from a loss of receiver data.
Clock Losses (CLK LOSS)	The number of times a receiver sync loss results from a loss of receiver clock.
Receiver Clock-Data Phase Changes (C-D CHA)	The number of times that the clock-data phase changed since the beginning of the test.
Power Loss (PWR LOSS)	The number of power losses since the last manual test restart or major switch change.
Signal Loss (Carrier) (SIG LOSS)	The number of times the receiver signal is lost.
Yellow Alarm Seconds (YEL SEC)	The number of seconds since the beginning of the test in which a yellow alarm was active.
Excess Zero Seconds (XS0 SEC)	The number of seconds since the beginning of the test in which excess zeros have occurred.
AIS Seconds (AIS SEC)	The number of seconds since the beginning of the test in which the AIS alarm was active.

5.5.4 Messages

The FIREBERD alerts the user to several conditions by temporarily placing a message in the display. The messages are listed and described below.

Test complete	This message indicates that receiver analysis is complete when the ANALYSIS MODE switch is set to the SINGLE position.
T1 frame loss	This message is displayed if frame sync is lost while a 1.544 Mb/s pseudoternary interface with framing is in use.
2M frame loss	This message is displayed if frame sync is lost while a 2.048 Mb/s interface with framing is in use.
Different intf	This message is displayed if the program being recalled through the RECALL/STORE function had selected an external interface which does not match the external interface currently installed.
Gen hold <sig> off	If the generator is being inhibited because of signaling, this message shows which signal is causing the hold condition (<sig> is replaced by the name of the signal). Transmission can be stopped by CTS, RTS, DTR, DSR, or RLSD via Auxiliary Function 08.
Async framing err	This message is displayed any time that the USART detects framing errors in the incoming asynchronous data.
Data overrun	The message occurs if, in asynchronous operation, the USART receives too many characters before the FIREBERD receives the data from the USART.
No interface	This message is displayed when the external interface previously selected is removed and the FIREBERD is powered up with no interface installed.

5.5.5 Methods of Results Accumulation

There are two methods of accumulating analysis results: Single and Continuous. In Single mode, all results are accumulated over the period specified through the TEST INTERVAL function of the MENU switch. The test interval may be set to any time period from 1 second to 24 hours (with 1-second resolution). Alternatively, the test interval may be set to 10^n bits where n = 4, 5, 6, 7, 8, 9, or 10. At the end of the user-specified test interval, accumulation of results stops and a "Test complete" message appears in the display.

In Continuous mode, error and signal analysis continue indefinitely from the start of the test. However, results printouts may be obtained at user-specified intervals; these intervals may be set through the PRINT EVENT function of the MENU switch. This print capability is augmented by the Delta print function which, if selected, causes only the results accumulated during the most recent test interval to be printed at the completion of each interval. (Refer to Section 7 for more information on the Delta print function.)

5.6 TIMING MODES

The FIREBERD 6000 offers four timing selections: synchronous, asynchronous, recovered, and pseudoternary. Synchronous operation requires both a data and a clock signal. Asynchronous operation uses only the data signal, but several parameters must be coordinated between the transmit unit and the receive unit (such as baud rate, number of bits, parity, etc.). Recovered operation is similar to synchronous operation except that the received clock (if any) is ignored and a clock is derived from the data. Pseudoternary operation has the clock and data encoded in the same signal, but the bit rates are restricted to certain frequencies and it requires specific interfaces to convert to this format.

With the exception of pseudoternary operation, the timing is selected by the TIMING MODE switch. When a pseudoternary interface is selected, the TIMING MODE switch is disabled. These four timing modes are described in detail in the following sections.

5.6.1 Synchronous Timing and Operation

With synchronous timing, the FIREBERD operates as normal DTE or DCE with several features which provide additional flexibility for testing. The data is a stream of bits that is accompanied by clock.

The FIREBERD provides data and a synchronous clock based on the generator clock source selected. The generator clock source switch (GEN CLK) allows selection from three clock sources: the synthesizer (SYNTH), the interface (INTF), and a user-provided clock source (BNC). The INTF setting uses a clock source from the data interface module. In emulate DTE operation, this interface clock is usually sourced from the remote unit; in emulate DCE operation, the receiver clock may be used as the clock source.

The FIREBERD's receiver requires data and a clock synchronized to that data. If the clock is not synchronized to the data, clock slips and/or clock-data phase changes may occur as a result of the data bits being sampled at the wrong time. The FIREBERD automatically selects a receiver clock appropriate for the timing mode used and the interface selected. In emulate DCE operation, the TT (Transmit Timing) signal is normally used. If TT is not active, then ST (Send Timing) is automatically selected. Auxiliary Function 07 allows an override for this feature.

5.6.2 Recovered Timing

The FIREBERD 6000 can operate in two different recovered timing modes depending on the options used. A Clock Recovery option is offered as an internal mainframe option for isochronous data rates to 520 kb/s.

Each pseudoternary interface includes a custom clock-recovery circuit to extract the clock from the pseudoternary signal.

5.6.2.1 Recovered Operation With DTE/DCE Data Interfaces

Any data interface that can use synchronous timing, including the built-in RS-232 data interface, can also be used with recovered timing when the frequency of operation is below 520 kb/s. With the Clock Recovery option, synchronously received data may be analyzed, even though the received clock is missing or unusable, by extracting a clock from the receiver data. To use this feature, the synthesizer frequency must be set to the expected receiver frequency. In normal operation where the receive and transmit frequencies are the same, no problems will be encountered. When in receive-only operation, the synthesizer must still be set to the expected receive frequency. To run the FIREBERD in split frequency and also use the option, the synthesizer must be set to the receiver frequency and the GEN CLK switch must be set either to the INTF position or to the BNC position with an external source connected to the GEN CLK IN rear panel BNC connector. The receiver frequency and the synthesizer frequency setting may differ by over 1 percent with acceptable operation; however, the best noise immunity is obtained when that difference is minimized as much as possible. This is accomplished by setting the synthesizer to what the expected receiver frequency is, and then reading the actual receiver frequency (RCV FREQ) result (available in the SIGNAL category of the ANALYSIS RESULTS block) and setting the synthesizer to that frequency.

5.6.2.2 Recovered Operation With Pseudoternary Data Interfaces

Pseudoternary signals have the clock imbedded in the data, which requires that pseudoternary interfaces must recover the clock from the signal. The TIMING MODE switch is disabled when using a pseudoternary data interface, since clock recovery is performed automatically. The INTF position of the GEN CLK switch selects either an oscillator on the interface or a clock recovered from the received data depending on the interface used and its switch settings. The BNC position of the GEN CLK switch allows an external time base to be used so that generator timing is synchronous with a system clock source.

5.6.3 Asynchronous Timing and Operation

Asynchronous timing capability is provided in the FIREBERD 6000 to allow generation and error analysis on character data. Using the frequency synthesizer, any baud rate from 50 b/s to 20 kb/s may be selected. Split frequency operation is also allowed with the use of a customer-provided, external reference.

To generate asynchronous data, the GEN CLK switch must be set to either the SYNTH or the BNC position. When set to the SYNTH position, the baud rate of the data to be generated must be entered as the synthesizer frequency. When the GEN CLK switch is set to the BNC position, a clock at 16 times the desired generator baud rate must be provided at the GEN CLK IN BNC input. In all cases where receiver operation is necessary, the synthesizer must be set to the expected receive baud rate. This means that split frequency operation is only allowed when the generator is operated with an external 16-times clock source through the GEN CLK IN BNC input.

SECTION 6
OPERATION INSTRUCTIONS

6.1 INTRODUCTION

This section contains detailed instructions for exercising each of the test capabilities of the FIREBERD 6000. Familiarity with Section 5 of this manual will lend a more intuitive understanding to the following procedures and aid in interpreting the numerous results provided by the instrument. For first-time use of the FIREBERD 6000, refer to Section 2 (Preparation For Use) before executing any of the instructions set forth in this section.

NOTE: If during any of the following procedures a front panel switch is set to a position that causes a switch contention (signified by flashing switch position indicator LEDs), the contention must be resolved before continuing. Switch contentions represent invalid combinations of switch settings and result in a "lock-out" of all switches not involved in the contention until the contention is resolved. There is one exception: a program can be recalled to resolve the contention by using the MENU switch to select the RECALL/STORE function, thereby recalling a set of switch and menu settings. Resolving a switch contention may require performing some of the following steps in an order different than that indicated.

6.2 PERFORMING ERROR ANALYSIS

The following step-by-step procedure may be followed to prepare to make error analysis measurements with the FIREBERD 6000. It is intended to serve as a guide and is not the only operating sequence.

(1) Select a measurement configuration. If loopback testing is to be performed, only one FIREBERD 6000 will be required. If end-to-end testing is desired, two test sets will be needed and the setup procedure should be followed for the unit at each end of the link.

(2) With ac power to the FIREBERD 6000 turned OFF, install a data interface of the type required to connect to the system under test in the rear panel data interface slot. Press the interface in gently until the aluminum panel of the module makes contact with the rear panel of the FIREBERD 6000. Tighten by hand the two captive fasteners on the data interface's panel to prevent the module from being accidentally pulled out during operation. If the FIREBERD's internal RS-232C data interface is to be used for testing, no interface need be installed in the rear panel slot.

(3) Connect the FIREBERD 6000 to an ac power source and press the front-panel POWER switch to the ON position.

(4) If using a data interface that allows the FIREBERD to emulate either DTE (data terminal equipment) or DCE (data communications equipment), determine which emulation mode is required. For data interfaces having only a single interface connector, emulation mode is determined by whether or not the DTE/DCE adaptor cable furnished with the interface is attached to the connector and also, for most interfaces, by the setting of a toggle switch on the data interface's panel. DCE emulation requires use of the DTE/DCE adaptor cable for these single-connector interfaces. For data interfaces having two interface connectors (such as the internal RS-232C interface) emulation mode is determined by which connector is used to interface to the system under test and also the emulation mode selection made in the interface setup menu. For DTE emulation, connect the system under test to the connector on the interface marked TO DCE using an ordinary "straight-through" cable; then set the FIREBERD's front panel MENU switch to the INTF SETUP function, use the soft keys to select the desired interface, and then again to select DTE emulation mode. DCE emulation requires connecting the system under test to the interface connector marked TO DTE and selecting DCE emulation mode via the interface setup menu. No DTE/DCE adaptor cable is required for these dual-connector interfaces. For further information on emulation mode selection, refer to the individual interface descriptions in Section 8. When emulation mode selection is completed, verify that EMULATE DTE or EMULATE DCE, as appropriate, is displayed via backlit labels over the signaling controls and indicators at the right-hand side of the FIREBERD's front panel.

(5) Complete any additional interface setup that may be required by setting switches on the interface itself to the desired positions and setting any parameters controllable through the interface setup menu. For pseudoternary data interfaces offering a choice of standard or live traffic results (see Section 5.5), select standard results for now regardless of which results are to be used in actual system testing. See the individual data interface descriptions in Section 8 for complete information on interface setup.

(6) Connect the interface cable from the system under test to the data interface in the manner prescribed for the selected emulation mode as described in step 4.

(7) If an external printer or controller is to be used, connect it to the appropriate printer/controller interface on the rear panel of the FIREBERD 6000. Section 7 contains detailed information on the built-in RS-232 printer/controller interface and the optional IEEE-488 plug-in interface.

(8) Set the TIMING MODE switch to the desired position. If asynchronous operation is selected, set the MENU switch to the CHAR FORMAT function and use the soft keys to choose the number of data bits per character, parity, and number of stop bits per character. For detailed information on the use of soft keys to make menu selections, see Section 4.3.2.

(9) Use the GEN CLK switch to select the source of the clock that is to run the FIREBERD's data generator. Section 5.6 provides information on clock selection.

(10) If asynchronous or recovered timing was chosen in step 8, or if the internal frequency synthesizer was chosen as the generator clock source in step 9, the synthesizer frequency must now be set. For asynchronous or recovered timing operation, the synthesizer frequency must be set to within ± 1 percent of the bit rate of the incoming data. When the GEN CLK switch is set to the SYNTH position, the synthesizer frequency should be set to the desired bit rate of the data to be generated by the FIREBERD 6000. To set the synthesizer frequency, set the MENU switch to the SYNTH FREQ position, key in the appropriate frequency in kilohertz, and press the ENTER key. Alternatively, the soft keys may be used to quickly select one of the 11 common frequencies pre-programmed by the factory or programmed by the user through Auxiliary Function 32. Frequency restrictions for asynchronous and recovered timing are given in Section 5.6; available resolutions are discussed in Section 4.3.2.2.

(11) Set the DATA switch to the desired position. For end-to-end testing, both test sets must have their DATA switches in the same position. Section 5.2.2 provides information on the various data patterns capable of being generated and received by the FIREBERD 6000.

(12) If the 10^{-3} indicator above the ERROR INSERT switch is illuminated, press the switch once to turn off error insertion. Operation of the ERROR INSERT switch is different from that of the other front panel switches and is discussed in Section 4.2.1.

(13) If the SELF LOOP switch is not illuminated, press it once to cause the selected data interface to loop its clock and data outputs back to its clock and data inputs. This facilitates verification of the FIREBERD 6000's setup prior to system testing.

(14) If blocks and block errors are to be measured, use Auxiliary Function 30 to set the desired block length. Refer to Section 4.3.2.3 for information on the use of this as well as other auxiliary functions.

(15) Set any auxiliary functions that are to be used. If the AUX FUNC IN USE indicator (next to the MENU switch) is illuminated prior to the setting of any auxiliary functions, one or more of the status-select auxiliary functions are still set from the last time the instrument was used. A list of the "in use" functions may be obtained by pressing the IN USE soft key at the top level of the AUXILIARY menu. Alternatively, Auxiliary Function 99 may be used to clear all of the "in use" functions.

(16) If automatic results prints are to be sent to a printer or controller connected to the FIREBERD, set the MENU switch to the PRINT EVENT function and use the soft keys to select the print mode and, for the NORMAL mode, the events that are to cause a printout. Also, if the OFF/ON switch in the group of switches labeled "PRINTER" is not illuminated, press it once to turn it on. Print modes and print event selection are discussed in detail in Section 4.3.2.2.

(17) Set the MENU switch to the TEST INTERVAL function and set the test interval to the desired number of received bits or the desired time duration. The test interval specifies the period over which the BER and BPV Rate results are computed and also specifies the test duration (time after which all results stop accumulating) when the ANALYSIS MODE switch is set to SINGLE. Details of setting the test interval are given in section 4.3.2.2.

(18) Set the ANALYSIS MODE switch to the desired position. In the CONTINUOUS position, all test results accumulate continuously; in the SINGLE position, results accumulation stops at the end of one test interval.

(19) If the DISPLAY HOLD switch is illuminated, press it once to turn off the display hold function.

(20) If the selected data interface allows control of outgoing signaling leads via the two signaling control switches (immediately above the POWER switch), set these switches to the desired states. Illumination of the switch indicates the ON state of the signal specified by the backlit label next to it. If the LOOP UP and LOOP DOWN labels are illuminated, these switches have a momentary function which is meaningless in Self-Loop mode, and they should not be pressed.

The FIREBERD 6000 should now be operating with its data generator looped back to its receiver, and the green SYNC indicator should be illuminated indicating that the receiver has achieved synchronization to the generated data. Set the CATEGORY switch under either of the results displays to the ERROR position and, using the corresponding RESULT switch to select the BIT ERRS result, verify that no bit errors are being counted (BIT ERRS = 0). Momentarily, depress the ERROR INSERT switch and check to see that a single bit error is counted. Also verify that the red SYNC LOST indicator is off. If any of these indications of successful loopback are not present, check that the data interface is installed properly and that its maximum recommended speed is not being exceeded. Check that all selections available through the interface setup menu have been made properly and that any switches on the interface panel are set to their proper positions. If a problem still exists, look for front-panel warning indicators such as CLK INV, NO CLK, or illumination of the red "no generator clock activity" LED inside the GEN CLK switch. These indicators, along with the MK and SP indicators which show data activity at the receiver's input, should aid in diagnosing the problem.

Once successful self-loop operation has been achieved, the FIREBERD 6000 is ready to perform on-line testing. At this point, if the Live Traffic results mode (available with certain pseudoternary data interfaces) is to be used for system testing, it should be selected via the interface setup menu.

To connect the FIREBERD data generator and receiver to the system under test, press the SELF LOOP switch. This will cause the red LED inside the switch to turn off, indicating that the test set is "on-line." If the data and, for synchronous systems, clock generated by the FIREBERD 6000 and being sent out through the data interface are getting through the system under test and making it back to the corresponding line receivers on the data interface, the SYNC indicator will be illuminated and error analysis results will be available for display and printout.

Should the SYNC indicator fail to illuminate, check the group of indicators labeled RECEIVER for a possible clue to the source of the trouble. For synchronous testing, the frequency of the clock being received by the FIREBERD should also be checked to ascertain that it is the same as the expected received data rate. This may be done by setting one of the CATEGORY switches to SIGNAL and then using the corresponding RESULT switch to select the RCV FREQ result. Note that in DCE emulation, improper setting of Auxiliary Function 07 (Receiver Clock Select) could result in the FIREBERD's using the wrong timing signal to clock in the received data, thereby preventing receiver synchronization.

In the case of the Live Traffic results mode, receiver synchronization to the incoming data is not required, and results become available as soon as signal presence is detected. In this mode, the SYNC indicator is used to indicate signal presence rather than receiver synchronization.

Use of the two ANALYSIS RESULTS switches to view the many results counted by the FIREBERD 6000 is described in Section 4.2.1. Section 4.4 provides a list of the results available. Result availability as a function of operating mode is discussed in Section 5.5, which also provides detailed information on results furnished by the FIREBERD. Section 5.2.3.1 explains how accumulation of error analysis results are affected by loss of receiver synchronization.

6.3 PERFORMING TIMING ANALYSIS

Timing analysis refers to the measurement of certain characteristics of clock signals employed by a synchronous, digital communication system. Such measurements provide information that will aid in isolating the cause of clock related system errors or failures.

Timing analysis capabilities offered by the FIREBERD 6000 fall into two broad categories: those that do not require receiver synchronization and those that do. The entire setup procedure described in Section 6.2 must be performed to obtain those timing analysis results requiring receiver synchronization. Timing analysis results not requiring receiver synchronization may be obtained on clock and data sourced by a FIREBERD 6000 or on "live" signals. In setting up the test set to perform timing analysis on live signals, the procedure of Section 6.2 should be followed, but those steps involved in setting up the data generator (e.g., setting the GEN CLK switch, entering the synthesizer frequency, etc.) may be skipped. Also, the SYNC indicator need not illuminate when the SELF LOOP switch is turned off when making measurements on live signals.

6.3.1 Timing Analysis Results Not Requiring Receiver Sync

The most basic timing analysis result provided by the FIREBERD 6000 is clock activity detection. A red NO CLK indicator illuminates when no incoming clock signal is detected in Synchronous timing mode. In DCE emulation the operation of this indicator is affected by the setting of Auxiliary Function 07 (Receiver Clock Select). When this auxiliary function is set to AUTO, the test set selects the clock sourced by the DTE on the Terminal Timing (TT) line if it is present; otherwise, the FIREBERD defaults to its own generator clock (Send Timing, or ST). Because of this receiver clock autoselection, the NO CLK indicator will not turn on unless no signal is present on the incoming TT line and no activity is detected at the selected source of generator clock. If in the operating configuration of interest a clock is expected from the DTE, a possible source of confusion will be eliminated by setting the auxiliary function to TT, thus forcing the receiver to select the TT signal whether it is present or not. Under this circumstance, the NO CLK indicator will illuminate (and the receiver, consequently, will be inoperative) whenever no clock activity is detected on the TT line.

A red LED inside the GEN CLK switch illuminates whenever no clock activity is detected at the selected source. When the GEN CLK switch is set to the INTF position, this indicator provides further information about timing signals at the interface. In DTE emulation mode, Send Timing is chosen in this position; in DCE emulation, Terminal Timing is chosen. In both cases, the red warning indicator inside the switch illuminates to signal the absence of a clock signal at the selected source.

A more sophisticated form of timing analysis performed by the FIREBERD 6000 is the detection of an improper phase relationship between the incoming clock and data. If the sampling edge of the clock (as defined by the applicable interface standard) is, on the average, closer to the data transitions than to the mid-bit position, an inverted clock condition is declared and the red CLK INV indicator is lit. Section 5.3.1 explains how the information supplied by the inverted clock detector is used to correct the polarity of the incoming clock before applying it to the receiver so that error analysis may be performed on the data irrespective of clock-data phasing.

If the frequency of the receiver clock is slightly different than that of the incoming data (less than about 2 Hz difference), the CLK INV indicator will flash on and off at a rate corresponding to the frequency difference as the clock slowly "slips by" the data. The numeric C-D CHA (clock-data phase change) result, available through the ANALYSIS RESULTS switches and displays, records the number of times the CLK INV indicator has changed status since the beginning of the test. This result aids greatly in diagnosing problems resulting from slowly slipping clocks by essentially "watching" the CLK INV indicator over long-term tests during which the operator is not present.

A third timing analysis result not requiring receiver synchronization is the FIREBERD 6000's ability to simultaneously measure the frequencies of the generator clock and the receiver clock. These measurements, available through the ANALYSIS RESULTS switches and displays (in the SIGNAL category), have 6 digits of resolution and ±5 ppm ±1 count (optionally ±1 ppm ±1 count) accuracy, regardless of frequency. Frequency measurement capability aids in the diagnosis of problems resulting from wrong frequency or improperly selected timing signals. Frequency measurements can also reveal electrical noise from crosstalk or other sources that is superimposed on clock signals. When of sufficient magnitude to impair system operation, such noise will generally manifest itself in the form of clock frequency measurements that are somewhat higher than the actual clock rate.

6.3.2 Timing Analysis Results Requiring Receiver Sync

The primary timing analysis capability requiring receiver synchronization is clock slip measurement. In a binary, synchronous communication system, one clock edge is expected for each received data bit. If this one-to-one correspondence is lost, even momentarily, a clock slip is said to have occurred. Possible causes of clock slips include noise on the clock signal, missing or extra clock pulses, and small frequency differences between the data and accompanying clock. Although more rare in occurrence, a missing data bit or bits ("data slips") also have the effect of disrupting the one-to-one correspondence between clock edges and data bits, and thus are counted as clock slips.

The FIREBERD 6000 provides clock slip measurements on pseudorandom data patterns in the Synchronous and Recovered timing modes as well as with pseudoternary data interfaces, which recover a clock from the incoming data pulses. In recovered clock operation, counted clock slips are generally representative of data slips but may also represent inability of the clock recovery circuit to "track" the data due to excessive jitter or noise on the received signal.

If the data being analyzed passes through a repeater that recovers clock in order to regenerate the signal, clock slips may result from failure of the repeater's clock recovery circuit to track the incoming data. The FIREBERD 6000's internal frequency synthesizer may be used to help diagnose this kind of problem through a timing analysis technique commonly known as frequency deviation stress testing. This is done by selecting the synthesizer as the source of the generator clock and then offsetting its frequency slightly from the frequency expected by the system under test. If this results in a noticeable increase in the rate at which clock slips are counted or in the bit error rate, the system clock recovery is probably faulty. It should be remembered also that the longer pseudorandom patterns stress clock recovery systems more because they contain longer sequences of zeros. By varying the synthesizer frequency and data pattern, then, and by observing the effects on the bit error rate and clock slips count, clock recovery circuits may be rather accurately characterized.

6.4 PERFORMING DELAY MEASUREMENTS

The FIREBERD 6000 is capable of measuring delays between the rising or falling edge of any of the user-selected start-of-measurement and end-of-measurement signals listed below:

Start-of-Measurement Signal Sources:

- DTR
- DSR
- RTS
- CTS (emulate DCE only)
- RLSD
- Generator data (GDATA)
- Generator pattern sync pulse* (GPATT)
- DELAY START rear-panel test point

End-of-Measurement Signal Sources:

- DTR
- DSR
- RTS
- CTS (emulate DTE only)
- RLSD
- Receiver data (RDATA)
- Receiver pattern sync pulse* (RPATT)
- DELAY STOP rear-panel test point

*Not available in Asychronous timing mode. Also, no edge selection is available for these signals.

To make a delay measurement, use Auxiliary Function 31 to select the precise delay interval to be measured. Pressing the START soft key gives access to the list of start-of-measurement signal sources. Once the start-of-measurement signal has been selected by pressing the appropriate soft key, the signal edge selection may be made. The character "/" represents the rising edge of the indicated signal, which is defined as the OFF-to-ON transition of signaling leads, the Space-to-Mark transition of data signals, and the logic-low-to-logic-high transition of the rear-panel test point inputs. The character "\" represents the falling edge of the indicated signal. After making the edge selection for the start-of-the-measurement signal, press the up-arrow key twice to return to the top level of the DELAY menu. Press the STOP soft key and proceed to select the end-of-measurement signal and signal edge to complete the delay measurement setup.

The delay measurement circuitry is armed immediately upon completion of the setup, and the DELAY result, available through the SIGNAL category of the ANALYSIS RESULTS switches and displays, is blanked until the measurement is completed. The measurement is performed with a resolution of 0.1 milliseconds over a range of 0.0 to 9999.9

milliseconds. If the end-of-measurement event is not detected within 9999.9 milliseconds of the start-of-measurement event, the display will show ">9999.9 ms".

After a delay measurement is completed, the measurement may be restarted by pressing the RESTART switch, changing or reselecting the start-of-measurement or end-of-measurement event through Auxiliary Function 31, or changing any major switch on the FIREBERD's front panel. The DELAY result is blanked whenever the delay measurement circuitry is armed.

With synchronous and recovered timing as well as the pseudoternary data interfaces, the FIREBERD 6000 allows the measurement of delay between a generator pattern sync pulse and the following receiver pattern sync pulse. Since these pulses occur at the same place in each pattern, the time delay between the generator pattern sync pulse and the receiver pattern sync pulse in loopback testing is equal to the round-trip data delay. In order to obtain prompt and accurate results, care must be exercised in choosing the length of the pseudorandom pattern used for making such round-trip delay measurements. Specifically, the pattern must be of sufficient length to ensure that transmission of one complete pattern at the data rate of operation takes a greater period of time than the longest possible delay that is to be measured. On the other hand, the pattern should not be so long that many seconds elapse between pattern sync pulses, requiring the user to wait an inordinate amount of time before obtaining a result. These constraints imply that the best pattern to use is the shortest pattern longer than the minimum usable pattern length, given by

minimum usable pattern length = (data rate) x (maximum delay to be measured)

where data rate is in bits per second, maximum delay to be measured is in seconds, and the minimum usable pattern length is given in bits. If the maximum delay to be measured is unknown, it is probably safe to use 0.7 seconds, which significantly exceeds the round-trip delay through a satellite in geosynchronous orbit of approximately 0.6 seconds. For example, to make a round-trip delay measurement at 1.544 Mb/s in an environment in which the delay is completely unknown, the minimum usable pattern length would be 1,544,000 b/s x 0.7 s = 1,080,800 bits. The shortest pattern provided by the FIREBERD 6000 that exceeds this length is the 2^{23}-1 pattern which has a length of 8,388,607 bits. Using this pattern will give a result in less than 6 seconds.

Several important things should be noted about making round-trip data delay measurements. First of all, the receiver must be steadily synchronized to the incoming data in order to obtain a valid measurement. When the receiver is out of sync, it does not supply receiver pattern sync pulses to the delay measurement circuitry, making the round-trip delay measurement impossible. For this reason, the delay measurement is prevented from being initiated until the receiver is in sync (this restriction does not apply to delay measurements between other events).

Round-trip delay measurements should only be made using the 63, 511, 2047, 2^{15}-1, 2^{20}-1, or 2^{23}-1 pseudorandom patterns. Measurements made using fixed patterns will provide erroneous results, and measurements made using the QRSS pattern will yield results that are 20.5 bit periods longer than the actual delay.

Round-trip delay measurements made with the recommended pseudorandom patterns are always one-half bit period longer than the actual delay. Under most circumstances, this difference will not even be noticed because one-half bit period is only 0.1 milliseconds (the resolution of the measurement) at a data rate of 5 kb/s, and even less at higher rates. At lower data rates, one-half bit period should be subtracted from the measured round-trip delay if precise results are required.

SECTION 7
PRINTER/CONTROLLER INTERFACES

7.1 INTRODUCTION

The FIREBERD 6000 is capable of communicating with external devices, such as printers and controllers, through its built-in RS-232 Printer/Controller Interface or the optional IEEE-488 Printer/Controller Interface. These printer/controller interfaces enable the FIREBERD to send all results and/or status information to an external printer or computer, allowing the user to obtain hard-copy printouts of all results and configurations. The printer/controller interfaces also allow a remote user to exercise full control over all normal FIREBERD functions (except power) and, additionally, they allow the user to gain access to many remote-control-only functions, including use of the BERD-BASIC programming language.

The FIREBERD printer/controller interfaces are designed to communicate equally well with either a user operating a dumb terminal or a computer running an applications program. When communicating with a user operating a dumb terminal, the FIREBERD runs interactively; that is, it sends a prompt character to the terminal whenever it is ready to receive a command, and it echoes all command characters back to the terminal as the user types them. The FIREBERD also provides full on-line help to aid the user in entering commands. When communicating with a computer running an application program, the FIREBERD disables the prompt and echo functions. This allows the remote computer to concentrate on sending commands and getting results. Both of these modes are possible through either of the RS-232 or the IEEE-488 printer/controller interfaces.

The RS-232 Printer/Controller interface is configured as data communications equipment (DCE), which allows it to be connected directly to a printer or to any other piece of data terminal equipment. All communications through the RS-232 port are asynchronous using the standard ASCII characters, with the exception of graphics codes used to produce output to graphics printers, such as the PR-85 printer. The baud rate and character format, as well as other RS-232 specific functions, can be configured using Auxiliary Function 38. The RS-232 Printer/Controller Interface is discussed in more detail in Section 7.5.

The optional IEEE-488 Printer/Controller interface, which installs into a slot on the FIREBERD rear panel, complies with the IEEE Standard Digital Interface for Programmable Instrumentation (STD 488 1978). The interface offers both Talk-Only and Addressable modes. When operating in Talk-Only mode, the FIREBERD should be connected directly to a listen-only printer. In Addressable mode, the FIREBERD may be connected with up to 14 other devices, one of which must be a controller. Auxiliary Function 39 is used to select other IEEE-488 specific functions. The IEEE-488 Printer/Controller Interface is discussed in more detail in Section 7.6.

7.1.1 Printer Selection

The FIREBERD 6000 may be connected to an RS-232 external printer or may communicate to a printer via the IEEE-488 interface. When both the RS-232 and IEEE-488 interfaces are installed, Auxiliary Function 11 is used to select which one the FIREBERD is to print to. The user may specify either that the FIREBERD always print to the RS-232, always print to the IEEE-488 or, alternately, that the FIREBERD decide which interface to print to. (The FIREBERD will select the RS-232 interface whenever it detects the DTR signal true; otherwise, it will select the IEEE-488.)

Auxiliary Function 11 is accessed through the AUXILIARY function of the MENU switch. When this function is selected, the following soft-key labels will be displayed.

(1) AUTO - Select RS-232 first; if no device connected (no DTR), then send to IEEE-488.
(2) RS-232 - Select RS-232 only.
(3) 488 - Select IEEE-488 only.

7.1.2 Controller Selection

The FIREBERD 6000 can operate in one of three control modes; Local, Remote, or Program. On power-up, the FIREBERD enters Local mode, in which the front panel switches control all functions. Upon reception of a valid remote control command from the controller, the FIREBERD enters Remote mode. In Remote mode, the front panel switches are ignored and all FIREBERD functions are controlled by the remote user. The remote user may elect to enter and run a BERD-BASIC program (or use a previously entered one), thus placing the FIREBERD in Program mode. While in Program mode, the FIREBERD receives all of its commands from the running program. This continues until the program stops, either by design or because of a break request from the remote controller. At this point, the FIREBERD returns to Remote mode and the remote user again has control over the instrument. The user may then return the FIREBERD back to Local mode, re-enabling front panel operation.

Only one interface may control the FIREBERD at a time. Once either of the interfaces gains control (by sending a valid remote control comand), the other will be ignored until the FIREBERD is returned to Local mode. Once back in Local mode, both interfaces will be monitored, allowing either one the chance to take control of the FIREBERD.

7.2 PRINTER AND GRAPHICS FORMATS

The FIREBERD printouts can be divided into five broad categories: results prints, controls prints, status prints, histogram prints, and jitter frequency prints. Note that both the histogram and jitter frequency printouts may be either graphed on an Epson-compatible graphics printer or listed to a terminal. Each of these prints will be described in the following sections.

7.2.1 Results Print

Results prints may include some or all of the results accumulated by the FIREBERD. Results prints may be initiated by (1) a user request (pressing the RESULTS switch), (2) the occurrence of one of the user-selected print events, or (3) the occurrence of a results counter overflow. Note that, in a printout initiated because of a results counter overflow, the offending result will be marked with a double asterisk (**), indicating that it has just overflowed. In any subsequent printouts, this result will be marked with a single asterisk (*) indicating that it had previously overflowed.

The user may select which FIREBERD results are to be included in the results printouts using Auxiliary Function 35. A long results print includes all available results. A standard results print, on the other hand, includes only an abbreviated list of the more commonly-used results. If neither of these selections is suitable, a custom results print may be constructed in which the user may selectively include (or exclude) any of the available FIREBERD results.

If the Delta print function has been selected through the PRINT EVENT function of the MENU switch, automatic Delta printouts will occur at the end of each test interval. These printouts will contain only data accumulated over the last test interval. The Delta printout will not include average error rates, performance analysis results, or other long-term cumulative analysis results. In all other respects, the Delta printout will be treated in the same manner as any normal printout (with regard to format, results selections, etc.).

Figures 7-1 through 7-4 show sample results printouts.

```
MANUAL          PRINT
05:07:32    04 MAR 87
SITE ID         Alpha
BIT ERRS            0
AVG BER       0. E-08
BER           0. E-06
BLOCKS         312012
BLK ERRS            0
E A SEC          4875
E F EAS          4875
RCV FREQ      64000.0
GEN FREQ      64000.0
%EFS             100%
IF   INTERNAL RS-232
```

Figure 7-1
Standard Results Print

```
MANUAL          PRINT
05:08:11    04 MAR 87
SITE ID         Alpha
BIT ERRS            0
AVG BER       0. E-08
BER           0. E-06
BLOCKS         314538
BLK ERRS            0
AVG BLER      0. E-05
E A SEC          4914
ERR EAS             0
E F EAS          4914
CLK SLIP            0
ELAP SEC         4915
DELAY
RCV FREQ      64000.0
GEN FREQ      64000.0
SYN LOSS            0
DAT LOSS            0
CLK LOSS            0
PWR LOSS            0
C-D CHA             0
SYNL SEC            0
%SYN SEC         100%
AVL SEC          4914
%DEG MIN         0.0%
%SES             0.0%
%EFS             100%
EFS              4914
DEG MIN             0
ERR SEC             0
SES                 0
UNA SEC             0
%AVL SEC         100%
IF   INTERNAL RS-232
DTR: OFF    RTS: OFF
DSR: OFF    CTS: OFF
RLSD: OFF
SELF LOOP ON
```

Figure 7-2
Long Results Print

```
MANUAL          PRINT
05:17:45    04 MAR 87
BIT ERRS            0
BER           0. E-04
BLK ERRS            0
CHAR ERR            0
ERR EAS             0
DELAY
SYN LOSS            0
DTR: OFF    RTS: OFF
DSR: OFF    CTS: OFF
RLSD: OFF
```

Figure 7-3
Custom Results Print

```
DELTA           PRINT
03:46:32    04 MAR 87
SITE ID         Alpha
BIT ERRS            0
BER           0. E-06
BLOCKS           1000
BLK ERRS            0
E A SEC            15
E F EAS            15
IF  INTERNAL RS-232
```

Figure 7-4
Delta Print

7.2.2 Controls Print

The controls printout lists the current state of all FIREBERD mainframe controls. When applicable, the state of interface controls are listed also. This provides the user with enough information to duplicate the current configuration of the FIREBERD at another time or site.

Figure 7-5 shows a sample controls printout.

7.2.3 Status Prints

The FIREBERD will automatically generate a status printout to inform the user of important developments with the ongoing test. Like the results in a results print, the

```
15:05:03        28 MAY 86
SITE:               Alpha
DATA:                MARK
ERROR INS:            OFF
SELF LOOP:             ON
GEN CLOCK:          SYNTH
TIMING MODE:        ASYNC
SYN FRQ:          9.6 kHz
INTERFACE:
 INTERNAL RS-232
 RI:                  OFF
 CTS:                 OFF
EMULATE:              DTE
 DTR:                 OFF
 RTS:                 OFF
TEST INT:            10^4
ASYNC CHAR FORMAT:
 DATA BITS:             8
 STOP BITS              1
 PARITY:              ODD
JITTER:
 WDBAND:
  FILTER:            FULL
  THR:             6.5 UI
SPECTRUM ANALY:
 FREQ:              10 Hz
 SWEEP:               OFF
 MASK:              0.171
PRINT    EVENT:     DELTA
 TEST INT:            OFF
 SYNC LOSS:           OFF
 ERROR:               OFF
 TIME:                OFF
ANALY MODE:           CON
DISPLAY HOLD:         OFF
BLOCK LENGTH:
              100000 BITS
DELAY:     DTR/      DTR/
XON CHARACTER:         11
XOFF CHARACTER:        13
AUX FUNC IN USE:     NONE
REMOTE RS-232:
 DATA BITS:             8
 PRINT SPEED:        FAST
 BAUD:               4800
 PARITY:             EVEN
 TERM:              CR LF
```

Figure 7-5
Controls Print

various status messages may be individually enabled or disabled using Auxiliary Function 36. Most status printouts include a status message along with the current time/date and site identification name. These status message include G.821 transition, overflow print, data loss, clock loss, signal loss, sync loss, sync acquired, frame error (async character), receiver clock polarity change, test restart, new configuration, signaling change, and power up. When applicable, these messages also include the count of the number of times they have occurred in the current test.

Figure 7-6 shows several sample status prints.

```
NEW CONFIGURATION
SITE ID              Alpha
15:08:50       28 MAY 86

SYNC ACQUIRED            1
SITE ID              Alpha
15:08:81       28 MAY 86

CLOCK LOSS               1
SITE ID              Alpha
15:09:40       28 MAY 86

SYNC LOSS                1
SITE ID              Alpha
15:09:40       28 MAY 86

SYNC ACQUIRED            2
SITE ID              Alpha
15:09:41       28 MAY 86

LAST POWER DOWN
15:09:47       28 MAY 86
POWER UP
15:09:51       28 MAY 86
SITE ID              Alpha
```

Figure 7-6
Status Prints

7.2.4 Histogram Print

A histogram print offers the user a perspective as to how a FIREBERD result is changing with time. For instance, a histogram could be used to monitor the accumulated bit errors in each hour over a 60-hour period. From this information, the user could determine whether the bit errors were uniformly distributed over the 60 hours or biased towards one point in time.

Histogram analysis of any integer results may be initiated and printed using Auxiliary Function 44. In this discussion, the applicable auxiliary function soft-key labels are shown in parentheses. The user must select the result to be monitored (RESULT), the units of the graph vertical axis (VERT), and the measurement interval (1, 10, or 60 minutes—to be plotted along the horizontal axis) per histogram "bar" (HORIZ). Changing the measurement interval (HORIZ) or the result will cause the histogram analysis to restart; changing the units of the vertical axis will not cause a restart, thus allowing the data to be replotted with a new vertical scale.

The user may select either a graphics (GRAPH) or list (LIST) format for histogram prints. When printing graphics through the RS-232 interface, the user must be sure that the character format (selected with Auxiliary Function 38) is set for eight data bits. The histogram will be printed along with its start time, any sync loss indicators ("s") indicating intervals in which sync was lost, and any G.821 availability transition indicators ("t") indicating intervals in which transitions were made from available to unavailable time or from unavailable to available time.

Once the histogram analysis is turned on, the FIREBERD will begin accumulating data for, at most, 60 intervals. When all intervals have been accumulated, the results will be printed and the histogram analysis will restart.

Figures 7-7 and 7-8 are examples of the histogram list and graph printouts.

7.2.5 Jitter Frequency Prints

When the DS1 Jitter Spectral Analysis option is installed, a "jitter frequency list" result is also available, either by itself or as part of a results print. This printout contains the jitter measurements for each of the 40 frequencies monitored by the spectrum analyzer. These measurements include the maximum unit intervals of jitter measured at each frequency along with the percentage of the selected jitter mask that this reading corresponds to. Again, like the Maximum Jitter result, when this result is included in a Delta print, it reflects only the measurements made during the test interval.

Jitter printouts may be initiated in either graphics or list format using the front panel JITTER function of the MENU switch. Note that when generating a graphics print through the RS-232 interface, the character format must be set for eight data bits.

Figures 7-9 and 7-10 are examples of the jitter frequency list and graph.

HISTOGRAM BEGAN AT
20:57:00 01 JAN 87

MINUTE	CHAR ERR
1	0
2	209
3	0
4	93
5	6
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	0
17	0
18	14
19	1
20	0
21	0
22	0
23	0
24	0
25	0
26	0
27	0
28	0
29	13
30	1
31	11
32	3
33	145

Figure 7-7
Histogram List Print

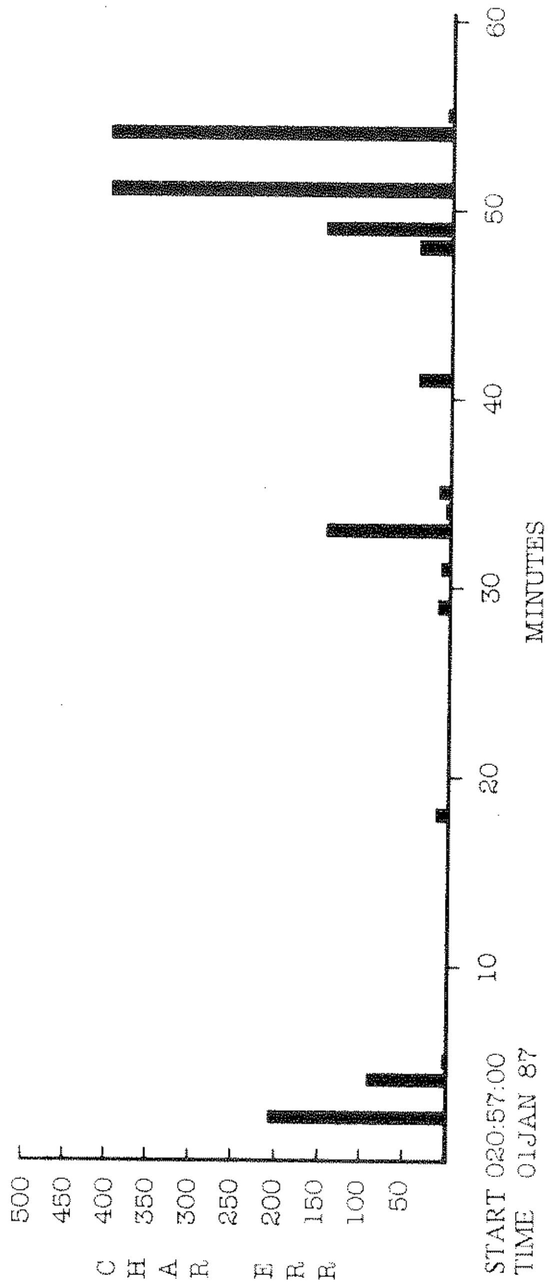


Figure 7-8
Histogram Graph Print

```
JITTER    FREQ    LIST   :
15:10:23         01 JAN 87
MASK:                0.171
FREQ(Hz)    UI      %MASK
   10      0.04        0.4
   20      0.03        0.3
   30      0.02        0.2
   40      0.05        0.5
   50      0.02        0.2
   60      0.01        0.1
   70      0.01        0.1
   80      0.01        0.1
  100      0.02        0.2
  133      0.02        0.2
  166      0.03        0.3
  200      0.02        0.2
  233      0.03        0.3
  300      0.13        1.9
  400      1.06       20.9
  500      8.15      201.2
  600      0.44       13.0
  700      0.14        4.8
  800      0.10        3.9
  1.0k     0.11        5.3
  1.3k     0.05        3.2
  1.6k     0.04        3.2
  2.0k     0.03        2.9
  2.3k     0.03        3.3
  3.0k     0.03        4.3
  4.0k     0.03        5.7
  5.0k     0.05       11.9
  6.0k     0.03        8.5
  7.0k     0.03       10.0
  8.0k     0.04        6.6
  10k      0.04       13.3
  13k      0.04       13.3
  16k      0.01        3.3
  20k      0.02        6.6
  23k      0.01        3.3
  26k      0.01        3.3
  30k      0.01        3.3
  33k      0.02        6.6
  36k      0.02        6.6
  40k      0.01        3.3
```

Figure 7-9
Jitter Frequency List

7.2.6 Print Formats

Auxiliary Function 37 may be used to specify the printout formats. This includes selecting the printout width (20 or 80 characters), printout spacing (condensed or normal), and printout order (forward—first line first, or backwards—last line first).

The soft-key labels for Auxiliary Function 37 are listed below.

(1) COLUMN-changes printout width from 20 to 80 columns.
(2) MODE-accesses soft-key labels COND (condensed) and NORMAL.
(3) LAYOUT-accesses soft-key labels FWD (forward) and BACKWD (backward).

The BACKWD setting should be selected for use with the PR-2000 20-column printer or other printers in which the paper is fed downward across the print mechanism. The FWD setting should be selected for use with CRTs, the PR-85 Printer, and most other printers.

7.3 REMOTE CONTROLLER COMMANDS

7.3.1 Terminal Operation and the On-Line HELP Functions

The FIREBERD 6000 provides extensive on-line help information intended to aid the user operating from a dumb terminal. This help includes a 7-page, on-line mini-manual as well as a parameter syntax guide for every remote control command.

To operate the FIREBERD from a dumb terminal, the user must first log in by typing a period (".") or the word "TERMINAL" followed by a carriage return. From there the FIREBERD will inform the user to type HELP followed by a carriage return to call up the main help screen. The main help screen will, in turn, inform the user of how to get more help on specific subjects. The pages of the on-line mini-manual are presented in an appendix of this manual.

From a dumb terminal, the user may then select to enter interactive configuration mode. This is done using the built-in BERD-BASIC programs accessed via the **PROG** command. Once in interactive mode, the FIREBERD will ask all questions necessary to configure a test, thereby alleviating the need for the user to memorize dozens of remote control commands.

Note that the log-in sequence is only to inform the FIREBERD that the controller is operating from a dumb terminal. This command should not be used when operating the FIREBERD from a computer, because it causes the FIREBERD to enable the prompt and echo functions, both of which will only confuse a computer program attempting to decipher the results returning from the FIREBERD.

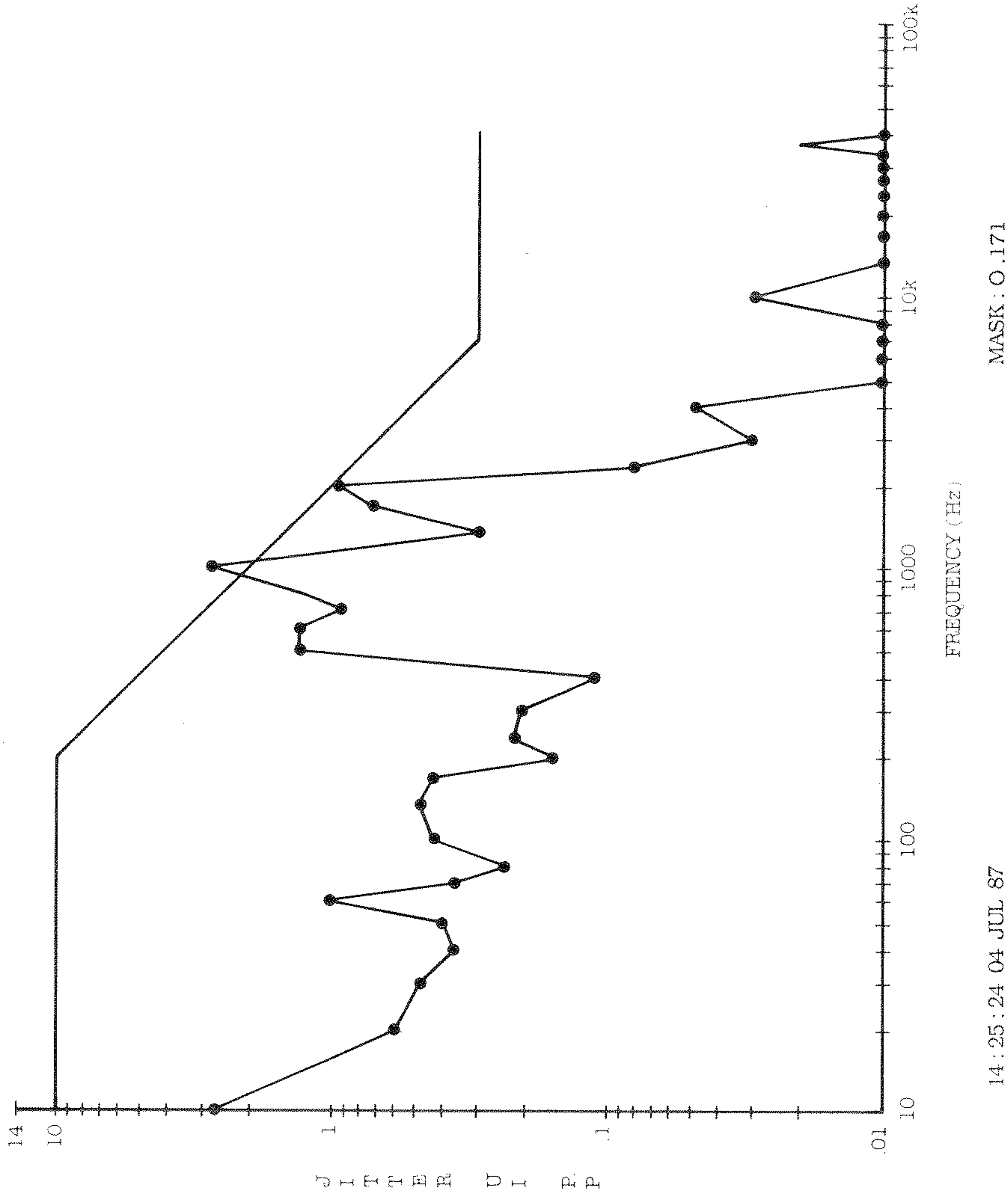


Figure 7-10
Jitter Frequency Graph

7.3.2 Remote Control Command Formats

The general format for a remote control command is as follows:

command name (parameter . . .)

where **command name** is the command name as listed in Section 7.3.4 and **(parameter . . .)** is an optional parameter list associated with the command. Whenever possible, the remote control command and parameter names have been made consistent with those appearing on the FIREBERD's front panel. In general, remote control names are derived by shortening all words shown on the front panel to their first three letters, while leaving all numbers unchanged and representing exponents with a caret ("^").

Most FIREBERD commands may be used to either select a new command state or to print the currently selected command state (without changing it). To select a new command state, both the command name and the desired parameter are entered in the command line. To obtain the currently selected state, only the command name is entered. In other words, entering a command name without selecting a new state will cause the FIREBERD to print the currently selected state. This is referred to as a status request for the particular command.

7.3.3 Remote Control Command Entry Sequence

All commands may be entered to the FIREBERD in either upper or lower case, although the examples in this manual are listed in upper case only.

All space characters (" ") are ignored by the FIREBERD and thus may be used freely to make the commands more legible (as will also be done in all examples throughout this manual).

Entering a BACK-SPACE character (ASCII code 08H, Control H) causes the FIREBERD to discard the most recently entered character.

Entering a CANCEL character (ASCII code 18H, Control X) causes the entire command line currently being entered to be discarded.

All command lines to the FIREBERD must be terminated by a valid statement terminator. This may be a carriage return character (ASCII code 0DH), a linefeed character (ASCII code 0AH), or any character transmitted with the EOI line asserted (IEEE-488 only). Note that commands are not interpreted by the FIREBERD until this terminator is received.

7.3.4 FIREBERD Commands by Groups

Auxiliary Functions

AUX 1	–select/print generator clock polarity
AUX 2	–select/print receiver clock polarity
AUX 3	–select/print receiver action on sync loss
AUX 4	–select/print single transmit
AUX 5	–select/print data interface controller
AUX 6	–select/print generator data invert
AUX 7	–select/print receiver clock select
AUX 8	–select/print out of band flow contol
AUX 9	–select/print in band flow control
AUX 10	–select/print sync loss threshold
AUX 11	–select/print printer select
AUX 30	–select/print block length
AUX 31	–select/print delay measurement
AUX 32	–select/print common frequencies
AUX 33	–select/print programmable data pattern
AUX 34	–select/print site identification
AUX 35	–select/print custom results printout
AUX 36	–select/print custom status printouts
AUX 37	–select/print printout format
AUX 38	–select/print RS-232 printer/ controller configuration
AUX 39	–select/print IEEE-488 printer/ controller configuration
AUX 40	–print software revision level (see HELLO)
AUX 41	–set/print user message
AUX 42	–print pre-sync loss results
AUX 43	–clear all novram
AUX 44	–select/print histogram set-up
AUX 60	–set/print time and date
AUX 99	–clear auxiliary functions in use

Controller and General Configuration

BYE	–return the FIREBERD to a power-up state (see DEVICE CLEAR)
DATE	–set/print the date (see AUX 60)
DEVICE CLEAR	–return the FIREBERD to a power-up state
ECHO	–select/print controller echo mode
END	–end an ENTER sequence
ENTER	–disable contention checking on subsequent commands

HELLO	–print the software revision level
HELP	–print help information
ISU	–control the Interface Switching Unit
LOCAL	–return to FIREBERD local mode
MACRO	–define user macro sequences
OPTIONS	–list options currently installed in the FIREBERD
PROG	–Use built-in BERD-BASIC programs
PROMPT	–select/print the prompt mode
SELFTEST	-print the results of the automatic self test
TERMINAL	–configure the FIREBERD to talk to a dumb terminal
TIME	–set/print the time (see AUX 60)
TPZ	–set state of rear panel test point "Z"

Display and Audio Indicator Functions

ANA RES 1	–select left display result
ANA RES2	–select right display result
AUDIO	–select/print audio level override
BEEP	–sound the beeper
DIS HOL	–select/print display hold mode
DISPLAY	–select/print front panel display mode
SYN LOS	–clear the sync lost LED

Interface Signaling, Etc.

DSR	–manipulate/print DSR/(DM) control line state (DCE only)
DTR	–manipulate/print DTR/(TR) control line state (DTE only)
LOO	–generate loop codes (T-carrier only)
RLS	–manipulate/print RLSD/(RR) control line state (DCE only)
OCT TIM	–control octet timing transmission for 64 kb/s 6.703 Data Interface
RTS	–manipulate/print RTS/(RS) control line state (DTE only)

Printer Configuration

CUSTOM	–select/print custom results prints (see AUX 35)
FORMAT	–select formatted printer output (see AUX 37)
LONG	–select long results prints (see AUX 35)
PLAIN	
ENGLISH	–select character or hex user message prints
STANDARD	–select standard results prints (see AUX 35)
STATUS	–select/print custom status prints (see AUX 36)
TERM 232	–set/print RS-232 print line terminator (see AUX 38)
TERM 488	–set/print IEEE-488 print line terminator (see AUX 39)
UNFORMAT	–selected unformatted printer output (see AUX 37)
WIDTH	–select/print printout width (see AUX 37)

Printer Functions

CLEAR FIFO	–clear the printer buffer (see PRI)
CLS	–clear the terminal screen
CONTROLS	–generate a controls printout (see PRI)
HOLD	–hold all printer outputs
LEDS	–print front panel LED status
LPRINT	–print the literal string
NUMBER	–list command or parameter numbers
PAGE	–print pages from the on-line mini-manual
PRI	–select/print printer enable/function
PRINT	–print the single FIREBERD results or BERD-BASIC variable
REL	–release all accumulated printer outputs from HOLD
RESULTS	–generate a results printout (see PRI)

Test Configuration

ANA MOD	–select/print analysis mode
CHA FOR	–select/print async character format
DAT	–select/print generator data pattern
ERR INS	–select/print logic error insertion rate
ERROR	–insert a single logic error (see ERR INS)
GEN CLK	–select/print generator clock source
INT SET	–select/print data interface configuration
JIT	–select/print jitter measurement parameters
PRI EVE	–select/print automatic result print events
REC	–recall stored front panel program
RES	–restart the test
SEL LOO	–select/print self loop mode
STO	–store front panel program
SYN FRE	–select/print internal synthesizer frequency
TES INT	–select/print test interval
TIM MOD	–select/print timing mode
USER	–load user message with ASCII text

7.3.5 Command Line Shortcuts

A macro is a useful string of characters that can be inserted into a command at any point using just one or two keystrokes. The FIREBERD allows both user-defined and automatic macros. User macros are defined using the MACRO command and are recalled using the character sequence **& (number)** in the command line, where **(number)** is the macro identification number. The automatic help/status macro is set whenever a help (see the **HELP** command) or status request is issued for a particular command. The user can then refer to that command by simply using the "*" character in the command line. This saves the user the trouble of having to retype the command name again to alter its state.

Any command or command parameter issued to the FIREBERD may be abbreviated by entering its first few letters followed by a period ("."). The few-letters command should be enough to uniquely identify it from all other FIREBERD commands or command parameters respectively. If a non-unique entry is generated in this manner, the FIREBERD will choose the first command or command parameter (as listed in the **HELP!** or **HELP (command name)** printouts respectively) that matches the entered abbreviation. For instance, **CU.** can be used as an abbreviation for the **CUSTOM** command since no other commands begin with the letters **CU**. On the other hand, **CO.** could not be used to abbreviate the **CONTROLS** command since the **COMMON** command also begins with the letters **CO** and the **COMMON** command appears first in the **HELP!** printout. (This means that **CO.** could be used to abbreviate the **COMMON** command; correspondingly, **CON.** could be used to abbreviate the **CONTROLS** command.)

Multiple parameters may be selected from the same command by separating them with commas (",") on the command line. For example, to set the asynchronous character format to 7 data bits and even parity, the controller could either enter the two commands **CHA FOR DAT 7** and **CHA FOR PAR EVE**, or enter the single command **CHA FOR DAT 7, PAR EVE**. Note that in the latter example, the **CHA FOR** command had only to be specified once and the comma separated the two parameter selections. One prompt will be returned to the controller for each parameter selected (preceded by an error message if the command was illegal).

Multiple commands may be issued to the FIREBERD on the same command line by separating them with semicolons (";"). The commands will be executed in the sequence in which they were entered. One prompt will be returned to the controller for each executed command (preceded by an error message if the command was illegal).

7.3.6 Pausing FIREBERD Printouts

Entering an X-OFF character (ASCII code 13H, Control S) or pressing the space bar will cause the FIREBERD to temporarily halt all printouts until either an X-ON character (ASCII code 11H, Control Q) or a statement terminator is received. Similarly, entering a space character (" ") will cause the FIREBERD to temporarily halt all printouts, following the completion of the current line, until a statement terminator is received.

7.3.7 Aborting FIREBERD Operations

Entering a Control C character (ASCII code 03H, ETX) will cause the current input line to be discarded, the print buffer to be cleared, any **WAIT** or **LOO** commands in progress to be aborted, and any BERD-BASIC program currently executing to stop. This is the "break" command that gets the FIREBERD back to normal command mode.

7.4 BERD-BASIC PROGRAMMING CONCEPTS

A BERD-BASIC program is simply a sequence of commands that instruct the FIREBERD to perform desired functions. The program is written ahead of time and may be carried out later, possibly many times, without requiring the user to be present. The program itself takes control of the FIREBERD and, in effect, takes the place of the remote user.

A program needs to contain information as to both what commands are to be executed and in what order. This information is entered into the program as a sequence of **program lines**. Each program line is made up of two parts, a **line number** and a **command**. The **command** specified in a program line is the same remote control command that would be specified by the remote user; it tells the FIREBERD what to do. The **line number**, on the other hand, tells the FIREBERD when to do it. Program lines may be entered in any order; the FIREBERD will automatically sort them from lowest to highest line number as they are entered.

In general, a program will be executed starting with the lowest numbered line and proceeding, in sequence, to the highest numbered line. (For this reason, it is conventional to initially enter program lines numbered by tens, that is, 10, 20, 30, 40, etc. This ensures that several new lines can be easily inserted between two existing lines in case new commands need to be added later.) The absolute ordering of program line execution from lowest to highest line number may, however, be overridden. For example, the program can instruct the FIREBERD to "go back to" or "skip to" a specified line or, more importantly, the program can instruct the FIREBERD to "go to" a specified line only if a certain condition is true. In this way, the program can take certain actions depending on the values of one or more of the FIREBERD results.

BERD-BASIC also provides simple integer variables that can be used to count events. The program may print, change, or test the current value of any of these variables.

The FIREBERD allows the user to maintain up to five BERD-BASIC programs at a time—one "working" program and four stored on the ramdisk. The user can save and load programs to and from the ramdisk using easy-to-remember program names. Additionally, the running program may invoke the execution of any of the stored programs. Note that all five programs are stored in non-volatile RAM and, therefore, are not lost when the FIREBERD is powered down.

BERD-BASIC Program Commands

BREAK	–select program action on error
END	–end program execution
GOSUB	–transfer program execution to a subroutine
GOTO	–transfer program execution to specified line
IF-THEN	–conditional GOTO statement (based on results or variable value)
INPUT	–enter input from terminal into user macro
LET	–assign new value to BERD-BASIC variable
REM	–remark or comment
RETURN	–return from subroutine
STOP	–stop program execution (temporarily)
WAIT	–wait for sync or the specified time

BERD-BASIC Program Control Statements

CONT	–continue program execution from Control C or STOP
LIST	–list current BERD-BASIC program
RUN	–start program execution

BERD-BASIC Program Line Entry

(line number) (command)	–enter a program line
(line number)	–delete a program line

BERD-BASIC Ramdisk Operations

CHAIN	–chain execution to saved program
COMMON	–preserve all variable values thru the next CHAIN
DIR	–list names of saved programs
KILL	–delete (unsave) a saved program from the ramdisk
LOAD	–load a saved program
SAVE	–save the current program on the ramdisk

Figure 7-11 shows an example of a BERD-BASIC program.

7.5 RS-232 PRINTER/ CONTROLLER INTERFACE

7.5.1 Interface Description

The RS-232 Printer/Controller Interface is a built-in, standard feature of the FIREBERD 6000; the female, 25-pin D connector is located on the FIREBERD rear panel. The interface is configured such that the FIREBERD acts as DCE and may be directly connected directly to a printer (or any other piece of data terminal equipment). All communications through the RS-232 port are asynchronous using ASCII code, with the exception of Epson-compatible graphics codes used to produce output to graphics printers.

The following is a list of the RS-232 interface pins and their associated functions:

pin 1:	protective ground	–connected to chassis ground
pin 2:	transmit data	–data transmitted to the FIREBERD
pin 3:	receive data	–data received from the FIREBERD
pin 5:	clear to send	–output true when the FIREBERD is ready to receive
pin 6:	data set ready	–output true when the FIREBERD is on
pin 7:	signal ground	–connected to circuit ground
pin 8:	data carrier detect	–output true when the FIREBERD is on
pin 20:	data terminal ready	–must be input true before the FIREBERD will send

Note especially that the DTR signal (on pin 20) must be driven true by the printer before the FIREBERD will send any data.

Auxiliary Function 38 provides control over the RS-232 communication port configuration. Five categories of parameters may be controlled: baud rate; number of data bits per character; parity; line terminator; and print speed.

The baud rate may be set to 110, 300, 600, 1200, 2400, 4800, or 9600. The number of data bits may be either 7 or 8. The parity may be odd, even, or none. The line terminator transmitted from the FIREBERD may be set to carriage return (CR), linefeed (LF), both (CRLF), or none.

```
10 REM    ==== T1 NETWORK INTERFACE TEST ====
20 REC 3; WAIT 900; REM....REC = RECALL PROGRAM....900 SEC = 15 MINUTES
30 IF %MAS <= 100 THEN 50; REM....%MAS = MAX % OF JITTER SPECTRAL MASK
40 LPRINT "*** JITTER EXCEEDS AT&T PUB 62411 MASK ***"
50 IF BPVS <= 300 THEN 70; REM.........BPVS = BIPOLAR VIOLATIONS COUNT
60 LPRINT "*** MORE THAN 300 BPVS IN THE 15-MINUTE interval ***"
70 IF RCV FRE < 1543920 THEN 80; IF RCV FRE > 1544080 THEN 80; GOTO 90
80 LPRINT "*** RECEIVED T1 FREQUENCY OUT OF TOLERANCE ***"
90 REM......EQUIPMENT NEEDED — FIREBERD 6000 AND A DUMB TERMINAL......
```

Figure 7-11
Sample BERD-BASIC Program

If the print speed is set to fast, the FIREBERD will send as fast as the baud rate allows. If the print speed is set to slow, the FIREBERD will send no more than 20 characters per second, and will pause for one-half second between lines.

The default settings for the FIREBERD are: 2400 baud, 7 data bits, even parity, carriage return, and slow print speed. If reconfigured, the FIREBERD will remember the new settings when powered down.

If the controller sends commands to the FIREBERD faster than it can process them (that is, if the controller ignores the Clear To Send signal output from the FIREBERD), the FIREBERD may not be able to keep up. If this occurs, the FIREBERD will respond with either a receiver overrun or receive buffer overflow error message and the command(s) will be discarded. To be safe, it is suggested that the controller either monitor the Clear To Send signal being output by the FIREBERD or allow the FIREBERD ample processing time following each command. (200 milliseconds is a good conservative figure for most commands.)

7.5.2 Auto-Baud Function

To simplify the chore of setting up RS-232 remote control communications, the FIREBERD offers a very simple auto-baud function. This allows a remote user to configure the FIREBERD's baud rate, data bits, and parity without the trial-and-error approach normally associated with RS-232 communications. In fact, the remote user need not even known the configuration he is using; the FIREBERD will figure it all out automatically (and even tell the user, via Auxiliary Function 38).

To initiate Auto-Baud mode, the remote controller must sent three **BREAK** characters (generally a separate key on the terminal that forces a steady space condition on the RS-232 line) at 1-second intervals. Following this, the user must repeatedly type **SPACE** characters (ASCII code 20H) at a 5 Hz to 10 Hz rate for 10 seconds (or until the FIREBERD responds with the message "auto-baud achieved, press **ESCAPE** to continue"). Once this is done, the user must send an **ESCAPE** (ASCII code 1BH) character and the FIREBERD will respond with the message "Character format determined." At this point, the FIREBERD is fully configured and the user may enter **TERMINAL** mode, if desired, and begin remote control.

There are a few items to note about the auto-baud procedure:

(1) If auto-baud is not achieved within 30 seconds of being initiated, the FIREBERD will abort the function and revert back to its prior RS-232 settings. This timeout is necessary since many terminals and printers will generate a **Break** character as they are powered up or down, and thus might fool the FIREBERD into entering Auto-Baud mode when it is not supposed to. If this happens, the FIREBERD front panel display will flash the message "RS-232 auto-baud" until the 30-second timeout is finished, at which time the FIREBERD will abort Auto-Baud mode (bringing the RS-232 configuration back to what it was). Note also that changing Auxiliary Function 38 from the front panel will also abort the auto-baud function.

(2) The **SPACE** characters sent to identify the terminal's baud rate to the FIREBERD must be transmitted at such a rate that there is "dead time" between characters on the RS-232 communications link. Usually, using the terminal's "auto-repeat" function is fine; however, at 110 baud this may be too fast. If this is the case, then the user may transmit the **SPACE** characters by hand at a minimum frequency of three per second. Note also that when auto-bauding by computer, the computer should send the **SPACE** characters at about five per second.

(3) The message "Auto-baud achieved, press ESCAPE to continue" will always be transmitted with 7 data bits, 2 stop bits, and even parity, since the FIREBERD has not yet determined the character format of the remote controller. For this reason, it may not appear normal on some terminals configured differently. The solution to this is to just go ahead and send the **ESCAPE** character anyway. The FIREBERD will then figure out the character format and everything will work properly.

(4) While in Auto-Baud mode, the FIREBERD will constantly transmit a single asterisk (*) and bell (Control G, ASCII code 07H) character at the end of each baud rate that is scans. This is provided to give the user some indication that the FIREBERD is in Auto-Baud mode and that the user should be sending the **SPACE** characters.

7.6 IEEE-488 PRINTER/ CONTROLLER INTERFACE

The FIREBERD IEEE-488 interface complies with the IEEE Standard Digital Interface for Programmable Instrumentation (STD 488—1978). The interface offers bothTalk-Only and Addressable modes. When operating in Talk-Only mode, the FIREBERD should be connected directly to a listen-only printer. In Addressable mode, the FIREBERD may be connected with up to 14 other devices, one of which must be a controller.

The rear panel DIP switch located on the IEEE-488 panel is used to select the interface mode along with the FIREBERD's interface address (used only in addressable mode). The DIP switch configuration is as follows:

	SW1	SW2	SW3	SW4	SW5	SW6
(0 = DOWN, 1 = UP)	A0	A1	A2	A3	A4	Adressable Talker Only

where Addressable/Talker Only selects the operating mode and A0 through A4 are the unit address. Although the FIREBERD IEEE-488 interface offers both Talk-Only and Addressable modes, remote control is available only in Addressable mode. Additionally, when operating in Addressable mode, the FIREBERD will respond to the IEEE-488 Device Clear (DCL) by performing a re-power-up.

The following is a typical remote control input sequence.

(1) The controller addresses the FIREBERD to listen.
(2) The controller sends a remote control command.
(3) The controller sends a terminator.
(4) Upon receipt of the terminator, the FIREBERD analyzes the command and responds appropriately.

As characters are received, ASCII null and space characters are discarded, and the remaining characters are saved until a terminator is received. The FIREBERD automatically recognizes any one or a combination of the following terminator sequences: CR; LF; or CR, LF.

Once the terminator has been received, the command will be analyzed. If there is an error with the command, a service request will be issued and the least significant bit of the serial poll register will be set. If there is no error, the FIREBERD will generate the appropriate response for the command and then prepare to receive another command.

Auxiliary Function 39 provides control over the IEEE-488 communication port configuration. Three categories of parameters may be controlled: service request, line terminator, and print speed.

If service request is set to data, the FIREBERD will generate a service request (SRQ) whenever an erroneous command is received, or when it has data ready to transmit. If service request is set to error, the FIREBERD will generate a service request only when an erroneous command is received. In either case, the FIREBERD will set the most significant bit of its serial poll register (dav) whenever it has data to transmit. See Figure 7-12.

B7	B6	B5	B4	B3	B2	B1	B0
dav	rsv						syn

dav = data available in FIREBERD print buffer
rsv = request service (SRQ)
syn = command syntax error

Figure 7-12
Serial Poll Status Byte

The line terminator transmitted from the FIREBERD may be set to carriage return (CR), linefeed (LF), both CRLF), or none. Regardless of mode or terminator selection, the EOI signal is raised with the final character of each line. (For software revision D and above only). If the print speed is set to fast, the FIREBERD will send as fast as the interface allows. If the print speed is set to slow, the FIREBERD will send no more than 20 characters per second, and will pause for one-half second between lines.

The default settings for the FIREBERD 6000 are: error service request, CRLF line terminator, and fast print speed. If reconfigured, the FIREBERD will remember the new settings when powered down.

IN2.1 Unlike an RS-232 connection, the IEEE-488 bus requires that one device on the bus act as controller. All other devices connected to the bus must act as slaves to that controller. The FIREBERD can only act as a slave. Another intelligent device must be used as the bus as the bus controller.

Devices commonly used as a controller include the following:

- Hewlett-Packard HP-85 computer with the 82937 Interface.
- IBM-PC with a National Instruments GPIB-PC interface card and system software.

In most cases, a software program is required to operate the controller. Sample programs for the HP-85 and National Instruments GPIB-PC are shown in Appendix B.

7.6.1 IEEE-488 Programming Hints

A device must be addressed to respond to a command. It is possible to address any single device or any group of devices on the bus.

Addressing a single device is accomplished with a statement such as Output (701); "DAT63" to the device at address 1 of the HP-85's port 7.

To address multiple devices using the HP-85, the REMOTE x,x,x statement is used. The x's constitute a lost of devices to be addressed. Once the group of devices has been addressed, the group format of the commands may be used. One example is "Trigger 7," which causes all addressed devices on the bus to perform their DEVICE Trigger function.

Before attempting to read data from a device, it is necessary to know if the device has data to send.

The controller has two ways of determining that the FIREBERD has data: (1) bit 7 of the serial poll register (dav) is set whenever a line of data is available, and (2) if the FIREBERD AUX 39 SRQ mode selection is set to DAT, the FIREBERD makes a service request to the 488 controller whenever it has data available.

Both of these methods are demonstrated in the sample programs shown in Appendix B.

The statement used ot read data from the FIREBERD must be one that terminates the read operation when the last character of the line is encountered. Since it is up to the user to specify the FIREBERD's line terminator (CR, LF, CRLF), the most foolproof way to detect the last character is by sensing the EOI signal.

The HP-85 statement "ENTER 701 USING "#%,%K";A$" reads characters from device 1 until the EOI signal is encountered.

SECTION 8
DATA INTERFACES

8.1 INTRODUCTION

Data interface modules are used to interface the FIREBERD 6000 with different types of data communications circuits. This section contains functional descriptions, operating instructions, and specifications for the built-in RS-232 Data Interface as well as for many of the other data interfaces available for use with the FIREBERD. The following is a list of the data interfaces described in this section.

8.2 Built-In RS-232 Data Interface

8.3 V.35/306 DTE/DCE Data Interface (Model 40202)

8.4 RS-449 DTE/DCE Data Interface (Model 40200)

8.5 DS0/DS0A Data Interface (Model 30481)

8.6 DS1/D4/Fe Data Interface (Model 40460)

8.7 DS1/T1 (D4 Framing) Data Interface (Model 40405)

8.8 DS1C/DS2 Data Interface (Model 30447)

8.9 2.048 Mb/s G.703 Data Interface (Model 40380)

8.10 LAB Data Interface (Model 40204)

8.11 DS1/T1 Data Interface (Model 40540)

8.12 8448 kb/s G.703 Data Interface (Model 30524)

Separate operating manuals are available for many of these data interfaces and many other data interfaces may be used with the FIREBERD 6000—consult TTC for additional information.

8.2 BUILT-IN RS-232-C/V.24 DATA INTERFACE

8.2.1 Introduction

The RS-232-C/V.24 Data Interface, provided as a built-in feature of the FIREBERD, meets EIA RS-232-C, CCITT V.24 and V.28, and ISO 2110-1980 Standards. This data interface has two 25-pin D connectors which enable the FIREBERD to emulate both data terminal equipment (DTE) and data communications equipment (DCE). DTE or DCE operation can be selected by selecting the INTF SETUP function of the FIREBERD front panel MENU switch. The 25-pin D connectors are located on the FIREBERD's rear panel. The DTE connector is labeled TO DCE, and the DCE connector is labeled TO DTE. The two connectors share the FIREBERD's drivers and receivers and should not be used concurrently.

8.2.2 Functional Description

8.2.2.1 DTE Operation

In a typical RS-232 circuit, the DCE supplies timing to the FIREBERD (DTE) on the TC (Transmit Clock, DCE source) lead. When the interface clock is being used as the source of timing, the FIREBERD will generate TD (Transmit Data) and XTC (Transmit Clock, DTE source) coincident with the clock received on TC.

When the FIREBERD's synthesizer is being used as the source of timing, the FIREBERD will ignore TC and generate TD and XTC coincident with the selected internal rate. The BNC input may also be used to supply generator timing. Data and clock signals received on the RD (Receive Data) and RC (Receive Clock) leads are used for error analysis.

Two switches on the FIREBERD front panel allow RTS (Request to Send) and DTR (Data Terminal Ready) to be turned on and off. CTS (Clear to Send), DSR (Data Set Ready), and RLSD (Received Line Signal Detector) are received and their status displayed on the FIREBERD front panel.

8.2.2.2 DCE Operation

In a typical circuit, the FIREBERD (DCE) supplies timing to the DTE on the TC lead. The DTE will return TD and XTC to the FIREBERD for error analysis.

When the interface's clock is being used for generator timing, RD and RC (Receive Signal Element Timing) will be generated coincident with XTC from the DTE. The FIREBERD may also generate RD and RC coincident with the synthesizer rate or the BNC rate.

Two switches on the FIREBERD front panel allow RLSD and DSR to be turned on and off in DCE mode. DTR and RTS are received and their status displayed on the FIREBERD front panel. CTS and RI (Ring Indicator) can be turned on and off by selecting the INTF SETUP function of the FIREBERD's MENU switch and pressing the INT232 soft key. See Figure 8-1 for a diagram of the INT232 menu tree. (Refer to Section 4 for detailed instructions on the MENU switch and its selectable functions).

8.2.2.3 Timing Modes

Synchronous, asynchronous, or recovered timing can be used with this interface. With asynchronous timing, asynchronous data analysis can be performed at rates to 20 kb/s. The interface can be operated at rates to 64 kb/s using synchronous or recovered timing.

8.2.2.4 Self-Loop

The SELF LOOP switch on the front panel of the FIREBERD connects the transmit clock and data outputs to the receive clock and data inputs. User connections do not have to be removed to perform a loop test. In DTE operation, timing for the loop test can be provided on the TC lead (DCE source), by the FIREBERD's synthesizer, or through the rear panel BNC connector. In DCE operation, timing can be provided by the synthesizer or through the BNC connector. The self-loop function tests the actual drivers and receivers that are used during normal operation.

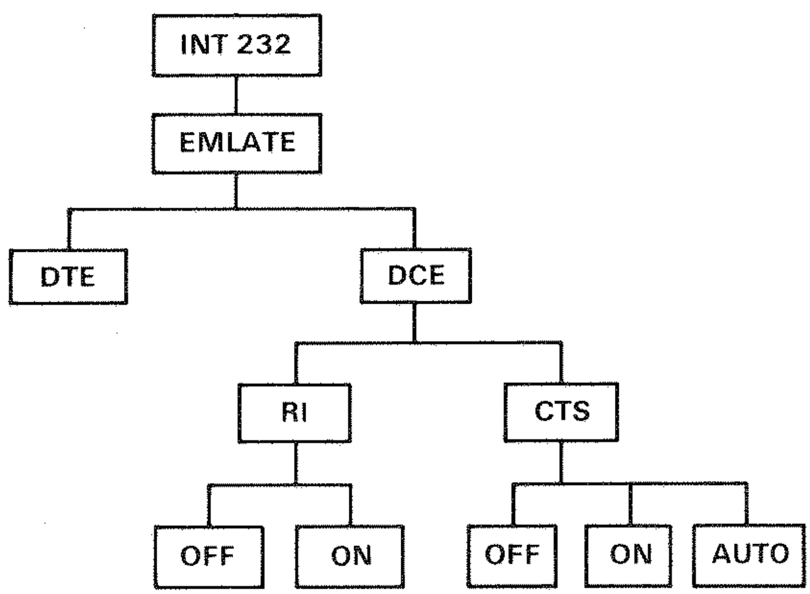


Figure 8-1
INT232 Menu Tree

8.2.3 Specifications

8.2.3.1 General

Maximum Speed:	• 64 kb/s.
Data Polarity:	• Mark (binary 1): less than -3 volts.
	• Space (binary 0): greater than +3 volts.
Signal Polarity:	• On: greater than +3 volts.
	• Off: open or less than -3 volts.

8.2.3.2 Drivers

Output rise time:	• greater than 20 microseconds.
Generator Impedance:	• less than 100 ohms.
Signal Swing:	• +10V into 7K ohms typical.
Short Circuit Current:	• less than 100 mA.

8.2.3.3 Receivers

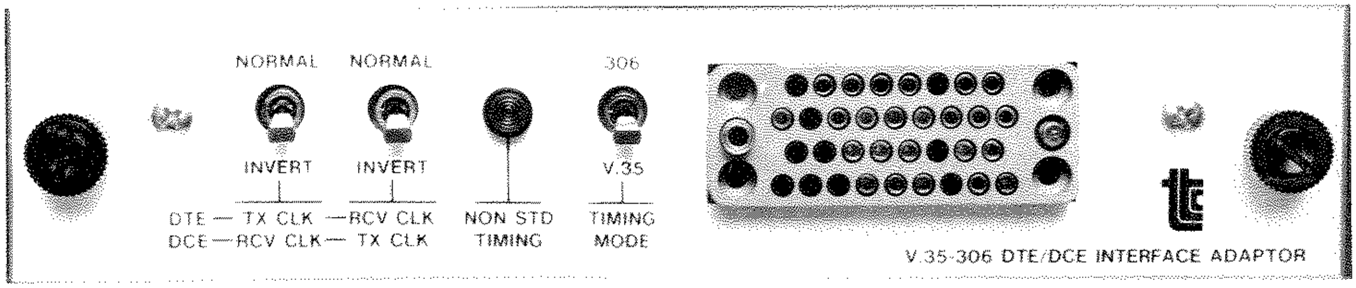
Load Impedance:	• 3K to 7K ohms.
Maximum Input Voltage:	• +25V.

Table 8-1
Internal RS-232-C/V.24 Data Interface
Pin Assignments

PIN	EIA	CCITT	SIGNAL NAME	STATUS AT CONNECTORS	
				"TO DCE"	"TO DTE"
1	AA	—	Protective Ground	Connected to chassis ground	
2	BA	103	Transmitted Data	output	input
3	BB	104	Received Data	input	output
4	CA	105	Request To Send	output	input
5	CB	106	Clear To Send/Ready for Sending	input	output
6	CC	107	Data Set Ready	input	output
7	AB	102	Signal Ground	Connected to signal ground	
8	CF	109	Received Line Signal Dector	input	output
15	DB	114	Transmit Clock (DCE source)	input	output
17	DD	115	Receive Clock (DCE source)	input	output
20	CD	108/2	Data Terminal Ready	output	input
22	CE	125	Ring (Calling) Indicator	input*	output
24	DA	113	Transmit Clock (DTE source)	output	input

* Received; reserved for future use.

8.3 V.35/306 DTE/DCE DATA INTERFACE (Model 40202)



8.3.1 Introduction

The V.35/306 DTE/DCE Data Interface is designed in accordance with the following interface specifications:

- CCITT Recommendation V.35
- 306 Type Wideband Data Set. Bell System Technical Reference Publication PUB41304
- Digital Data System Data Service Unit. Bell System Technical Reference Publication PUB41450.

This interface enables a FIREBERD to act as Data Terminal Equipment (DTE) for use in testing Data Communications Equipment (DCE). With the use of an adaptor cable (included) the FIREBERD can be configured as DCE or DTE. The data is exchanged in serial binary format.

8.3.2 Functional Description

8.3.2.1 DTE Operation

The V.35/306 DTE/DCE Data Interface converts the signal characteristics specified by the appropriate interface specifications to the TTL signals used by the FIREBERD.

In a 306-type system, the DCE supplies timing to the FIREBERD (DTE) on the SCT (Serial Clock Transmit) leads. When using the interface clock as a source of generator timing, the FIREBERD will generate SD (Send Data) and SCTE (Serial Clock Transmit External) coincident with the clock received on the SCT leads. When the FIREBERD's synthesizer is used as the timing source, the FIREBERD will ignore the SCT leads and generate SD and SCTE coincident with the selected internal rate.

In a V.35 or Data Service Unit (DSU) type of system, timing is supplied to the FIREBERD on the SCT leads in the same manner as the 306-type system. However, the V.35, DSU-type systems do not accept the SCTE signal from the FIREBERD. With the interface set for V.35 operation, the SCTE driver is disabled and the interface's generator clock should be used. (When the clock source is the synthesizer, data only will appear at the interface connector). In both the V.35 and 306 modes, data and clock are received for BER measurement on the RD (Receive Data) and the SCR (Serial Clock Receive) leads, respectively.

All clock and data drivers and receivers are high-speed, balanced V.35 type. All signaling drivers and receivers are single-ended RS-232 (CCITT V.28) type. RTS (Request to Send) and DTR (Data Terminal Ready) are controlled by FIREBERD front panel switches. DSR (Data Set Ready), RLSD (Received Line Signal Detector) and CTS (Clear to Send) are received and their status displayed on the front panel of the FIREBERD.

8.3.2.2 DCE Operation

The V.35/306 DTE/DCE Data Interface can easily be configured to look like DCE for testing of DTE by using an adaptor cable (included). When the adaptor cable is connected to the interface, configuration as DCE is done automatically. (A spare grounded pin in the interface cable tells the FIREBERD that it is being used as DCE.)

In a 306-type system, the FIREBERD (DCE) supplies timing to the DTE on the SCT leads. The DTE will return to the FIREBERD both SD and SCTE which may or may not be coincident with the clock on the SCT leads (depending upon the configuration of the DTE). The SD and SCTE signals are then translated to TTL and sent to the receiver section of the FIREBERD for analysis.

In a V.35 or DSU-type system, SCT is generated in the FIREBERD (DCE) as in the 306-type system. However, the DTE will not return timing on the SCTE leads. The DTE returns only SD to the FIREBERD coincident with the DCE-generated SCT. In the V.35 mode as DCE, the SCTE receiver is disabled.

In both the V.35 and 306 modes, the FIREBERD as DCE generates SCR and RD and sends them to the DTE.

All clock and data drivers and receivers are high-speed, balanced V.35 type. All signaling drivers and receivers are single-ended RS-232 (CCITT V.28) type. Two switches on the front panel of the FIREBERD allow the RLSD and DSR signals to be turned on and off in the DCE mode. DTR, RTS, and LT are received and their status displayed on the FIREBERD front panel. The DTE-generated RTS is tied directly back to the DTE-received CTS.

8.3.2.3 Timing Modes

Synchronous, asynchronous, or recovered timing can be used with this interface. With asynchronous timing, asynchronous data analysis can be performed at speeds to 20 kb/s. Recovered timing provides a clock derived from the received data transitions at speeds to 520 kb/s.

8.3.2.4 Self-Loop

The SELF LOOP switch on the front panel of the FIREBERD connects the transmit clock and data outputs to the receive clock and data inputs. User connections do not have to be removed to perform a loop test. The self-loop function tests the actual drivers and receivers that are used during normal operation.

8.3.2.5 Clock Polarity Control

Auxiliary Function 05 determines whether the FIREBERD or the interface has control of the transmit- and receive clock polarities. When the auxiliary function is set to F-BERD (default), clock polarities are controlled by Auxiliary Functions 01 and 02. In this case the clock invert switches on the interface are disabled, and the interface's NON-STANDARD TIMING indicator should be ignored. When Auxiliary Function 05 is set to INTF, the interface's clock invert switches are enabled.

8.3.3 Interface Switches and Indicators

TRANSMIT CLOCK INVERT Switch

As DTE, setting the TRANSMIT CLOCK INVERT switch to the INVERT position causes SD to be valid on the rising edge of the chosen clock source instead of the falling edge (normal). When the switch is in the INVERT position as DCE, the FIREBERD expects valid SD on the rising edge of the SCTE for 306 mode, or SCT if V.35 mode is chosen.

RECEIVE CLOCK INVERT Switch

As DTE, setting the RECEIVE CLOCK INVERT switch to the INVERT position causes the FIREBERD to expect valid data (RD) on the rising edge of the SCR clock instead of the falling edge (normal). As DCE, setting this switch to the INVERT position causes the FIREBERD to generate valid data (RD) on the rising edge of SCR.

NON-STANDARD TIMING Indicator

This indicator is illuminated when either of the interface's clock invert switches are set to the INVERT position. When Auxiliary Function 05 is set to F-BERD, this indicator should be ignored.

8.3.4 Specifications

8.3.4.1 General

Maximum speed (306 mode):	• 15 MHz.
Maximum speed (V.35 mode):	• Cable length dependent.
Delay SCT to SD:	• approximately 70 ns typical.
Skew SCTE to SD:	• approximately 20 ns typical.

8.3.4.2 Balanced Drivers

Signal swing (Bipolar):	• ±.55V ±.1 into 100 ohms.
Short circuit current:	• less than 100 mA.
Rise Time:	• less than 20 ns.
Generator Impedance:	• 100 ohms.

8.3.4.3 Balanced Receivers

Load resistance:	• 100 ohms.

8.3.4.4 Unbalanced Drivers (RS-232)

Rise time:	• greater than 20 microseconds.
Generator Impedance:	• less than 100 ohms.
Short circuit current:	• less than 100 mA.
Output level (7K Load):	• ± 10 volts typical.

8.3.4.5 Unbalanced Receivers

Load Impedance:	• 3K to 7K ohms.
Maximum input voltage:	• ± 25 volts.

8.3.4.6 Polarity

Data Polarity:	• Mark (binary 1): "A" lead negative with respect to "B" lead. • Space (binary 0): "A" lead positive with respect to "B" lead.
Signaling Polarity:	• On: greater than +3 volts. • Off: open or less than -3 volts.

Table 8-2
V.35/306 DTE/DCE Connector Pin Assignments

PIN	CIRCUIT	V.35/306 DESCRIPTION	COMMENT*
A	AA	Protective Ground	internally connected to B
B	AB	Signal Ground	internally connected to A
C	CA	Request to Send	output
D	CB	Clear to Send	input
E	CC	Data Set Ready	input
F	CF	Received Line Signal Detector	input
H	CD	Data Terminal Ready	output
J	CE	Ring Indicator	open
K	—	Local Test	open
R	RD (A)	Received Data	input
T	RD (B)	Received Data	input
V	SCR (A)	Serial Clock Receive	input
X	SCR (B)	Serial Clock Receive	input
P	SD (A)	Send Data	output
S	SD (B)	Send Data	output
U	SCTE (A)	Serial Clock Transmit External	output
W	SCTE (B)	Serial Clock Transmit External	output
Y	SCT (A)	Serial Clock Transmit	input
AA or a	SCT (B)	Serial Clock Transmit	input
BB	SCT (A) (DCE mode only)	Spare	output (disabled in DTE mode)
Z	SCT (B) (DCE mode only)	Spare	output (disabled in DTE mode)
EE	GND	Spare	internally connected to B
CC	DTE/DCE	Spare	connected to B in DCE mode

* Comments refer to Interface Panel Connector and are applicable for DTE operation only.

Table 8-3
Cross-Reference for Connector Pin Lettering

MIL. SPEC. C-22857-C Connector	Commercial Connector
A	A
B	B
C	C
D	D
E	E
F	F
H	H
J	J
K	K
L	L
M	M
N	N
P	P
R	R
S	S
T	T
U	U
V	V
W	W
X	X
Y	Y
Z	Z
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DD	d
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HH	h
JJ	i
KK	j
LL	k
MM	m
NN	n

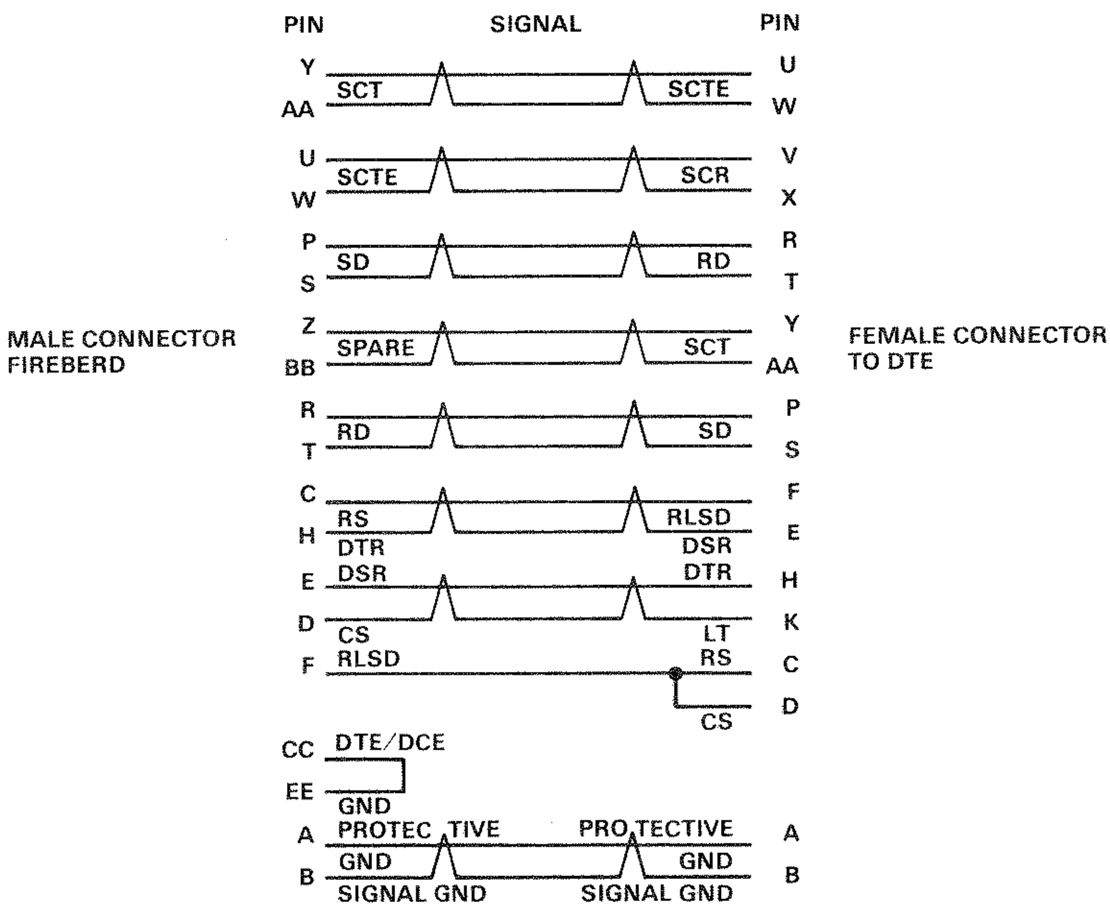
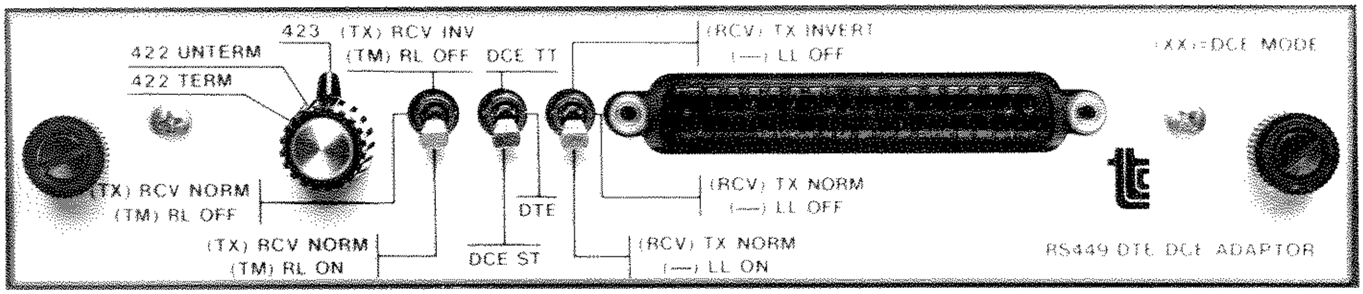


Figure 8-2
V.35/306 DTE to DCE Adaptor Cable FIREBERD

8.4 RS-449 DTE/DCE DATA INTERFACE (Model 40200)



8.4.1 Introduction

The RS-449 DTE/DCE Data Interface is designed in accordance with EIA RS-449, CCITT V.10 and V.11, and ISO 4902-1980. This interface enables a FIREBERD to act as data terminal equipment (DTE) for use in testing data communications equipment (DCE). With the use of an adaptor cable (included) the FIREBERD can be configured as DCE. The data is exchanged in a serial binary format. The RS-449 Specification describes two categories of signals: Category 1 and Category 2. The specification (and the interface) allow Category 1 circuits to be implemented with either RS-422-A/V.11 (balanced) or RS-423-A/V.10 (unbalanced) drivers and receivers. All Category 2 circuits are implemented with RS-423-A/V.10 drivers and receivers.

The RS-449 DTE/DCE Data Interface converts signals with characteristics specified by the RS-449 interface specification to the TTL signals used by the FIREBERD.

8.4.2 Functional Description

8.4.2.1 DTE Operation

In a typical RS-449 circuit, the DCE supplies timing to the FIREBERD (DTE) on the ST (Send Timing) leads. Depending on the setting of the GEN CLK switch, the FIREBERD will generate SD (Send Data) and TT (Terminal Timing) coincident with the clock received on the ST leads or will ignore the ST leads and generate SD and TT using the BNC input or the synthesizer as the source of generator timing. Data and clock are received on the RD (Receive Data) and RT (Receive Timing) leads for analysis.

Two switches on the FIREBERD front panel allow RS (Request to Send) and TR (Terminal Ready) to be turned on and off. CS (Clear to Send), RR (Receiver Ready), and DM (Data Mode) are received and their status displayed on the front panel of the FIREBERD.

8.4.2.2 DCE Operation

The FIREBERD RS-449 DCE/DTE Data Interface can easily be configured to look like DCE for testing of DTE by using an adaptor cable (included).

In a typical RS-449 circuit, the FIREBERD (DCE) supplies timing to the DTE on the ST (Send Timing) leads. The DTE will return to the FIREBERD both SD (Send Data) and TT (Terminal Timing). Two DCE modes are selectable on the interface panel: DCE TT and DCE ST. In the DCE TT mode, SD and TT are sent to the receive section of the FIREBERD for analysis. In the DCE ST mode, SD and the internally generated ST are sent to the receive section of FIREBERD for analysis. Depending on the position of the GEN CLK switch, RD (Receive Data) and RT (Receive Timing) will be generated coincident with TT (Terminal Timing) from the DTE, or will be generated using the BNC input or the internal synthesizer as the source of timing.

At the DTE end of the adaptor cable, CS (Clear to Send) is tied directly to RS (Request to Send). Two switches on the front panel of the FIREBERD allow RR (Receiver Ready) and DM (Data Mode) to be turned on and off. TR (Terminal Ready), RS (Request to Send), LL (Local Loopback), and RL (Remote Loopback) are received and their status displayed on the front panel of the FIREBERD.

8.4.2.3 Timing Modes

Synchronous, asynchronous, or recovered timing can be used with this interface. With asynchronous timing, asynchronous data analysis can be performed at speeds to 20 kb/s. Operation with RS-423/V.10 drivers and receivers is limited to 130 kb/s with synchronous and recovered timing. With RS-422/V.11 drivers and receivers, operation at speeds to 520 kb/s with recovered timing and 15 Mb/s with synchronous timing is possible.

8.4.2.4 Self-Loop

The SELF LOOP switch on the front panel of the FIREBERD activates interface relays to connect the clock and data drivers to the clock and data receivers. User connections do not have to be removed during a self-loop test. The self-loop function tests actual drivers and receivers that are used during normal operation.

8.4.2.5 Clock Polarity Control

Auxiliary Function 05 determines whether the FIREBERD or the interface has control of the transmit- and receive-clock polarities. In DTE operation, setting the auxiliary function to F-BERD (default) allows Auxiliary Functions 01 and 02 to control the clock polarities, and the two clock invert switches on the interface control only LL (Local Loopback) and RL (Remote Loopback). If Auxiliary Function 05 is set to INTF, the two interface switches become enabled. When the auxiliary function is set to F-BERD in DCE operation, the interface's TRANSMIT CLOCK INVERT switch controls only TM (Test Mode), and the RECEIVE CLOCK INVERT switch is disabled. When the auxiliary function is set to INTF, the interface's two clock invert switches are enabled.

8.4.3 Interface Switches

TRANSMIT CLOCK INVERT Switch

As DTE, setting the TRANSMIT CLOCK INVERT switch to the INV (up) position causes SD to be valid on the rising edge of the selected clock source instead of the falling edge (normal, middle position). By setting the switch down, the transmit clock is unaffected and LL is turned on. As DCE, setting the TRANSMIT CLOCK INVERT switch to the INV (up) position causes the FIREBERD to expect valid SD on the rising edge of the selected clock source instead of the falling edge (normal, middle position). Setting the switch down turns on TM with no inversion of the clock.

RECEIVE CLOCK INVERT Switch

As DTE, setting the RECEIVE CLOCK INVERT switch to the INV (up) position causes the FIREBERD to expect valid RD on the rising edge of the RT clock instead of the falling edge (normal-middle position). Setting the switch down causes the receive clock to be unaffected, and RL is turned on. As DCE, setting the RECEIVE CLOCK INVERT switch to the INV (up) position causes the FIREBERD to generate valid RD on the rising edge of the RT clock instead of the falling edge (normal-middle position). In DCE operation, this switch has no secondary function.

8.4.4 Specifications

8.4.4.1 RS-449 Category 1 Circuits (RS-423/RS422 TERM/RS-422 UNTERM):

- Send Data (SD).
- Receive Data (RD).
- Terminal Timing (TT).
- Send Timing (ST).
- Receive Timing (RT).
- Request to Send (RTS).
- Clear to Send (CTS).
- Receiver Ready (RR).
- Terminal Ready (TR).
- Data Mode (DM).

8.4.4.2 RS-449 Category 2 Circuits (RS-423/V.10 only):

- Local Loopback (LL).
- Remote Loopback (RL).
- Test Mode (TM).

8.4.4.3 RS-422/V.11 Data Mark (binary 1), Control Lead OFF:

- Lead (A) more negative than Lead (B).

8.4.4.4 RS-422/V.11 Data Space (binary 0), Control Lead ON:

- Lead (A) more positive than Lead (B).

8.4.4.5 RS-423/V.10 Data Mark (binary 1), Control Lead OFF:

- Negative polarity.

8.4.4.6 RS-423/V.10 Data Space (binary 0), Control Lead ON:

- Positive polarity.

8.4.4.7 RS-422/V.11 Line Drivers

Output differential voltage:	• 2.0 volts minimum with 100-ohm load.
Short circuit current:	• 150 mA maximum.
Output rise time:	• 20 ns maximum.

8.4.4.8 RS-423/V.11 Line Drivers

Output voltage:	• ±3.5 volts minimum with 450-ohm load.
Short circuit current:	• 150 mA maximum.
Output rise time:	• 1 microsecond typical (Model 40200-01). • 4 microseconds typical (Model 40200-02).

8.4.4.9 RS-422/V.11 Terminated Line Receivers

Load impedance:	• 100 ohms ±10%.
Differential input threshold voltage:	• ±0.25 volts.

8.4.4.10 RS-422/V.11 Unterminated Line Receivers

Load impedance:	• 2000 ohms minimum.
Differential input threshold voltage:	• ±0.25 volts.

8.4.4.11 RS-423/V.10 Receivers

Load impedance:	• 2000 ohms minimum.
Input threshold voltage:	• ±0.25 volts.

Table 8-4
RS-449 DTE/DCE
Connector Pin Assignments

PIN	CIRCUIT	449 DESCRIPTION	COMMENT*
1	SHIELD	Ground	internally connected to 20, 37, 19
2	SI	Signaling Rate Indicator	open
3	SPARE	Spare	ST (DCE only)
4	SD (A)	Send Data	output
5	ST (A)	Send Timing	input
6	RD (A)	Receive Data	input
7	RS (A)	Request To Send	output
8	RT (A)	Receive Timing	input
9	CS (A)	Clear To Send	input
10	LL	Local Loopback	423 output
11	DM (A)	Data Mode	input
12	TR (A)	Terminal Ready	output tied ON
13	RR (A)	Receiver Ready	input
14	RL	Remote Loopback	423 output
15	IC	Incoming Call	open
16	SF/SR	Select Frequency/Signaling Rate Selector	open
17	TT (A)	Terminal Timing	output
18	TM	Test Mode	input
19	SG	Signal Ground	
20	RC	Receive Common	
21	SPARE	Spare	ST (DCE only)
22	SD (B)	Send Data	output
23	ST (B)	Send Timing	input
24	RD (B)	Receive Data	input
25	RS (B)	Request To Send	output
26	RT (B)	Receive Timing	input
27	CS (B)	Clear To Send	input
28	IS	Terminal in Service	open
29	DM (B)	Data Mode	input
30	TR (B)	Terminal Ready	output tied ON
31	RR (B)	Receiver Ready	input
32	SS	Select Standby	open
33	SQ	Signal Quality	open
34	NS	New Signal	open
35	TT (B)	Terminal Timing	output
36	SB	Standby Indicator	open
37	SC	Send Common	

* Comments refer to Interface Panel Connector and are applicable for DTE operation only.

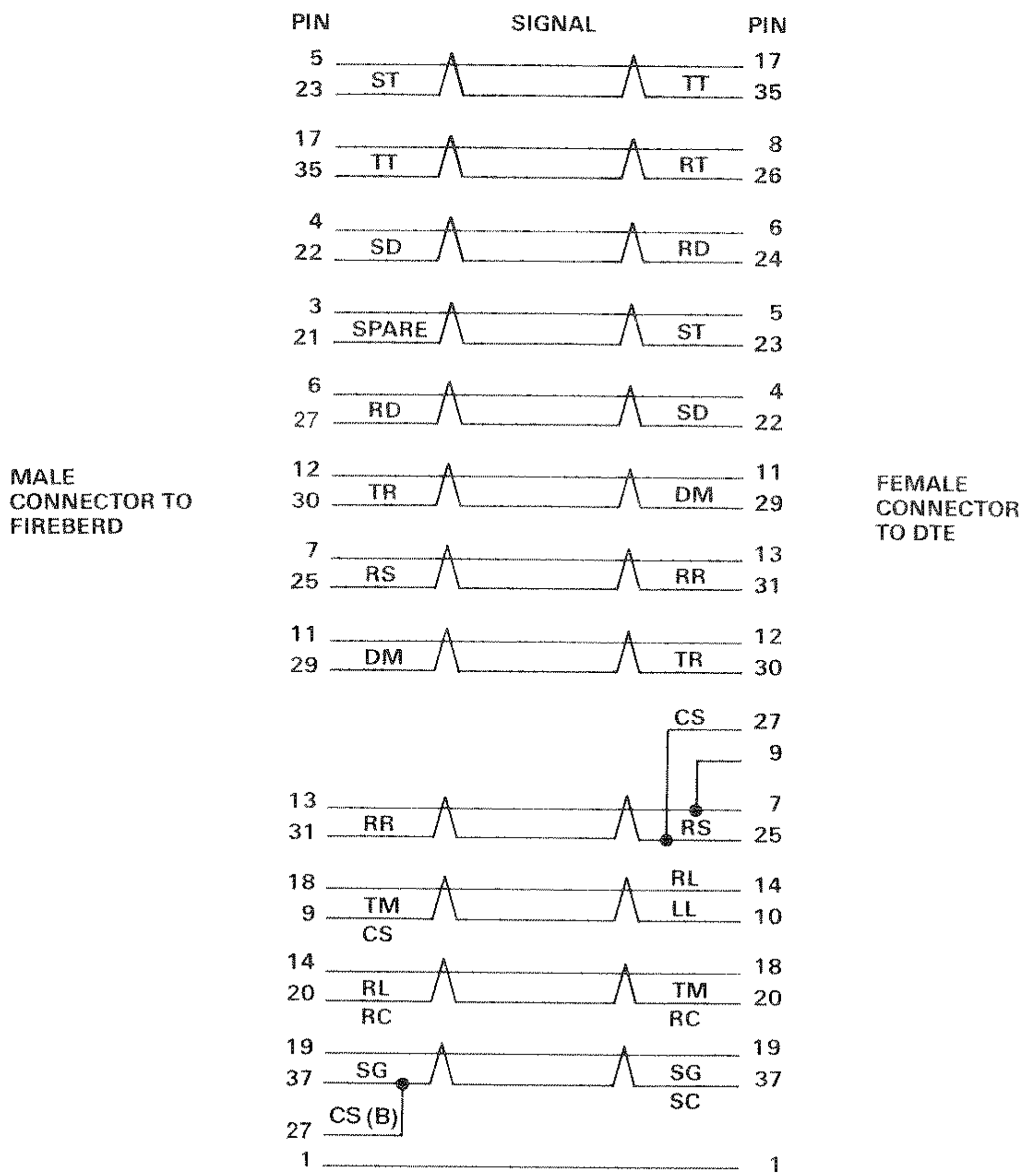
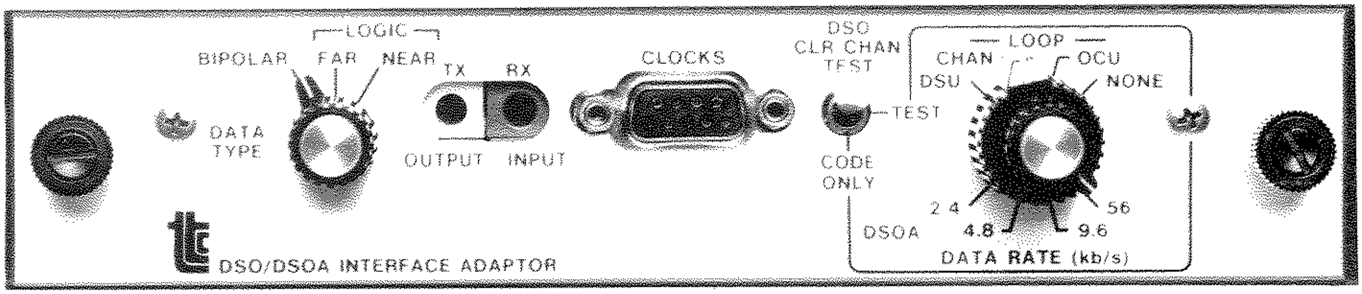


Figure 8-3
DCE Cable for RS-449 Interface

8.5 DS0/DS0A DATA INTERFACE (Model 30481)



8.5.1 Introduction

Designed to expand the capabilities of the FIREBERD for testing and maintenance of the digital data system, the DS0/DS0A Data Interface transmits and receives DS0 signals at the 64 kb/s synchronous data rate. The interface may be used to perform straightaway and loopback tests for 2.4, 4.8, 9.6, or 56 kb/s DS0A circuits. In addition, 64 kb/s channel testing may also be performed. Loopbacks may be generated for data service units (DSU), channel service units (CHAN), and office channel units (OCU).

Circuitry within the DS0/DS0A Data Interface terminates the 64 kHz and 8 kHz office clocks for synchronizing both the transmitter and receiver of the FIREBERD test set. The selected loop codes and pseudorandom data are output in bipolar or logic level formats for testing at any central office access point.

When equipped with a DS0/DS0A Data Interface, the FIREBERD is compatible with all FIREBERD models; it is also compatible with KS-type test sets. Included with the interface adaptor is a 9-pin D to 5-pin office adaptor cable, and several other adaptor cables are available for connecting the interface adaptor to a variety of central office equipment.

8.5.2 Functional Description

The DS0/DS0A Data Interface contains circuitry which accepts the 64 kHz and 8 kHz office clocks. Clocks may be received in either balanced or logic level formats. Clock format is determined by the adaptor cable used.

The interface transmits and receives data in three formats: logic far, logic near, or bipolar. Logic near causes transmission and reception on the connector tip; logic far causes tranmission and reception on the connector ring. When set to either logic format, the interface both transmits and receives at +5V and 0V levels.

When set to bipolar, the interface transmits at 5V bipolar levels and receives at 3.5 to 5.5 bipolar levels. Signals are non-return-to-zero (NRZ) with alternate mark inversion (AMI) coding. The receiver circuit will place a 135-ohm termination on the RX INPUT when the receiver sleeve is grounded in bipolar mode. When the sleeve is open, the RX INPUT presents a high impedance load. The DTR signaling indicator will light when the receiver input is terminated.

8.5.2.1 DS0 Clear Channel Testing

The interface may be used to test an entire 64 kb/s channel by using the DS0 Clear Channel mode. In this mode all 8 bits of each byte carry pseudorandom data. If the channel has 64 kb/s clear channel capability, any FIREBERD pattern may be used. If clear channel capability is not present, the 63, MARK, 1:1, or any programmable pattern with no more than seven consecutive zeros may be used.

8.5.2.2 DS0A Testing

The interface may also be used to test DS0A channels at four different customer data rates; 2.4 kb/s, 4.8 kb/s, 9.6 kb/s, and 56 kb/s. At subrates, bytes are repeated 20, 10, or 5 times. At 56 kb/s no bytes are repeated.

When used in the DS0A mode, loopback codes may be generated for DSU, CHAN, and OCU loopback testing. A momentary CODE ONLY function initiates the loopback by transmitting continous loop codes with no pseudorandom data. To maintain the loopback, loopback codes are transmitted alternating with pseudorandom data. For straightaway testing, pseudorandom data may be transmitted with no loop codes. If the CODE ONLY function is used with no loop code (NONE) selected, continuous Idle code is generated.

8.5.2.3 Self-Loop

The SELF LOOP switch on the FIREBERD front panel activates a relay in the interface which connects the TX OUTPUT to the RX INPUT. This allows the operation of the FIREBERD and the interface to be verified. The data cables need not be removed as the relay also isolates the input and output connectors. To perform a self-loop test, bit and byte clocks must be provided just as in normal operation. Self-loop testing may be performed in Clear Channel or DS0A modes and in bipolar data format or either of the logic data formats. When in DS0A mode, self-loop testing may be performed at any data rate, and straightaway (NONE) or CHAN loop codes may be selected.

8.5.3 Interface Setup

All functions of the DS0/DS0A Data Interface may be controlled by switches on the FIREBERD 6000 front panel. This is accomplished by using the FIREBERD's INTF SETUP function, which is described below. The switches on the interface are disabled when the FIREBERD is in control. If desired, the interface may be controlled through its own switches by using Auxiliary Function 05. When the auxiliary function is set to INTF, the interface operates exactly as it would in a FIREBERD 1500A or 2000. For information on DS0/DS0A Data Interface operation with the FIREBERD 1500A or 2000, refer to the DS0/DS0A Operating Manual (ML 10633).

When the DS0/DS0A Data Interface is installed in the FIREBERD 6000 and is to be controlled through the FIREBERD front panel, the MENU pushbutton switch should be pressed to select the INTF SETUP function. Two selections will then appear in the display: INT232 and DS0. Pressing the DS0 soft key selects the DS0/DS0A data interface. After DS0 has been selected, two more selections appear in the display: CLR CH and DS0A. The CLR CH selection is used only for clear channel testing; pseudorandom data will appear on the entire 64 kb/s channel and no loop codes will be transmitted or received. The DS0A selection will lead to further selections for data type, loop codes, and data rates. Figure 8-4 shows the DS0/DS0A interface menu tree. Described below are the choices available under the DATA, LOOP, and RATE selections.

DATA:

(1) BIPOL -When selected, the interface adaptor transmits at 5V bipolar levels and receives at 3.5 to 5.5V bipolar levels. Signals are NRZ with AMI coding.
(2) L NEAR - When selected, the interface adaptor both transmits and receives at +5V and 0V levels on tip only.
(3) L FAR -When selected, the interface adaptor both transmits and receives at +5V and 0V levels on ring only.

LOOP:

(1) DSU - This selection is for loopback at the customer's DSU.
(2) CHAN -This selection is for loopback at the customer's end of the local loop.
(3) OCU -This selection is for loopback at the office end of the local loop.
(4) NONE - This selection is for straightaway testing. No loopback codes are transmitted or received.

RATE:

The RATE selections specify the customer data rate.

(1) 2.4 kb/s— This selection will cause each byte to be repeated 20 times.
(2) 4.8 kb/s— This selection will cause each byte to be repeated 10 times.
(3) 9.6 kb/s— This selection will cause each byte to be repeated 5 times.
(4) 56 kb/s — This selection will not cause any byte repetitions.

Once the bottom of any branch of the DS0A menu is reached, a CODE selection will appear in the display. When the soft key beneath this selection is pressed, the interface adaptor transmits the selected loop code continually for approximately 1 second, with no pseudorandom data. If no loop code is selected, Idle code will be transmitted while the CODE soft key is held in the depressed position.

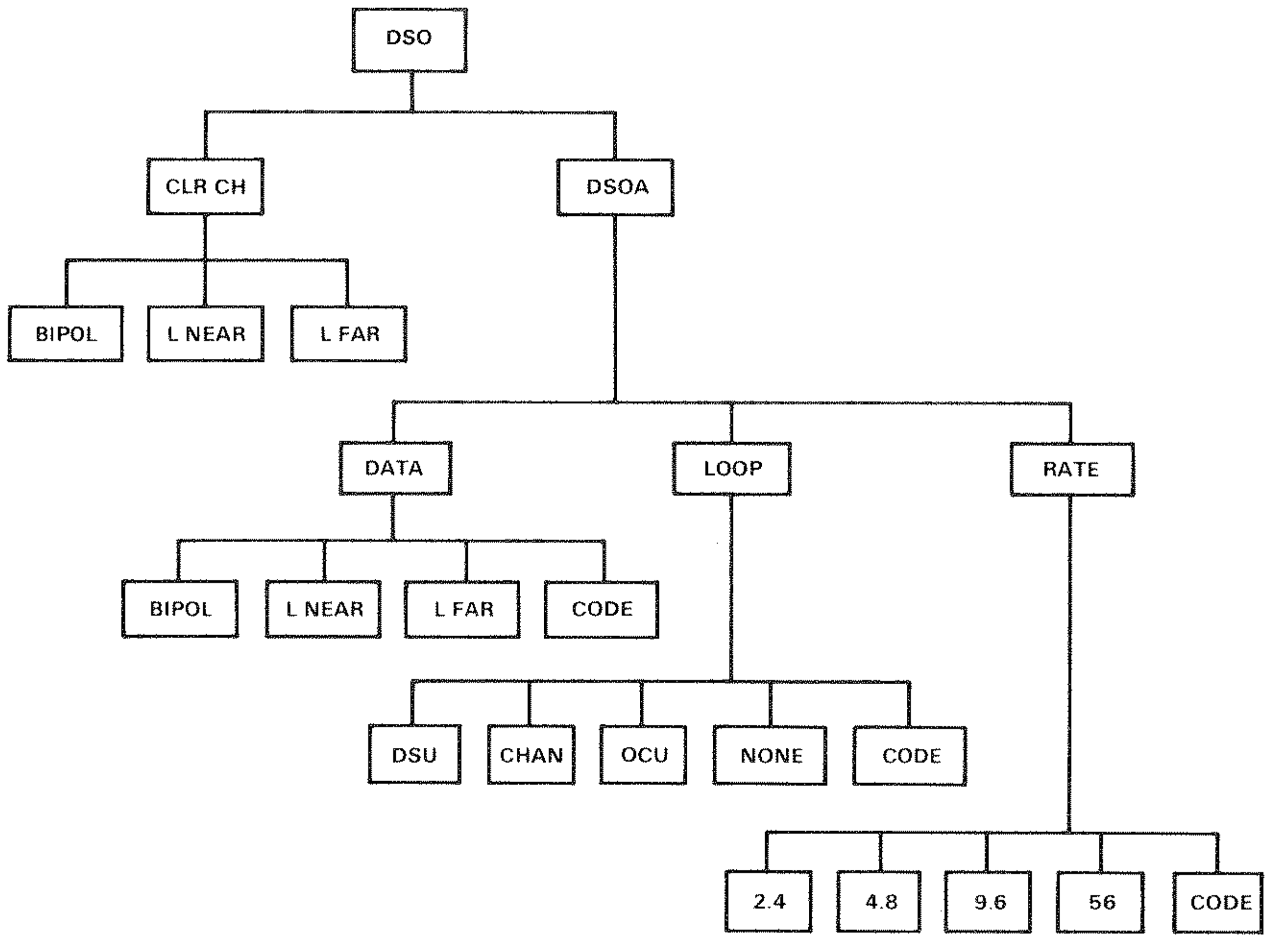


Figure 8-4
DS0/DS0A Interface Menu Tree

8.5.4 Interface Signaling Options

The DS0/DS0A Data Interface has three signaling options that affect indicators on the FIREBERD front panel. A fourth option, the CODE ONLY option, is not functional with the FIREBERD 6000. A four-position DIP switch located at the rear of the interface adaptor controls the options. The interface adaptor is shipped from the factory with the three signaling options enabled. The following instructions describe how to change the option selection.

(1) BIT 8 - The (LL) signaling indicator will show the level of bit 8 of each byte received. To disable this option, set switch 1 up (away from the switch number). To re-enable this option, set switch 1 down (toward the switch number).

(2) TERMINATED - The DTR signaling indicator will light when the receiver input is terminated. To disable this option, set switch 2 up (away from the switch number). To re-enable this option, set switch 2 down (toward the switch number).

(3) LOOPBACK ACHIEVED - The RTS signaling indicator will light when returning loopback codes have been received. To disable this option, set switch 3 up (away from the switch number). To re-enable this option, set switch 3 down (toward the switch number).

8.5.5 FIREBERD Switches and Indicators

GEN CLK Switch

When using the DS0/DS0A Data Interface, the FIREBERD's GEN CLK switch must be set to the INTF position.

TIMING Switch

The FIREBERD's TIMING switch will not be illuminated because the only applicable position is SYNC.

MK (Mark) and SP (Space) Indicators

Whenever the RX INPUT signal is a logical one, the MK indicator will be illuminated. Whenever the RX INPUT signal is a logical zero, the SP indicator will be illuminated. These indicators will respond to received loopcodes, control and framing bits, as well as data bits. Under normal conditions, both indicators will be illuminated.

(LL) Indicator

The (LL) signaling indicator will show the level of bit 8 of each byte received. This indicator will be illuminated when bit 8 is a one, which signifies that the channel is carrying data. When the channel is not carrying data, bit 8 will be a 0 and the (LL) indicator will remain dark.

DTR Indicator

The DTR signaling indicator will be illuminated when the receiver input is terminated.

RTS Indicator

The RTS signaling indicator will be illuminated when returning loopback codes are received.

8.5.6 Data-Clock Test Points

This section describes the phase relationship between the DS0/DS0A Data Interface's data and clock signals and the FIREBERD's rear panel test points.

RCVR DATA: The signal at this test point will be high when the received data is a logical high. The signal will be low when the received data level is a logical low. All data appearing at the RX INPUT will also appear at this test point, includng loopback codes, control, framing, and redundant data bits.

RCVR CLK: This test point provides a TTL clock signal phased so that the rising edge occurs at the midpoint of each received data bit. This signal will be inactive during loopback codes, control, framing, and redundant bits; it will be active only when pattern data is being clocked into the FIREBERD.

GEN DATA: The signal at this test point will be greater than 2.5V when the transmitted data is at a logical high. The signal will be less than 0.4V when the transmitted data is at a logical low. This signal will be inactive during loopback codes, control, framing, and redundant data bits; it is active only when pseudorandom data is being clocked out of the FIREBERD.

GEN CLK: The signal at this test point provides a TTL clock signal phased so that the rising edge occurs at the midpoint of each transmitted data bit. This signal will be inactive during loopback codes, control, framing, and redundant data bits; it is active only when pseudorandom data is being clocked out of the FIREBERD.

8.5.7 Specifications

8.5.7.1 Bipolar Input Specifications

Input Connection:	• Bantam jack, color coded red.
Input Impedance, Bipolar Terminated:	• 130 ohms ±5%.
Input Impedance, Bipolar Unterminated:	• 1000 ohms or greater.
Operating Signal Level:	• 3.5 to 5.5 volts peak.
Cable Length:	• 1500 feet of 24 gauge maximum.

8.5.7.2 Bipolar Output Specifications

Output Connection:	• Bantam jack, color coded white.
Test Load Impedance:	• 135 ohms resistive.
"Zero" Output Level:	• 0.7 volts maximum.
Pulse Amplitude:	• 5.0 ±0.5 volts with a maximum imbalance of ±0.25 volts.
Half Amplitude Pulse Width:	• 15.6 ±0.5 microseconds with a maximum imbalance of ±0.7 microseconds.
Rise and Fall Times:	• 0.5 microseconds maximum.
Data Format:	• Alternate Mark Inversion, Non Return to Zero.

8.5.7.3 Logic Data Input

Input Connection:	• Bantam jack, color coded red.
High Level Input Voltage:	• 1.6 volts minimum.
Low Level Input Voltage:	• 0.9 volts maximum.
High Level Input Current:	• 1mA maximum at 5.0 volts.
Low Level Output Current:	• 1mA maximum at 0.7 volts.

8.5.7.4 Logic Data Output

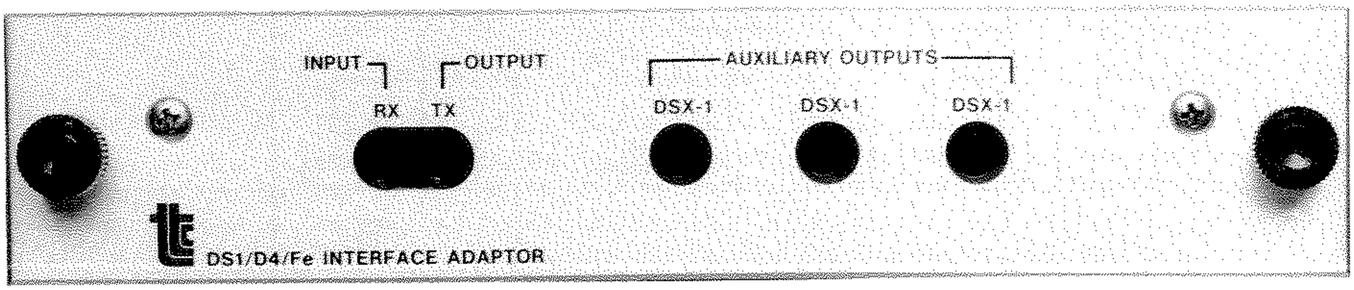
Output Connection:	• Bantam jack, color coded white.
High Level Output:	• 3.5 volts minimum for output current less than 1 mA.
Low Level Output:	• 0.7 volts maximum for input current less than 10 mA.
Data Format Near:	• Data transmitted on tip only.
Data Format Far:	• Data transmitted on ring only.

8.5.7.5 Data and Code Capabilities

Any data pattern offered by the FIREBERD may be transmitted and received.

Codes Transmitted:	• OCU loopback code. • CHAN loopback code. • DSU loopback code. • IDLE code.
Data Rates:	• 2.4 kb/s. • 4.8 kb/s. • 9.6 kb/s. • 56 kb/s. • 64 kb/s.

8.6 DS1/D4/Fe DATA INTERFACE (Model 40460)



8.6.1 Introduction

The DS1/D4/Fe Data Interface allows the FIREBERD to test communications systems that use the Bell System T1 (DS1) 1.544 Mb/s Digital Channel Service and similar systems. The T1 signals are serial, differential return-to-zero (RZ) pulses with alternate mark inversion (AMI) or bipolar with eight zero substitution (B8ZS) coding. The data interface will operate with either framed data, required by Digital Access Crossconnect Switches (DACS) and channel banks, or with unframed data as used in unswitched networks.

8.6.2 Functional Description

The interface panel has five bantam jacks: a primary output, three secondary outputs, and the receiver input. Each of the four outputs is capable of sourcing DSX level signals; the primary output also has selectable line build-out. A simplex current path is also provided between the primary output and the receiver input.

8.6.2.1 Timing Sources

Three transmit timing sources can be selected: (1) the clock recovered by the interface from the incoming T1 signal; (2) the synthesizer clock, which can provide an internal timing reference at or around 1.544 MHz; or (3) the external BNC input. Timing selection is made by using the GEN CLK switch on the FIREBERD front panel.

8.6.2.2 Self-Loop

The data interface includes a relay which is activated by the SELF LOOP switch on the FIREBERD's front panel. In Self-Loop mode, the primary T1 line driver is connected to the T1 line receiver. This provides quick verification of the FIREBERD and its data interface when performing bit error detection. The input and primary output connections need not be removed during the test because complete isolation is provided by the relay; the secondary outputs are unaffected by Self-Loop mode. Note that the FIREBERD's GEN CLK switch should not be set to the INTF position in Self-Loop mode and Thru mode should be off.

8.6.3 Interface Setup

The DS1/D4/Fe Data Interface is controlled through the FIREBERD front panel. After installation, the interface is enabled by using the MENU pushbutton switch to select the INTF SETUP function; when a selection menu appears in the display, the soft key beneath the DS1/Fe selection should be pressed. A new menu with seven categories will then appear in the display. The DS1/D4/Fe menu tree is shown in Figure 8-5. The seven main menu selections and their sub-selections are described below.

int 232 DS1/Fe

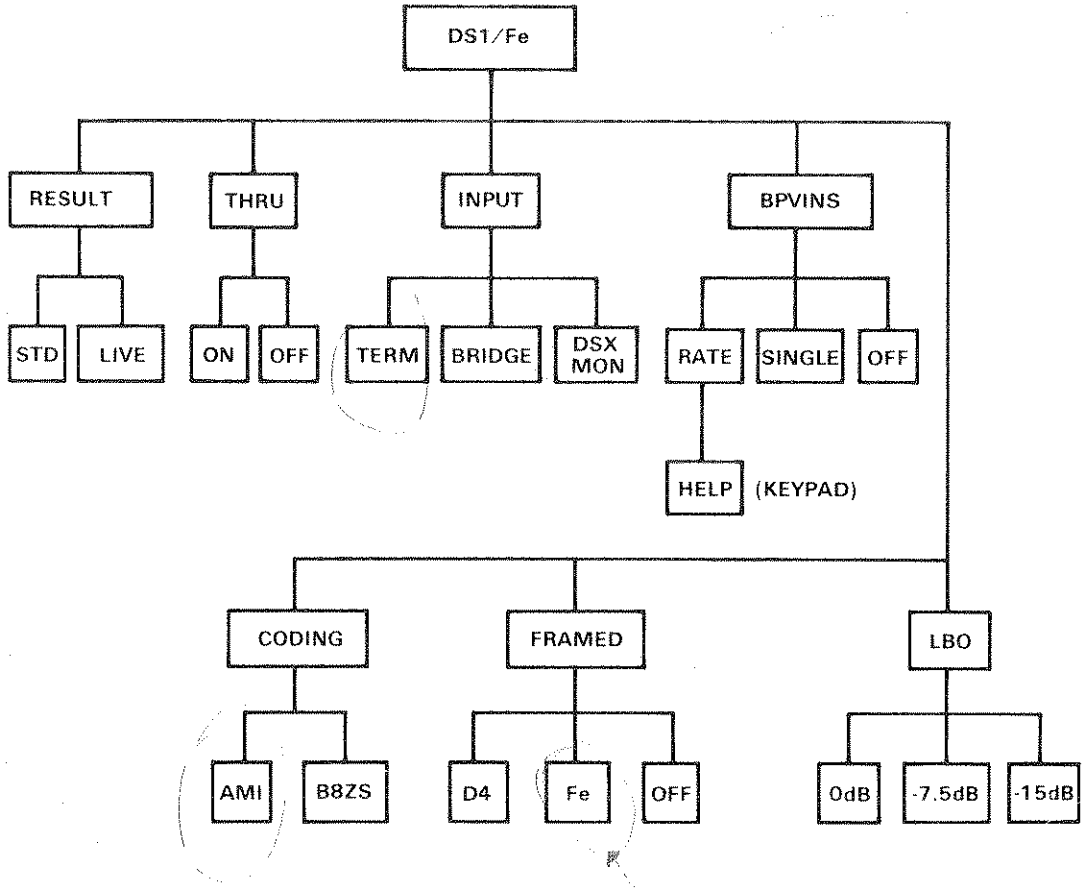


Figure 8-5
DS1/D4/Fe Interface Menu Tree

RESULT:

The RESULT category allows selection of standard or live traffic results (standard and live results are described in Section 5).

(1) STD (default)— Selects standard analysis results. Bit error, bipolar violation, framing error, and CRC error analysis are performed during the time in which bit error analysis is performed. Framing error analysis is only performed when this selection is combined with the FRAMED/D4 selection. CRC error analysis is only performed when this selection is combined with the FRAMED/Fe selection.

(2) LIVE— Selects live traffic analysis results. Bit error analysis is not performed; bipolar violation, framing error, and CRC error analysis are performed during the time in which the signal is present. Framing error analysis is only performed when this selection is combined with the FRAMED/D4 selection. CRC error analysis is only performed when this selection is combined with the FRAMED/Fe selection.

THRU:

(1) OFF (default)— Selects the normal operation of the interface in which the received data is analyzed by the data receiver of the FIREBERD and transmit data is generated by the data generator of the FIREBERD.

(2) ON— This selection causes the interface to act as a repeater. All data received will be echoed unchanged on the transmitter output. This setting can be used to emulate a CSU in line loopback mode. The received signal is still analyzed by the FIREBERD's data receiver. Note that the ON selection disables the BPVINS and CODING sections of the menu; the data is not re-encoded prior to transmission.

INPUT:

(1) TERM (default)— Selects normal operation in which the input is terminated by 100 ohms and will accept a T1 signal attenuated by 0 dB to 24 dB of cable attenuation.

(2) BRIDGE— This selection allows monitoring of T1 lines which are already terminated. In this mode, the input will exhibit an impedance greater than 1000 ohms, accepting signals attenuated by 0 dB to 24 dB of cable attenuation.

(3) DSX-MON— This selection conditions the receiver to operate with signals from DSX-Monitor ports. In this mode, the input accepts T1 signals resistively attenuated by 10 dB to 30 dB, and terminates the line with 100 ohms.

BPVINS:

(1) OFF (default)— Selects the normal mode of operation in which no BPVs are transmitted.

(2) SINGLE— This selection allows the insertion of a single BPV each time the soft key beneath SINGLE is pressed.

(3) RATE— This selection cause the insertion of bipolar violations at a user-selectable rate ranging from 1E-9 to 9E-3. To change the BPV insertion rate, press the RATE soft key. The cursor will be positioned under the mantissa; a new mantissa, from 1 to 9, may be entered. Once a number has been entered, the display will change to SET BPV RATE to indicate that a new rate is being entered, and the cursor will move to the exponent. A new exponent, from 3 to 9, may be entered. The new rate is selected by pressing the ENTER key; the previously selected rate will continue to be transmitted until the ENTER key is pressed.

NOTE: The synthesizer frequency must be set to 1544 kHz; any other setting causes the insertion rate to be inaccurate.

CODING:

(1) AMI (default)— This selection allows Alternate Mark Inversion (AMI) coding. AMI is encoded by transmitting a pulse of alternating polarity for every one (Mark) and no pulse for every zero (Space).

(2) B8ZS— This selection allows Bipolar with 8 Zero Substitution (B8ZS) coding, which also transmits a pulse of alternating polarity for every one and no pulse for every zero, except that strings containing eight consecutive zeros are replaced by a zero substitution code. In this case, the eight-zero sequence is replaced by 00V10V1, where 0 represents a Space, 1 represents a Mark, and V represents a bipolar violation (consecutive pulses of the same polarity). The B8ZS decoder will restore a detected B8ZS pattern to the original eight zeros.

FRAMED:

(1) OFF (default)— This selection (unframed data) performs data analysis on the full 1.544 Mb/s bandwidth of the T1 line; no framing bits are added upon transmission, and no data bits are stripped upon reception.

(2) D4— This selection allows the FIREBERD to transmit and analyze T1 signals with D4 (Superframe) framing. D4 framing occupies 8 kb/s of the 1544 kb/s bandwidth; the selected data pattern occupies the remaining 1536 kb/s. The D4 framing pattern is compatible with D1D, D2, D3, and D4 channel banks. When Live analysis mode is selected, both the Fs and Ft framing bits are examined for errors.

(3) Fe— This selection allows the FIREBERD to transmit and analyze T1 signals with Fe (Extended Superframe) framing. With Fe framed signals, the framing pattern occupies 2 kb/s, the CRC check bits occupy 2 kb/s, and a data link occupies 4 kb/s; the selected data pattern occupies the remaining 1536 kb/s. The data link is transmitted with an all-ones pattern and is examined only for the presence of a Yellow Alarm signal.

NOTE: In the D4 and Fe framing modes, receiver frequency measurements are available only when the data interface is in continuous frame sync to the incoming data. In the case of intermittent frame sync or no frame sync at all (e.g., unframed data), receiver frequency measurements may be obtained by setting FRAMED to OFF in the interface setup menu.

LBO:

(1) 0 dB (default)— This selection sets the primary output to the DSX level with no line build-out (0 dB attenuation).

(2) -7.5 dB— This selection provides a -7.5 dB line build-out, attenuating the primary output with 7.5 dB of simulated cable loss.

(3) -15 dB— This selection provides a -15 dB line build-out, attenuating the primary output with 15 dB of simulated cable loss.

8.6.4 FIREBERD Indicators

MK (Mark) and SP (Space) Indicators

An input signal consisting of a continuous string of ones (Marks) or framed ones in the framed data mode will cause the MK indicator to be illuminated. Absence of an input signal for AMI code or an all-Space pattern for B8ZS code will cause the SP indicator to be illuminated. Under normal operating conditions both the SP and MK indicators should be illuminated.

FRM SYNC Indicator

The FRM SYNC indicator will be illuminated when a framing pattern is present in the received data. The framing pattern can be D1D, D2, D3 or D4 when FRAMED/D4 is selected, or Fe when FRAMED/Fe is selected. This indicator is functional in both Standard and Live analysis modes. The frame detection circuitry prevents false synchronization indications for unframed pseudorandom patterns.

CODE Indicator

The CODE indicator will signal the presence of B8ZS sequences on received data. AMI and B8ZS encoding are front panel menu selections; however, B8ZS decoding is automatically performed. The CODE indicator will illuminate independently of AMI coding selection if a B8ZS pattern is detected.

ALM1 Indicator

The ALM1 indicator will be illuminated when a yellow alarm condition is detected in the received framed data. When the FRAMED/D4 selection is made, this indicator will be illuminated when 255 consecutive channel samples have bit 2 set to zero. If FRAMED/Fe is selected, the indicator will light when an alternating sequence of 1111 1111 0000 0000 is detected on the 4 kb/s data link for 16 consecutive periods.

ALM2 Indicator

The ALM2 indicator will light when an excess zero condition (16 or more consecutive zeros) is detected on the received data.

8.6.5 Data-Clock Test Points

This section describes the phase relationship between the DS1/D4/Fe interface's data and clock signals and the FIREBERD's rear panel test points.

RCVR DATA: The signal at this test point will be high when the received data bit is a Mark condition and will be low when the received data bit is a Space. Framing bits are removed prior to this test point.

RCVR CLK: This test point provides a TTL signal derived from the clock recovered from the data pulses. The phase relationship between this signal and RCVR DATA is such that mid-bit data sampling occurs at the rising edge transition of the RCVR CLK signal. This test point is inactive during received framing bits.

GEN DATA: This test point provides the TTL equivalent of the transmitter data. The signal at this test point will be high when transmitting a Mark and will be low when transmitting a Space. This test point is inactive during framing bits.

GEN CLK: This test point provides a TTL signal derived from the transmitter clock. The phase relationship between this signal and GEN DATA is such that mid-bit data sampling occurs at the rising edge transition of the GEN CLK signal. This test point is inactive during framing bits.

8.6.6 Specifications

8.6.6.1 T1 Transmitter Specifications

Connector

Connector Type:
- Bantam.

Configuration:
- Tip-Ring-Sleeve; Sleeve connected to ground, differential signal on Tip and Ring.

Pulse Mask

All specifications are for 0dB line build-out and with output terminated in 100-ohm resistive load. Meets pulse masks given in CCITT recommendation G.703 and in Bell Publications CB113, CB119, CB143, PUB 41451, PUB 62411, and PUB 62508.

Pulse Amplitude:
- ±3 ± 0.3 volts with a maximum imbalance of ± 0.15 volts.

Half Amplitude Pulse Width:
- 324 ± 24 ns with a maximum imbalance of ± 15 ns.

Rise and Fall Times:
- 100 ns maximum (10% to 90%).

Trailing Edge Overshoot:
- 10% to 30% of pulse height with decay to 10% of pulse height within 400 ns.

Line Codes:
- Bipolar (pseudoternary); selectable AMI or B8ZS.

Loopback Code Generation

Loop Up Code: • Repetitive "10000".
Loop Down Code: • Repetitive "100".

Line Buildout (Primary output only)

-7.5 dB LBO • -7.5 dB ± 1 dB attenuation at 772 kHz.

-15 dB LBO • -15.0 dB ± 1 dB attenuation at 772 kHz.

8.6.6.2 T1 Receiver Specifications

Connector

Connector Type: • Bantam.

Configuration: • Tip-Ring-Sleeve; Sleeve connected to ground, differential signal on Tip and Ring.

T1 Input Circuit

Input Impedance: • TERM or DSX-MON position - 100 ohms ± 5%.
• BRIDGE position - 1000 ohms minimum.

Input Level: • ± 3 volts (DSX-1) nominal, with 0 to 24 dB cable attenuation (BRIDGE, TERM), 10 to 30 dB resistive attenuation (DSX-MON).

Data Rate Range: • 1.544 Mb/s ±500 b/s minimum.

Line Code: • Bipolar (pseudoternary), AMI with automatic detection of B8ZS coding.

Jitter Tolerance: • Meets jitter mask given in CCITT Recommendation G.703 and in Bell publications PUB 41451 and PUB 62411.

Excess Zeros Detection: • 16 or more zeros.

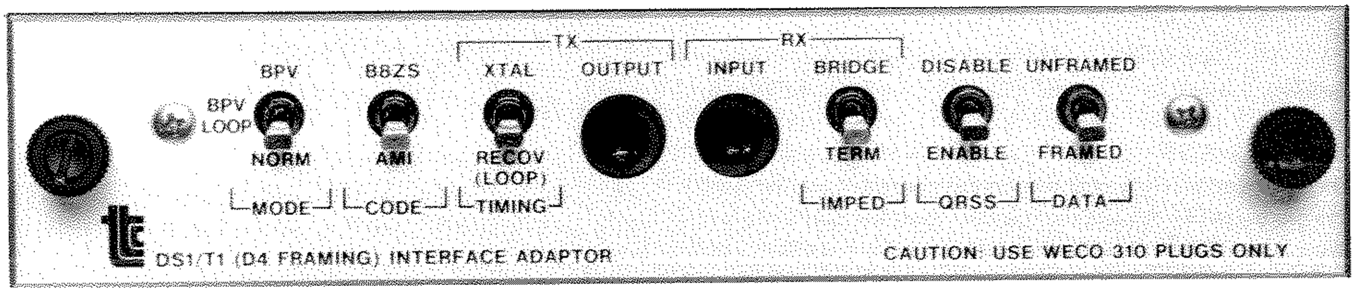
8.6.6.3 Simplex Current Path

All specifications are for OUTPUT (TX) connector Tip and Ring shorted together and INPUT (RX) connector Tip and Ring shorted together.

Current: • 60 mA nominal, 145 mA maximum.

Voltage Drop:	• 7.3 ± 0.5 volts at 60 mA.
Polarity:	• Bi-directional - either pair may be positive with respect to the other pair.
Breakdown Voltage:	• ± 150 volts minimum from Tip and Ring to Chassis Ground.

8.7 DS1/T1 (D4 FRAMING) DATA INTERFACE (Model 40405)



8.7.1 Introduction

The DS1/T1 (D4 Framing) Data Interface allows the FIREBERD to test communications systems that use the Bell System T1 (DS1) 1.544 Mb/s Digital Channel Service and similar systems. The T1 signals are serial, differential return-to-zero (RZ) pulses with alternate mark inversion (AMI) or bipolar with eight zero substitution (B8ZS) coding. The data interface will operate with either framed data, required by Digital Access Cross-Connect Switches (DACS) and channel banks, or with unframed data as used in unswitched networks.

In addition to making the conversion between the TTL levels required by the FIREBERD and T1 signal levels, the data interface has the following capabilities:

- It accepts low-level degraded signals, regenerates the data, and recovers the clock timing from the data.
- Bipolar violations (BPVs) in the received data can be detected and measurements of Violation-Free Seconds or Bipolar Violation Rates can be made.
- Data can be received and transmitted with or without the D1D, D2, D3, or D4 framing pattern inserted as the 193rd bit position.
- Received data can be looped (retransmitted) without removing BPVs, thus emulating a repeater or a Customer Service Unit (CSU) in loopback. Any BPVs in the received data are monitored.
- A simplex current path is provided which allows repeater powering when testing is performed on the "wet side" of a T1 span.
- Loop-up and loop-down codes can be transmitted to control loopbacks in compatible CSUs.
- The presence of B8ZS encoded data, frame patterns, or a Yellow Alarm condition cause signaling indicators to be illuminated.

8.7.2 Functional Description

The DS1/T1 Data Interface offers two modes of operation: bit error detection and bipolar violation detection. In normal bit error detection operation, code violations are ignored and the received data is sent to the FIREBERD for bit error analysis. Data can be in either framed or unframed format. In framed data format the framing bits are not checked for errors.

In bipolar violation detection operation, a bipolar violation is defined as a Mark having the same polarity as the preceding Mark. When this mode of operation is being used, the output data from the FIREBERD is looped within the data interface and an error is inserted in the looped-back pattern for each BPV detected. The output pattern of the data interface is selected on the FIREBERD front panel. The received data is not required to match the pattern selected on the FIREBERD front panel, which allows "live traffic" to be monitored for BPVs. A fail safe circuit will break the looped-back data path when no T1 data is present at the receive input.

A BPV-Loop mode allows all data received by the interface to be retransmitted. The interface emulates a repeater, or a CSU in loopback. Bipolar violations are monitored as described above, but are not removed from the data when it is retransmitted.

8.7.2.1 Timing Sources

The data interface offers both unframed and framed transmit timing. In Unframed mode, four sources of transmit timing are available: (1) an externally supplied signal connected to the GEN CLK IN rear-panel BNC connector; (2) the synthesizer clock; (3) the crystal oscillator on the data interface; or (4) the clock recovered from the incoming T1 data stream. In Framed mode, there are two sources: the crystal oscillator on the data interface and the clock recovered from the incoming T1 data stream. The FIREBERD's front panel GEN CLK switch, together with the TIMING switch on the data interface, determine which timing mode is selected in accordance with the table below.

Source	GEN CLK switch	TIMING switch
1. External signal	BNC	X
2. Synthesizer	SYNTH	X
3. Crystal oscillator	INTF	XTAL
4. Recovered	INTF	RECOV (Loop)

Note that in framed operation, the only valid setting of the GEN CLK Switch is the INTF position.

8.7.2.2 Self-Loop

The SELF LOOP switch on the FIREBERD front panel activates a relay in the interface which connects the T1 line driver to the T1 line receiver. This self-loop test provides quick verification of the FIREBERD and its data interface in bit error detection operation. The input and output connectors need not be removed during the test because complete isolation is provided by the relay.

8.7.3 Interface Switches and Connectors

MODE Switch

The MODE switch is a three-position toggle switch that selects the operating mode of the DS1/T1 (D4 Framing) Data Interface. The NORM position routes the data to the FIREBERD for logical bit error analysis. Both the BPV LOOP and the BPV positions detect bipolar violations in the received data. The differences between the BPV LOOP and BPV positions lie in the source of transmit data. When the BPV LOOP position is chosen, the data interface retransmits data that was received by the receiver, whereas the BPV position causes transmission of the pattern selected by the FIREBERD's DATA switch. In the BPV position, the transmitted pattern is unframed regardless of the position of the interface's DATA switch. The position of the DATA switch does not affect the detection of BPVs. The MODE switch should not be set to the BPV LOOP position when performing a self-loop test. When the BPV LOOP position is selected, only the IMPEDANCE and TIMING switches on the data interface are functional.

CODE Switch

The CODE switch is a two-position toggle switch which selects the coding format of the output data. When the AMI position is selected, a Mark is encoded with a pulse which has polarity opposite to the Mark preceding it. A Space is coded as the absence of a pulse.

The B8ZS position provides a similar code except that strings of eight sequential zeroes are replaced by the pattern 000V10V1 where V is a bipolar violation (BPV). This allows data that contains long strings of zeros to be transmitted on a T1 span without violating the ones density criterion.

This switch does not affect the reception or detection of B8ZS-coded data. The receiver will replace each B8ZS sequence detected in the incoming data stream with a string of eight zeros regardless of the position of the CODE switch.

TIMING Switch

The TIMING switch is a two-position switch that selects the transmit timing clock source when the FIREBERD's GEN CLK switch is set to the INTF position. The XTAL position selects a 1.544 MHz crystal oscillator located on the data interface. The RECOV (LOOP) position selects a clock recovered from the received data as the transmit timing clock source. In the BPV-Loop mode, the TIMING switch has no effect on the data rate of the data being received and retransmitted by the interface but does affect the data being looped back on the interface. The TIMING switch should be set to the RECOV(LOOP) position to ensure accurate BPV measurements.

In Self-Loop mode, TTC recommends that the XTAL position of the TIMING switch be used with the FIREBERD's GEN CLK switch set either to the INTF position or to the SYNTH position.

IMPEDANCE Switch

The IMPEDANCE switch is a two-position toggle switch which selects the input impedance at the receive input. The TERM position provides a 100-ohm input impedance. The TERM position should be used when the FIREBERD is terminating the line. The BRIDGE position provides greater than 1000 ohms input impedance and should be used if a termination is already present on the line. The IMPEDANCE switch is functional in the BVP-Loop mode.

QRSS Switch

The QRSS toggle switch allows a 2^{20}-1 pattern to be modifed to become the quasi-random signal source (QRSS) when the interface is used with a FIREBERD 1500A or 2000.

> **NOTE**: This switch should be in the DISABLE position for proper operation with the FIREBERD 6000.

DATA Switch

The DATA switch is a two-position toggle switch that determines whether the data is going to be transmitted and received framed or unframed. The FRAMED position of the switch causes transmission of data with a framing bit inserted every 192 data bits as the 193rd bit. The framing pattern is compatible with D1D, D2, D3, and D4 Channel Banks. The signaling bits in the 6th and 12th frames are included as part of the pseudorandom pattern; that is, these bits are not stolen for signaling. The framed data rate is 1.536 Mb/s; this is added to the framing bit rate of 8 kb/s to arrive at the T1 data rate of 1.544 Mb/s.

The UNFRAMED position allows data to be transmitted and received at the full 1.544 Mb/s without framing bits. This mode is compatible with TTC's Model 40365 T1 Data Interface.

Receiver frequency measurements are available in framed operation only when the data interface is in continuous frame sync to the incoming data. In the case of intermittent frame sync or no frame sync at all (e.g., unframed data), receiver frequency measurements may be obtained by setting the DATA switch to the UNFRAMED position. Note that when the MODE switch is set to BPV or BPV LOOP, the interface operates without respect to received framing, and receiver frequency measurements are always valid.

Connectors

Two WECO 310 jacks are provided for T1 line input and output. The jack sleeve is connected to ground; the differential signal appears tip and ring. An optional cable is available for mating with a 15-pin D connector.

8.7.4 FIREBERD Switches and Indicators

LOOP UP and LOOP DOWN Switches

The LOOP UP and LOOP DOWN switches will transmit loop-up and loop-down codes as described in Section 4.

MK (Mark) and SP (Space) Indicators

An input signal consisting of a continuous string of ones (Marks) or framed ones in the framed data mode will cause the MK indicator to be illuminated. Absence of an input signal for AMI code or an all-Space pattern for B8ZS code will cause the SP indicator to be illuminated. Under normal operating conditions both the SP and MK indicators should be illuminated.

CODE Indicator

The CODE indicator on the front panel of the FIREBERD will be illuminated whenever a B8ZS code is detected in the received data. The detection is not dependent on any switch position and is functional in all modes of operation.

FRM SYNC Indicator

The FRM SYNC indicator will be illuminated when a framing pattern is present in the receive data. The frame pattern can be either D1D, D2, D3, or D4 framing. Frame detection is functional in all modes and switch position combinations.* The frame detection circuitry prevents false synchronization indications on unframed pseudorandom patterns.

* Except when receiving a framed all-zero, B8ZS-coded pattern.

ALM1 Indicator

The ALM1 indicator will illuminate when a yellow alarm condition is detected in the received framed data. A yellow alarm condition occurs when 255 consecutive channel samples have bit 2 set to zero.

8.7.5 Data-Clock Test Points

This section describes the phase relationship between the DS1/T1 Data Interface's data and clock signals and the FIREBERD's rear panel test points.

RCVR DATA: The signal at this test point will be high when the received data bit is a Mark condition and will be low when the received data bit is a Space. This test point is inactive during received framing bits. Note that in BPV or BPV Loop modes, the data does not reflect the actual incoming data.

RCVR CLK: This test point provides a TTL signal derived from the clock recovered from the data pulses. The phase relationship between this signal and RCVR DATA is such that mid-bit data sampling occurs at the rising edge transition of the RCVR CLK signal. This test point is inactive during received framing bits.

GEN DATA: This test point provides the TTL equivalent of the transmitter data. The signal at this test point will be high when transmitting a Mark and will be low when transmitting a Space. This test point is inactive during transmitted framing bits.

GEN CLK: This test point provides a TTL signal derived from the transmitter clock. The phase relationship between this signal and GEN DATA is such that mid-bit data sampling occurs at the rising edge transition of the GEN CLK signal. This test point is inactive during framing bits.

8.7.6 Specifications

8.7.6.1 T1 Transmitter

Connector

Connector Type:
- WECO 310 jack.

Configuration:
- Tip-Ring-Sleeve; Sleeve connected to ground, differential signal on Tip and Ring.

Pulse Mask

All specifications are for output terminated in 100-ohm resistive load. Meets pulse masks given in CCITT recommendation G.703 and in Bell publications CB113, CB119, CB143, PUB 41451, PUB 62411, and PUB 62508.

Pulse Amplitude:
- ± 3 ± 0.3 volts with a maximum imbalance of ± 0.15 volts.

Half Amplitude Pulse Width:
- 324 ± 24 ns with a maximum imbalance of ± 15 ns.

Rise and Fall Times:
- 100 ns maximum (10% to 90%).

Trailing Edge Overshoot:
- 10% to 30% of pulse height with decay to 10% of pulse height within 400 ns.

Line Codes:
- Bipolar (pseudoternary); selectable AMI or B8ZS.

Loopback Code Generation

Loop Up Code:
- Repetitive "10000".

Loop Down Code:
- Repetitive "100".

8.7.6.2 T1 Receiver Specifications

Connector

Connector Type:
- WECO 310 jack.

Configuration:
- Tip-Ring-Sleeve; Sleeve connected to ground, differential signal on Tip and Ring.

T1 Input Circuit

Input Impedance:
- TERM position - 100 ohms ± 5%.
- BRIDGE position - 1000 ohms minimum.

Input Level:
- ± 3 volts (DSX-1) nominal, with 0 to 24dB cable attenuation.

Data Rate Range:
- 1.544 Mb/s ± 500 b/s minimum.

Line Code:
- Bipolar (pseudoternary), AMI with automatic detection of B8ZS coding.

Jitter Tolerance:
- Meets jitter mask given in CCITT Recommendation G.703 and in Bell publications PUB 41451 and PUB 62411 (9/83).

Simplex Current Path

All specifications are for Transmit (Output) connector Tip and Ring shorted together and Receive (Input) connector Tip and Ring shorted together.

Current:
- 60 mA nominal, 145 mA maximum.

Voltage Drop:
- 7.3 ± 0.5 volts at 60 mA; jumperable to 2.8 volts maximum at 60 mA.

Polarity:
- Bi-directional - either pair may be positive with respect to the other pair.

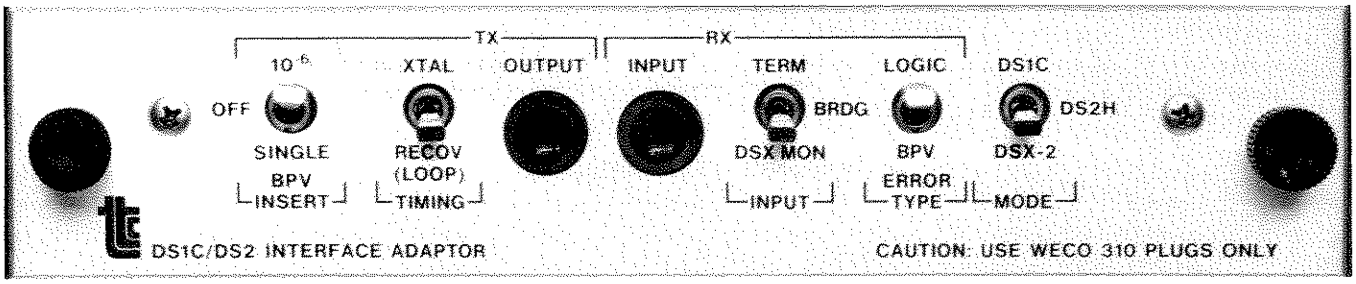
Break Down Voltage:
- ± 150 volts minimum from Tip and Ring to Chassis Ground.

Crystal Oscillator

Frequency:
- 1.54400 MHz.

Accuracy and Stability:	• ± 35 ppm (±54 Hz), 0° C to 50° C ambient.
Drift:	• 5 ppm per year typical.

8.8 DS1C/DS2 DATA INTERFACE (Model 30447)



8.8.1 Introduction

The DS1C/DS2 Data Interface allows the FIREBERD to test communications systems that utilize Bell System DS1C or DS2 type signals. The DS1C signal is a 3.152 Mb/s serial, differential bit stream consisting of bipolar, return to zero (RZ) pulses. The data is coded with alternate mark inversion (AMI) coding, where a Mark (one) is coded as a pulse, and a Space (zero) is zero volts, and pulses alternate in polarity. The DS2 signal is similar to DS1C except that it runs at a faster rate (6.312 Mb/s), and utilizes B6ZS (bipolar six zero substitution) line coding. The B6ZS scheme replaces strings of six consecutive zeroes with a code that contains pulses that violate the AMI rule (Bipolar violations or BPVs). The data interface operates with unframed data only.

In addition to standard bit and block error testing, the DS1C/DS2 interface gives the FIREBERD the following powerful capabilities:

- Live traffic monitoring—The FIREBERD can be bridged across a line to detect and count BPVs, and to detect all ones or excess zeros.
- Cable equalization—The receiver input can accommodate up to 1000 feet of connecting cable.
- BPV insertion—Bipolar violations can be inserted on the transmit signal to aid in identifying lines and checking out monitoring equipment.

8.8.2 Functional Description

The DS1C/DS2 Data Interface may be used with the FIREBERD in various applications; three test configurations are described in the following sections.

8.8.2.1 Terminal Configuration

As shown in Figure 8-6(A), the FIREBERD sources a test pattern to the system under test, where it is either looped back at some point or received by another FIREBERD. The receive line is terminated by using the INPUT switch. Logical errors in the data can be analyzed or BPVs can be analyzed depending on the ERROR TYPE switch. BPVs can be inserted on the transmit signal using the BPV INSERT switch. (See Section 8.8.3 for a description of the interface switches.) The transmit clock can be selected from four different sources: an externally supplied signal, the FIREBERD's synthesizer, the crystal oscillator on the data interface, and the recovered clock from the incoming data stream.

8.8.2.2 Bridging Configuration

As shown in Figure 8-6(B), the FIREBERD bridges a line with a high impedance termination so that non-disruptive monitoring of live data can be performed. All-ones conditions and excess zeros in the receive data are also detected.

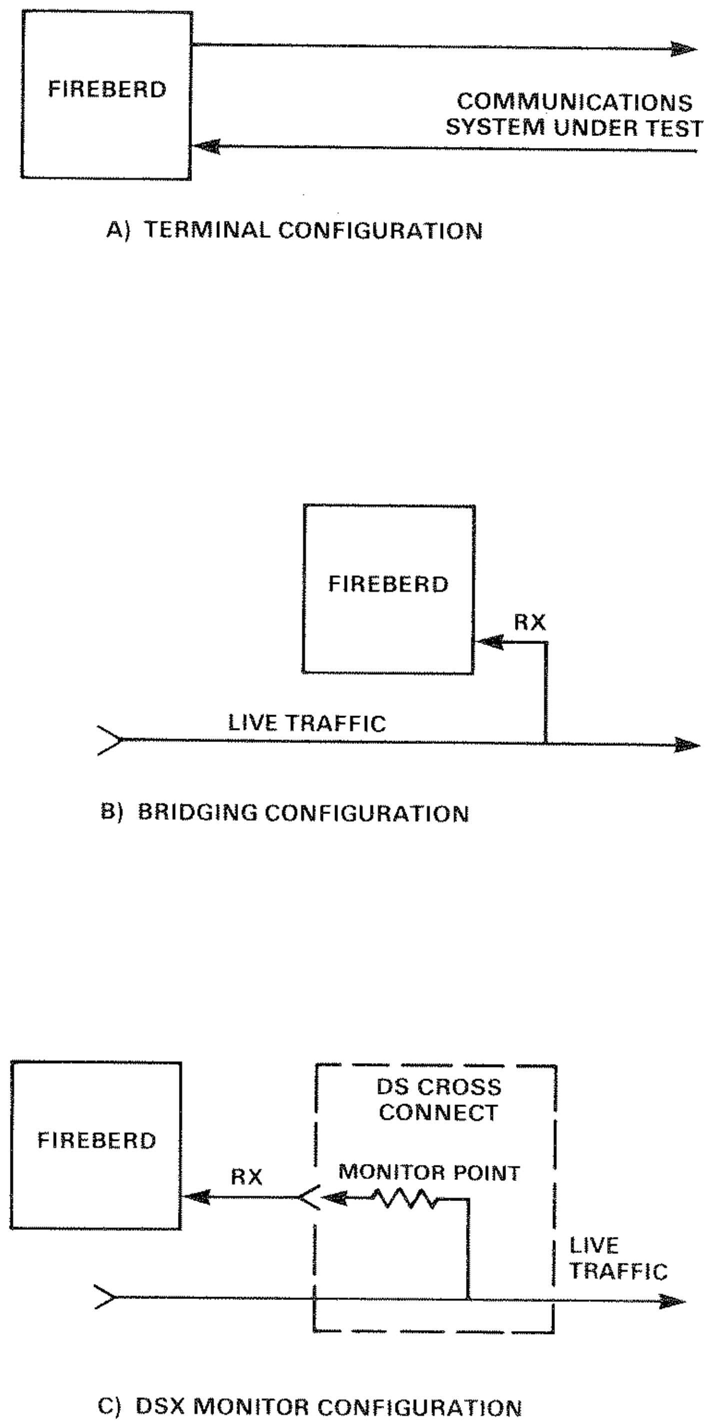


Figure 8-6
Typical Test Configurations

8.8.2.3 DSX Monitor Configuration

As shown in Figure 8-6(C), the FIREBERD monitors live traffic at a DSX (Digital Signal Cross-Connect) monitor point. Measurements are identical to those of the bridging configuration.

8.8.2.4 Self-Loop

Loopback relays are located at the input and output jacks of the interface to enable an internal loopback condition. This allows a complete self-check of the instrument and its setup. The loopback is enabled with the SELF LOOP switch located on the FIREBERD front panel. Cables need not be removed when performing internal loopback tests as the relays provide complete isolation between the data interface and the system under test.

8.8.3 Interface Switches and Connectors

TIMING Switch

This toggle switch selects the source of transmit timing when the FIREBERD's GEN CLK switch is set to the INTF position. The XTAL position selects a crystal oscillator on the data interface. The RECOV (LOOP) position selects the clock recovered from the receive data.

BPV INSERT Switch

This three-position toggle switch allows bipolar violations to be inserted on the transmit output signal. In the 10^{-6} position, BPVs are inserted at a rate of one every 10^6 bits. The OFF position disables the BPV insertion, and the SINGLE position is a momentary position which inserts a single BPV when depressed. BPVs that would fall within a B6ZS code are delayed and inserted after the B6ZS code.

ERROR TYPE Switch

The ERROR TYPE switch is a two-position toggle switch that determines what type of errors will be counted and analyzed by the FIREBERD. In the LOGIC position, only logical bit errors in the data are counted. In the BPV position, coding errors in the form of bipolar violations are counted. BPVs that are part of a B6ZS code are not counted. It is recommended that RECOV(LOOP) timing be used when measuring BPVs. When operating in a bridging configuration, the ERROR TYPE switch should be in the BPV position.

INPUT Switch

The INPUT switch allows selection of the input impedance of the receiver. Both the TERM and the DSX MON positions select a 100-ohm impedance to terminate the line, while the BRIDGE position selects an impedance of 1000 ohms or greater for bridging the line. The DSX MON position should be used when the input signal has undergone resistive attenuation, such as at a DSX monitor point.

MODE Switch

The MODE switch permits selection of DS1C (3.152 Mb/s), DS2H (6.312Mb/s), or DSX-2 (6.312 Mb/s) operation. In the DS1C or DSX-2 modes, the TX output complies with the appropriate DSX pulse mask. In the DS2H mode, the output is a rectangular pulse useful for driving long cable lengths (to 1000 feet).

Connectors

Two WECO 310 jacks are provided: one for the receive input and one for the transmit output. Each jack is tip-ring-sleeve, with the jack sleeve connected to ground and the differential signal appearing across the tip and ring.

8.8.4 FIREBERD Switches and Indicators

DATA Switch

For most applications, a 2^{20}-1 pattern should be selected because it conforms to the QRSS (quasi-random signal source) specifications for DS1C. The 2^{20}-1 pattern is also recommended for use with DS2.

MK (Mark) and SP (Space) Indicators

The MK indicator will be illuminated whenever a one (Mark) is detected in the data. The SP indicator will be illuminated whenever a zero (Space) is detected. Under normal operating conditions both indicators will appear to be illuminated continuously.

ALM1 Indicator

The ALM1 indicator on the front panel of the FIREBERD will be illuminated whenever 1025 or more consecutive ones are detected in the received data. This indicates a "blue alarm" or "keep alive" signal on the line.

ALM2 Indicator

The ALM2 indicator will be illuminated whenever excess zeros are detected in the received signal. An excess-zeros condition is defined as 34 or more consecutive zeros for DS1C, and 6 or more zeros for DS2.

8.8.5 Specifications

8.8.5.1 Output Specifications

Connector

Connector type:
- WECO 310 jack.

Configuration:
- Tip-Ring-Sleeve; sleeve is grounded, differential signal on tip and ring.

DS1C Output Signal

All specifications are for the output terminated into a 100 ohm resistive load.

Pulse Amplitude:
- 3 ± 0.3 volts.

Half Amplitude Pulse Width:
- 159 ± 15 ns with a maximum imbalance of 9 ns.

Rise and Fall Times:
- less than 50 ns (20% to 80%).
- less than 20 ns imbalance.

Trailing edge overshoot:
- less than 10% of pulse height.

DS2H Output Signal

All specifications are for the output terminated with a 110 ohm resistive load.

Pulse Amplitude:
- 2 ± 0.2 volts.

Half Amplitude Pulse Width:
- 78 ± 15 ns.

DSX-2 Output Signal

The DSX-2 output complies with all the specifications given for the DSX-2 interconnect in AT&T Compatibility Bulletin No. 119, "Interconnection Specification for Digital Cross-Connects".

8.8.5.2 Input Specifications

Connector

Connector type:	• WECO 310 jack.
Configuration:	• Tip-Ring-Sleeve; sleeve grounded, differential signal on tip and ring.
Input Impedance:	• 100 ohms ± 10%, TERM or MON switch position. • greater than 1000 ohms for BRIDGE position.

Input Level

Per DSX specifications, nominal pulse amplitudes are ± 3V (DS1C), ± 2V (DS2H), or ± 1V (DSX2). For the TERM or BRIDGE switch positions, the receiver will compensate for cable attenuation for cable lengths up to 1000 feet. In the MON position, the receiver will compensate for up to 24 dB of resistive attentuation only.

Frequency Range

DS1C:	• 3152 ± .3 kHz (± 95 ppm).
DS2:	• 6312 ± .6 kHz (± 95 ppm).

Jitter Tolerance

For DS2 operation, the receiver will tolerate jitter that lies within the mask given in Figure 8-7.

All-Ones Alarm

The all-ones alarm occurs if 1025 or more consecutive ones occur in the received data.

Excess Zeroes Alarm

The excess zeros alarm occurs if 34 or more consecutive zeroes occur in DS1C data, or if 6 or more consecutive zeros occur in DS2 data.

8.8.5.3 Crystal Oscillators

Frequencies:	• 3.152 MHz (DS1C). • 6.312 MHz (DS2).
Accuracy and Stability:	• ± 10 ppm. • 0° C to 50° C.
Drift:	• 5 ppm/year typical.

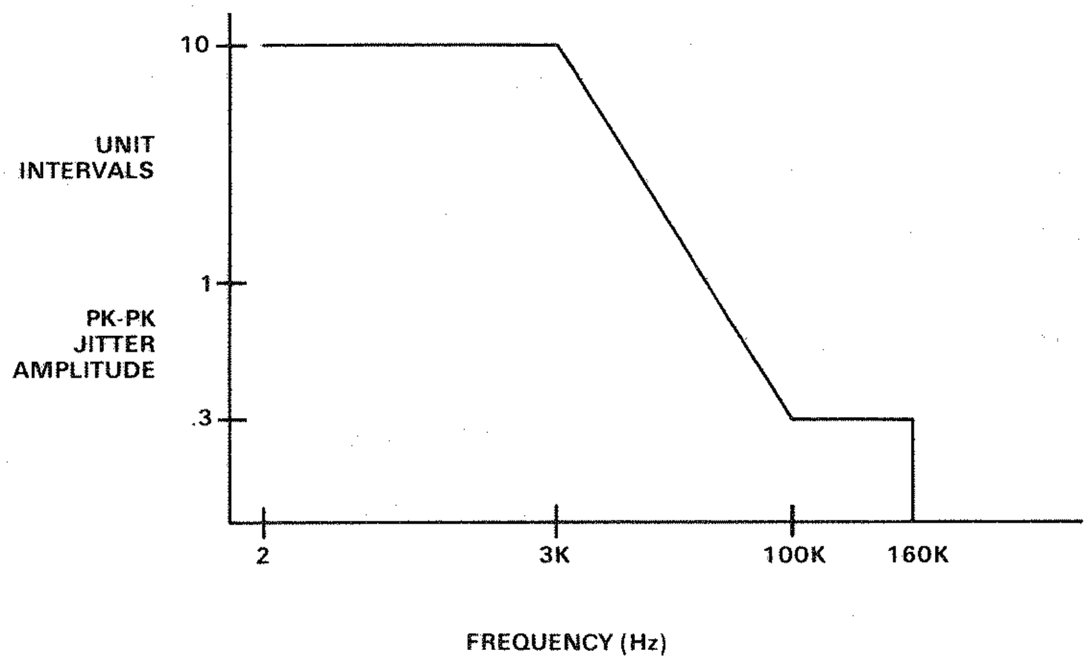
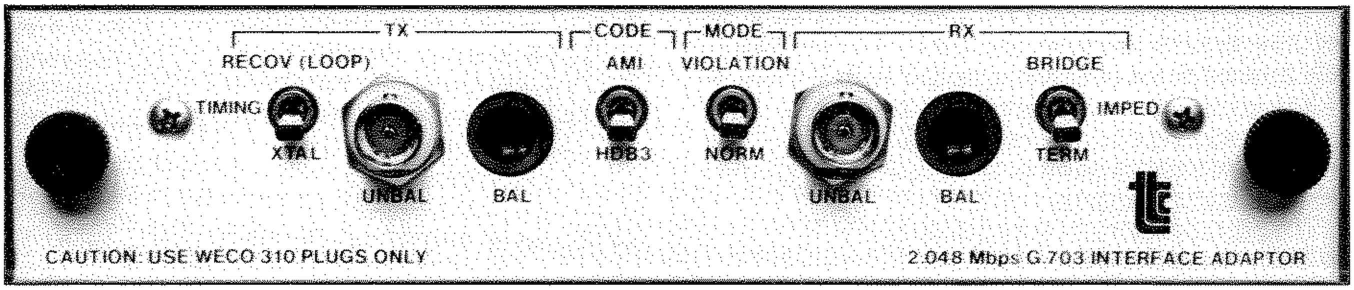


Figure 8-7
DS2 Jitter Tolerance Limits

8.9 2.048 Mb/s G.703 DATA INTERFACE (Model 40380)



8.9.1 Introduction

The 2.048 Mb/s G.703 Data Interface allows the FIREBERD to test data communications equipment utilizing the interface specification in Section 6 of CCITT Recommendation G.703. The G.703 signals are serial, differential return-to-zero (RZ) pulses with alternate mark inversion (AMI) or high density bipolar three (HDB3) encoding. This interface will operate with both the 75-ohm and the 120-ohm differential pair "preferred solution" of Recommendation G.703.

In addition to making the conversion between the TTL levels used on the FIREBERD and the G.703 signals, the interface has the following capabilities:

- It accepts low-level degraded signals, regenerates the data, and recovers the clock timing from the data.
- Bipolar violations (BPV) or HDB3 coding violations in the received data can be detected by the FIREBERD.

To conform with CCITT Specification O.151 for a 2^{15}-1 pseudorandom pattern, all data leaving the interface is inverted with respect to the "normal". Each logical one generated by the FIREBERD is transmitted as the absence of a pulse (Space) and each logical zero is transmitted as the presence of a pulse (Mark). The words Mark and Space refer to the presence or absence of a pulse, respectively, at the output of the data interface.

8.9.2 Functional Description

There are various operating modes available for use with the G.703 data interface. The normal mode of operation is bit error detection, in which coding violations are ignored and the received data is sent to the FIREBERD for bit error analysis.

Another method of operation is coding violation detection; circuitry within the interface detects coding violations in the received data. The CODE switch determines the criterion for which a coding violation is counted. When coding violation detection is in use, the output of the FIREBERD is looped back to its input by the data interface and an error is inserted in the looped-back pattern for each coding violation in the incoming signal. The output of the G.703 data interface is the pattern selected on the FIREBERD front panel. This mode allows live traffic to be monitored by the data interface because the data is only checked for coding violations and is not expected to match the pattern selected on the FIREBERD front panel. A fail-safe circuit automatically breaks the loopback path when no G.703 input signal is detected.

8.9.2.1 Timing Sources

Four clock sources are available for use as the source of transmit timing: (1) a crystal oscillator located on the data interface; (2) the clock recovered from the incoming G.703 data; (3) the FIREBERD's synthesizer; or (4) an externally supplied signal input through the FIREBERD rear panel BNC connector. The selection is made by using the GEN CLK switch on the FIREBERD front panel.

8.9.2.2 Self-Loop

The SELF LOOP switch on the FIREBERD front panel activates a relay in the data interface which connects the G.703 line driver to the G.703 line receiver. This allows quick verification of the FIREBERD and its interface in the bit error detection operation. The input and output connectors need not be removed during the test because complete isolation is provided by the relay when testing. Note that a timing source must be provided for the loop testing, and the RECOV (LOOP) position of the interface's TIMING switch should not be used.

8.9.3 Interface Switches and Connectors

MODE Switch

The MODE switch is a two-position toggle switch which selects the operating mode of the G.703 data interface and the FIREBERD. The NORM position selects bit error detection operation, while the VIOLATION position selects code violation detection operation. This switch should be in the NORM position when performing a self-loop test. If the switch is in the VIOLATION position during a self-loop test, operation of the interface and the FIREBERD should appear the same as when the switch is in the NORM position. However, the ability of the violation circuitry to detect coding violations is not checked in this mode because no coding violations are generated.

CODE Switch

The CODE switch is a two-position toggle switch which selects between AMI and HDB3 encoding/decoding of the data. When the HDB3 position is selected, the data is encoded with every Mark having the opposite polarity of the preceding Mark and any Space coded as no transition. Any string of four consecutive Spaces is replaced by the string 111V or 011V, where V represents a bipolar violation. Each violation pulse is of the opposite polarity of the violation preceding it. This is accomplished by either inserting or omitting a one in the first bit of the replacement string. Two successive violations of the same polarity constitute a single HDB3 coding violation.

In the AMI position, the data is coded with every Mark having the opposite polarity of the preceding Mark. When a Mark is detected with the same polarity as the preceding Mark, a violation is counted. A Space is coded as no transition.

TIMING Switch

The TIMING switch is a two-position toggle switch which selects the source of transmit timing when the FIREBERD's GEN CLK switch is set to the INTF position. The XTAL position of the TIMING switch selects the crystal oscillator on the data interface; the RECOV (LOOP) position selects the clock recovered from the incoming data stream. Note that the RECOV (LOOP) position should not be used with the FIREBERD in self-loop.

IMPEDANCE Switch

The IMPEDANCE switch is a two-position toggle switch which selects between bridging (BRIDGE) and terminated (TERM) input impedances. In the BRIDGE position the input impedances for both the balanced and unbalanced input are greater than 1000 ohms. The TERM position provides input impedances of 120 ohms for the BAL input and 75 ohms for the UNBAL input.

Connectors

Both WECO 310 jacks and BNC connectors are provided for connecting the data interface to the circuit under test. The WECO 310 jacks provide the balanced input and output. The BNC connectors provide the bipolar unbalanced input and output.

The WECO 310 jacks are tip-ring-sleeve jacks, with the jack sleeve connected to ground and the differential G.703 signal appearing across the tip and ring. The BNC connectors provide ground connection for the shield, and the bipolar unbalanced G.703 signal appears on the center conductor. Simultaneous connections should not be made to the receive BNC and the receive WECO 310 jack.

8.9.4 MK (Mark) and SP (Space) Indicators

The MK indicator will be illuminated in the absence of an input signal in AMI code or the presence of an all-HDB3-encoded Space pattern in HDB3 code. The SP indicator will be illuminated when an input signal consisting of a continuous string of Marks is detected. Under normal operating conditions both the MK and SP indicators should be illuminated.

8.9.5 Data-Clock Test Points

This section describes the phase relationship between the 2.048 Mb/s G.703 Data Interface's data and clock signals and the FIREBERD's rear panel test points.

RCVR DATA: The signal at this test point will be high when the received data bit is a Space and will be low when the received data bit is a Mark.

RCVR CLK: This test point provides a TTL signal derived from the clock recovered from the data pulses. The phase relationship between this signal and RCVR DATA is such that mid-bit data sampling occurs at the rising edge transition of the RCVR CLK signal.

GEN DATA: This test point provides the TTL equivalent of the transmitter data. The signal at this test point will be high when transmitting a Mark and will be low when transmitting a Space.

GEN CLK: This test point provides a TTL signal derived from the transmitter clock. The phase relationship between this signal and GEN DATA is such that mid-bit data sampling occurs at the rising edge transition of the GEN CLK signal.

8.9.6 Specifications

8.9.6.1 General

Operating bit rate:
- 2.048 Mb/s nominal.

Coding:
- AMI/HDB3 selectable.

Connectors:
- BNC and WECO 310.

8.9.6.2 Drivers

Pulse shape:
- Conforms to Figure 15 of CCITT Recommendation G.703.

Nominal Peak voltage of a Mark (pulse):
- 3 volts ± 10% into 120 ohms.
- 2.37 volts ± 10% into 75 ohms.

Peak voltage of a Space (no pulse):
- 0 ± .3 volts into 120 ohms.
- 0 ± 0.24 volts into 75 ohms.

Nominal Pulse Width:
- 244 ns.

Ratio of amplitudes of positive to negative pulses at midpoint of pulse:	• 0.95 to 1.05.
Ratio of widths of positive to negative pulses at nominal half amplitude:	• 0.95 to 1.05.

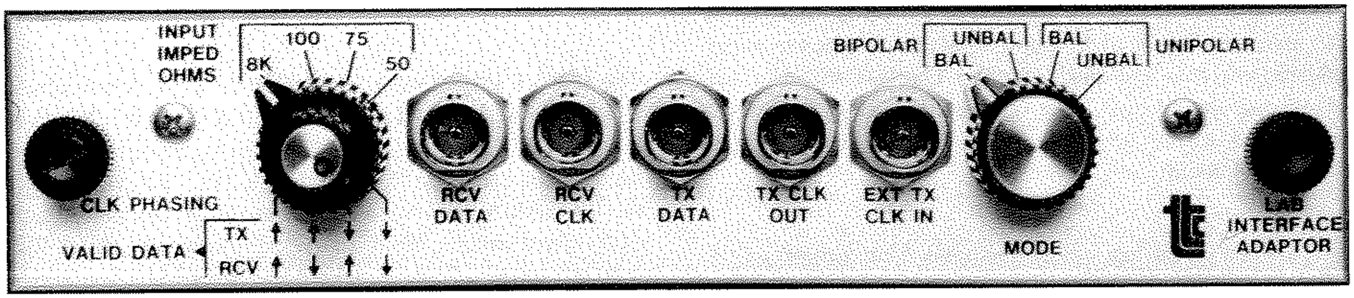
8.9.6.3 Receivers

BNC Load resistance:	• Switchable, 75 ohms with minimum 20 dB return loss or greater than 1K ohms.
WECO 310 Load resistance:	• Switchable, 120 ohms with minimum 20 dB return loss or greater than 1K ohms.
Operating bit rate:	• 2.048 Mb/s ± 1 kHz minimum.

8.9.6.4 Crystal Oscillator

Frequency:	• 2.048 MHz.
Accuracy and Stability:	• ± 35 ppm, 0°C to 50°C ambient.
Drift:	• 5 ppm per year typical.

8.10 LAB DATA INTERFACE (Model 40204)



8.10.1 Introduction

The Lab Data Interface is a versatile interface unit which allows the FIREBERD to test a wide variety of data handling devices. Capable of driving any load from 50 ohms to high impedances, with user-selectable receiving impedances, the Lab Data Interface allows the user to select bipolar or unipolar, balanced or unbalanced operating modes. Data is exchanged in a serial binary format. All connections with the Lab Data Interface are made through BNC connectors.

8.10.2 Functional Description

The Lab Data Interface is designed to convert between the TTL signals used within the FIREBERD and the user-selected signal type. Data generated by the FIREBERD is transmitted through the TX DATA jack. The synchronous transmitted clock signal is sent through the TX CLK OUT jack. Data is returned to the FIREBERD for analysis through the RCV DATA jack. The synchronous returned clock is sent through the RCV CLK jack.

8.10.2.1 Timing Sources

Timing for the transmitted data signal may be determined by: (1) the FIREBERD's synthesizer; (2) a clock signal via the EXT TX CLK IN jack on the data interface; or (3) the FIREBERD rear panel BNC connector. The timing source used is selected by the FIREBERD's GEN CLK switch.

8.10.2.2 Timing Modes

Synchronous, asynchronous, or recovered timing can be used with this interface. With asynchronous timing, asynchronous data analysis can be performed at speeds to 20 kb/s. Recovered timing operates to 520 kb/s and provides a clock derived from the received data transitions. Synchronous timing operates to 15 Mb/s with this interface.

8.10.2.3 Self-Loop

The SELF LOOP switch on the front panel of the FIREBERD connects the interface's TTL-level transmit data and clock signals directly to the FIREBERD's TTL-level receive data and clock inputs. When in self-loop, the data interface's transmit data and clock signals are unaffected. The receive data and clock signal terminations are not affected by the self-loop test, although these signals do not reach the FIREBERD itself.

8.10.2.4 Applications Information

The following information is provided to aid in using the Lab Data Interface to best advantage. The interface switches mentioned in the following paragraphs are described in detail in Section 8.10.3.

When operating at a high bit rate or when driving long cables, TTC recommends that a terminating impedance be placed at the receiving end. The Lab Interface line drivers are low-impedance drivers and can operate into any load down to 50 ohms. The terminating impedance will serve to reduce ringing and cable crosstalk.

When supplying the data interface with an external clock input, note that the external clock signal must be in the same mode (e.g., Unipolar Unbalanced) as the transmit and receive data and clock signals. The transmit data and clock outputs are high level (greater than 19 dBm into 50 ohms) and caution should be used when connecting to sensitive equipment.

When operating in the Unipolar Unbalanced mode with the INPUT IMPEDANCE switch set to 8K OHMS, the transmit and receive data and clock signals can be directly connected to any TTL family circuits. The data interface inputs and outputs are compatible with all TTL families (e.g. Schottky TTL, LS TTL).

When operating in the Unipolar Balanced mode with the INPUT IMPEDANCE switch set to either 8K OHMS or 100 OHMS and with CLOCK PHASING set to "▼▼", the data interface should be functionally compatible with RS-422A systems.*

When operating in the Bipolar Unbalanced mode with the INPUT IMPEDANCE switch set to 8K OHMS and CLOCK PHASING set to "▼▼", the data interface should be functionally compatible with RS-232C, RS-423A, or Military Standard 188-114 bipolar unbalanced systems.*

When operating in the Bipolar Balanced mode with the INPUT IMPEDANCE switch set to 100 OHMS and CLOCK PHASING set to "▼▼". the data interface should be functionally compatible with Military Standard Mil-188-114 bipolar balanced, and with a pad on the outputs, V.35 systems.*

* Full compliance with the mentioned system parameters is not guaranteed.

8.10.3 Interface Switches

The Lab Data Interface has three switches, each with four positions, affecting the operation of the unit. By properly selecting the switch positions, any of up to 64 operating modes may be accommodated.

INPUT IMPEDANCE Switch

The INPUT IMPEDANCE switch affects the three inputs: RCV DATA, RCV CLK, and EXT TX CLK IN. When in the 50 OHMS position, the switch places a 50-ohm terminating resistor across each of the three inputs. When placed in the 75 OHMS position, a 75-ohm resistor terminates each of the three inputs. The 100 OHM position provides a 100-ohm terminating resistor and the 8K OHMS position allows the input signals to go directly to the line receiver integrated circuits with no other resistive termination.

MODE Switch

The MODE switch controls the mode of operation of all five data and clock jacks. Two major modes of operation are available: the Bipolar configuration (both positive and negative with respect to ground) and the Unipolar configuration (positive only with respect to ground). For each of these two modes, an Unbalanced arrangement (the outer conductor tied directly to ground) or a Balanced arrangement (the outer connector used as a complementing driver) are selectable.

Figure 8-8 shows the output voltage levels and the signal arrangements for each of the four selectable modes. Figure 8-9 shows the voltage levels required by the RCV DATA, RCV CLK, and EXT TX CK IN signal jacks for proper operation. Note that the voltage levels required are independent of the terminating impedances.

CLOCK PHASING Switch

When Auxiliary Function 05 is set to F-BERD (default), transmit- and receive-clock polarities are controlled by Auxiliary Functions 01 and 02. However, when Auxiliary Function 05 is set to INTF, the CLOCK PHASING switch controls the data and clock phase relationships for both the transmit and receive ports. For both the transmit and receive sides, either falling-edge valid or rising-edge valid can be selected. Figure 8-10 shows the four available switch positions and the resultant data/clock relationships.

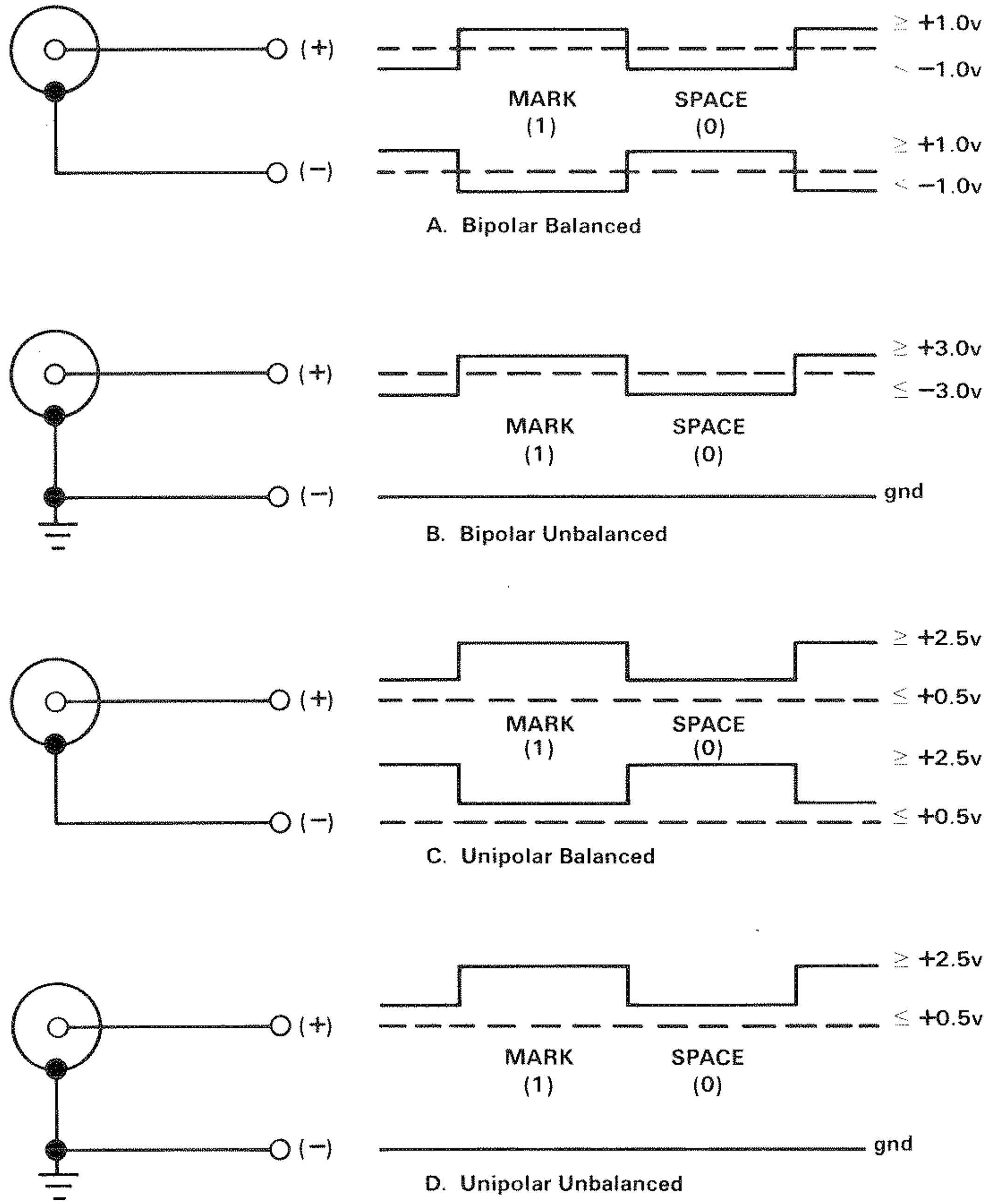
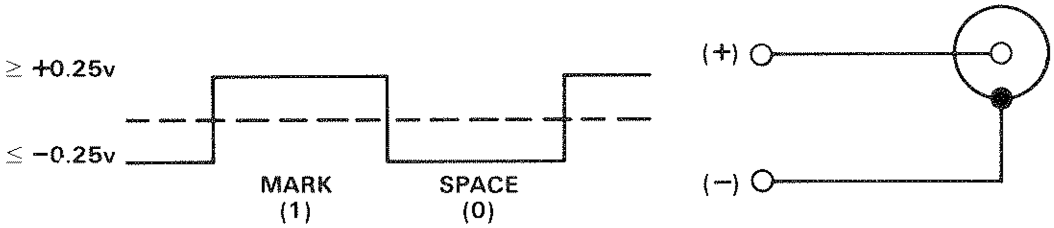
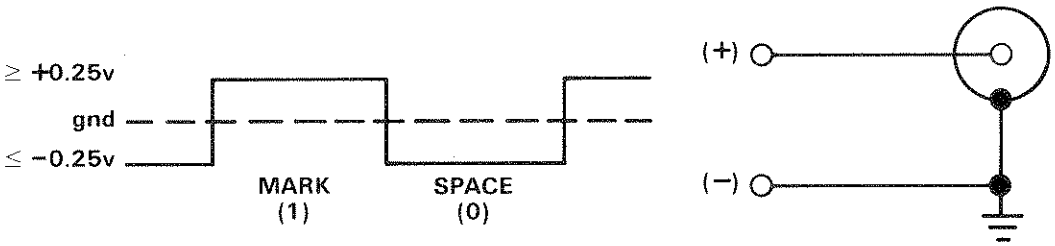


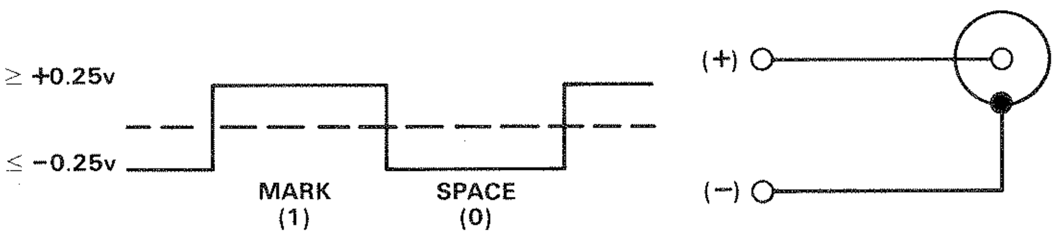
Figure 8-8
Selectable Operating Modes
Transmit Data and Clock Outputs



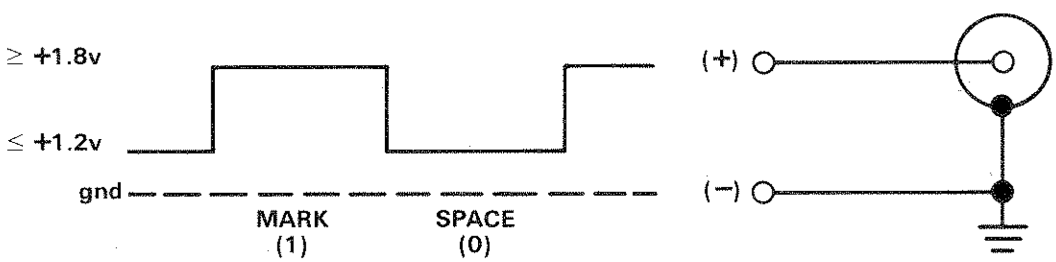
A. Bipolar Balanced (differential voltage)



B. Bipolar Unbalanced



C. Unipolar Balanced (differential voltage)



D. Unipolar Unbalanced

Figure 8-9
Selectable Operating Modes
Minimum Required Input Levels

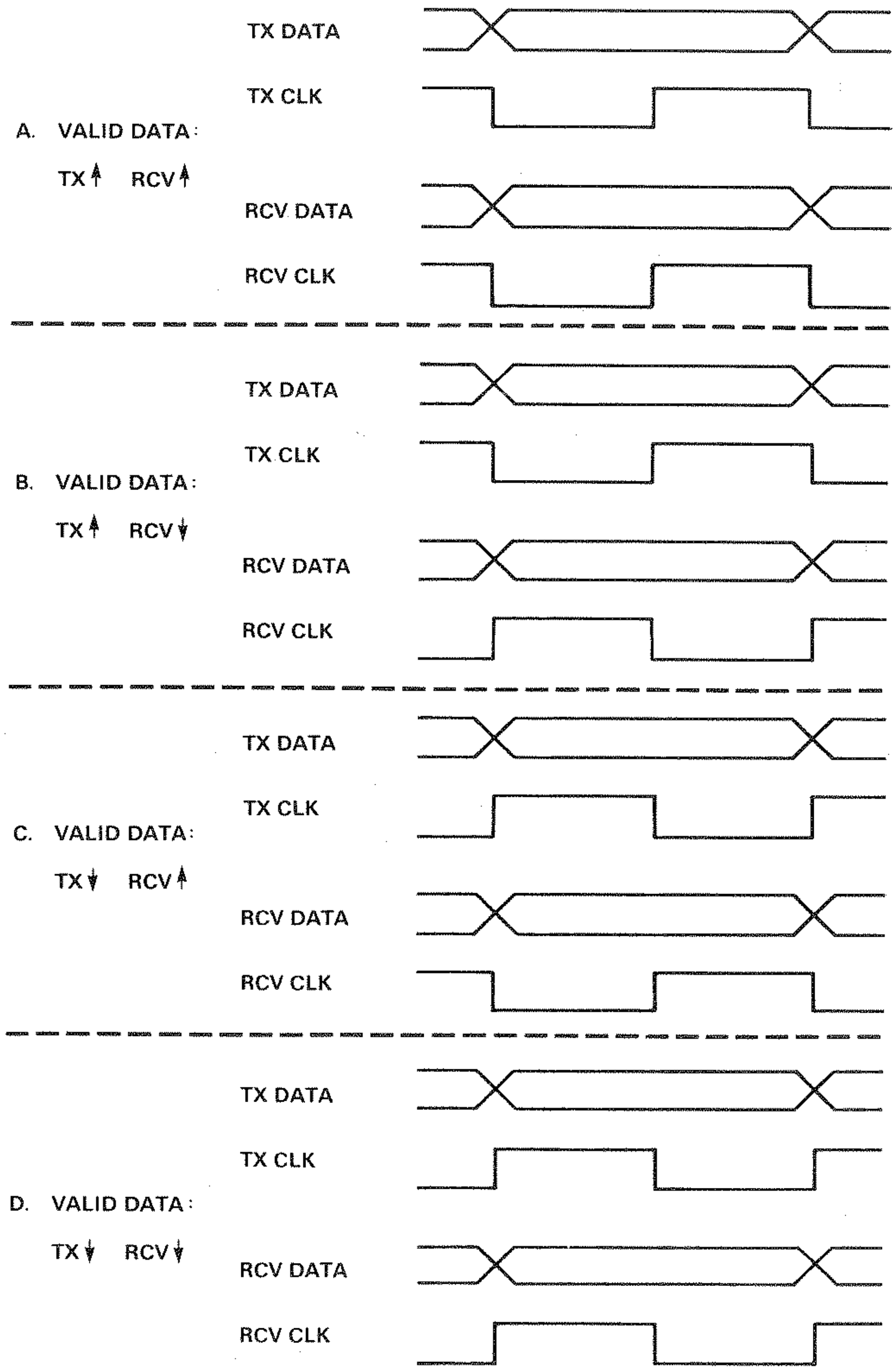


Figure 8-10
Clock Phasing Selections

8.10.4 Specifications

8.10.4.1 Output Levels

Bipolar Balanced:	• ± 2.0 volts minimum differential voltage (+19.0 dBm minimum into 50 ohms) (+17.3 dBm minimum into 75 ohms).
Bipolar Unbalanced:	• ± 3.0 volts dc minimum (+22.6 dBm minimum into 50 ohms) (+20.8 dBm minimum into 75 ohms).
Unipolar Balanced:	• ± 2.0 volts minimum differential voltage (+19.0 dBm minimum into 50 ohms) (+17.3 dBm minimum into 75 ohms).
Unipolar Unbalanced:	• +2.5 volts dc minimum Mark (logic 1). • +0.5 volts dc maximum Space (logic 0).

8.10.4.2 Input Levels

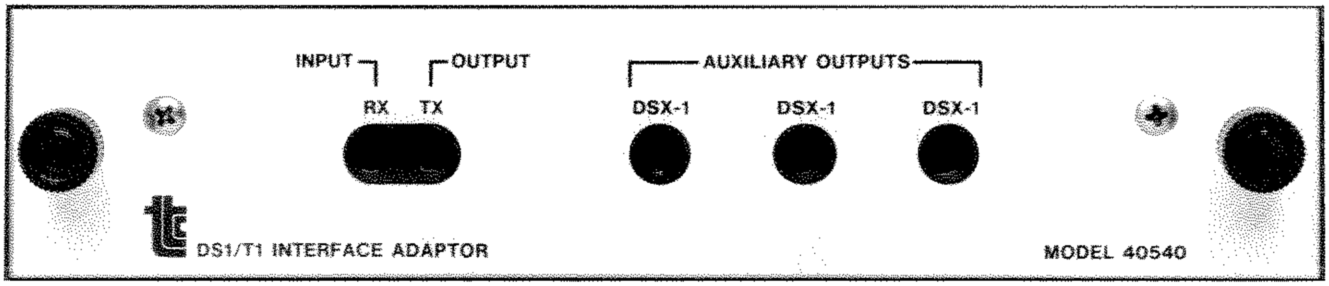
Bipolar Balanced:	• ± 0.25 volts minimum differential voltage (+1.0 dBm 50 ohms) (-0.5 dBm 75 ohms). • ±12.0 volts dc maximum with respect to FIREBERD ground.
Bipolar Unbalanced:	• +0.25 volts dc minimum Mark (logic 1). • -0.25 volts dc minimum Space (logic 0) (+1.0 dBm 50 ohms) (0.5 dBm 75 ohms).
Unipolar Balanced:	• ± 0.25 volts minimum differential voltage (+1.0 dBm 50 ohms) (-0.5 dBm 75ohms). • ± 12.0 volts dc maximum with respect to FIREBERD ground.
Unipolar Unbalanced:	• +1.8 volts dc minimum Mark (logic 1). • +1.2 volts dc maximum Space (logic 0).

8.10.4.3 Maximum Input Levels

The following voltage levels are not to be exceeded at any time (differential voltage for balanced operation, volts dc for unbalanced operation):

50 ohms	±3.3 volts (23.4 dBm)
75 ohms	±4.0 volts (23.3 dBm)
100 ohms	±4.7 volts (23.4 dBm)
8K ohms	±15.0 volts

8.11 DS1/T1 DATA INTERFACE (Model 40540)



8.11.1 Introduction

The DS1/T1 Data Interface allows the FIREBERD to test communications systems that use T1 (DS1) 1.544 Mb/s Digital Channel Service and similar systems. The T1 signals are serial, differential return-to-zero (RZ) pulses with alternate mark inversion (AMI) or bipolar with eight zero substitution (B8ZS) coding. The data interface will operate with either framed data (D4, Fe, or SLC*-96), required by Digital Access Crossconnect Switches (DACS) and channel banks, or with unframed data as used in unswitched networks.

8.11.2 Functional Description

The interface panel has five bantam jacks: a primary output, three secondary outputs, and the receiver input. Each of the four outputs is capable of sourcing DSX level signals; the primary output also has selectable line build-out. A simplex current path is also provided between the primary output and the receiver input.

Two THRU-DATA modes, where the received T1 data is retransmitted by the interface, provide repeater emulation (LLB) and APS testing capability (TLB). The TLB mode also allows jitterizing the retransmitted data as well as inserting BPVs, logic errors, or logic and BPV errors at user-selectable rates.

This interface is also compatible with all jitter options (Wideband Jitter Measurement, Spectral Analysis, and Jitter Generator) described in Section 9.

*SLC is a trademark of AT&T Technologies.

8.11.2.1 Timing Sources

Three transmit timing sources can be selected: (1) the clock recovered by the interface from the incoming T1 signal; (2) the synthesizer clock, which can provide an internal timing reference at or around 1.544 MHz; or (3) the external BNC input. Timing selection is made by using the GEN CLK switch on the FIREBERD front panel.

8.11.2.2 Self-Loop

The data interface includes a relay which is activated by the SELF LOOP switch on the FIREBERD's front panel. In Self-Loop mode, the primary T1 line driver is connected to the T1 line receiver. This provides quick verification of the FIREBERD and its data interface when performing bit error detection. The input and primary output connections need not be removed during the test because complete isolation is provided by the relay; the secondary outputs are unaffected by Self-Loop mode. Note that the FIREBERD's GEN CLK switch should not be set to the INTF position in Self-Loop mode and Thru mode should be off.

8.11.3 Interface Setup

The DS1/T1 Data Interface is controlled through the FIREBERD front panel. After installation, the interface is enabled by using the MENU pushbutton switch to select the INTF SETUP function; when a selection menu appears in the display, the soft key beneath the DS1/T1 selection should be pressed. A new menu with seven categories will then appear in the display. The DS1/T1 menu tree is shown in Figure 8-11. The seven main menu selections and their sub-selections are described below.

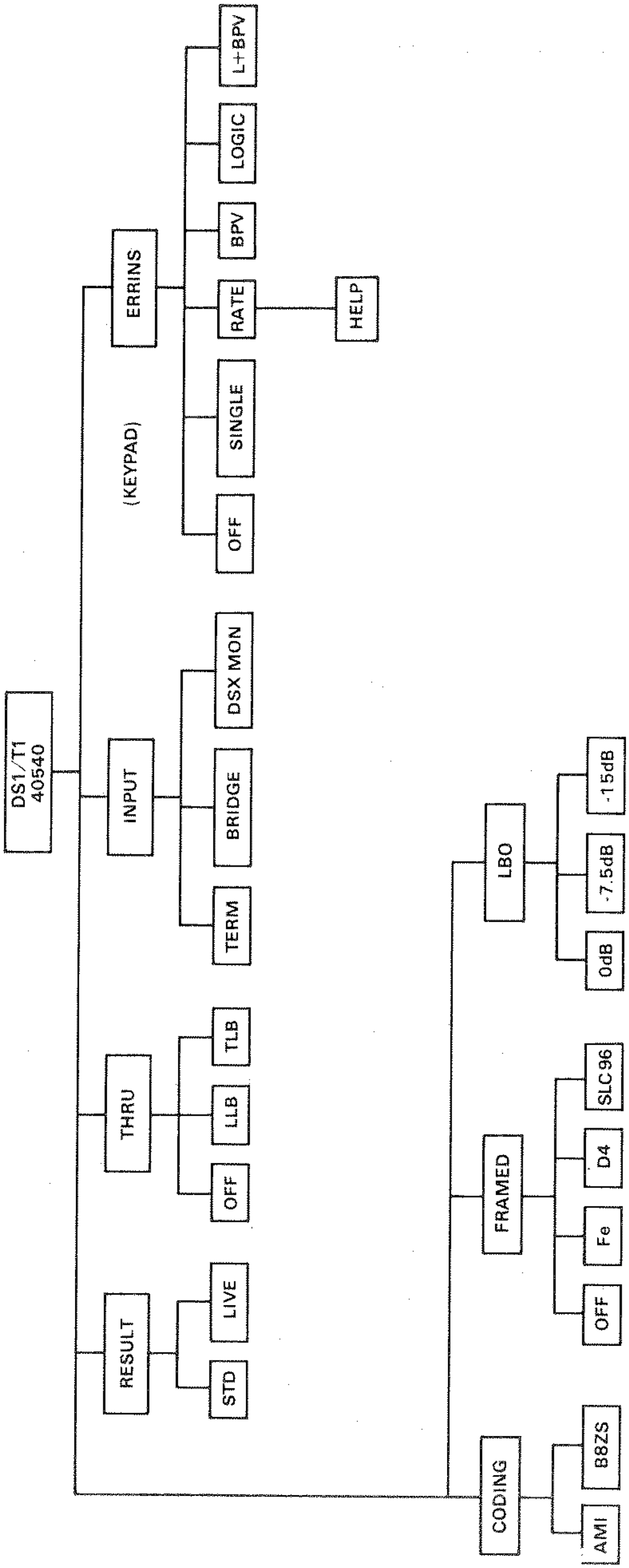


Figure 8-11
DS1/T1 Interface Menu Tree

RESULTS:

The RESULTS category allows selection of standard or live traffic results (standard and live results are described in Section 5).

(1) STD (default)— Selects standard analysis results. Bit error, bipolar violation, framing error, and CRC error analysis are performed. While frame synchronization and frame losses are detected, framing error and CRC error analysis are not performed. Framing error analysis is only performed when this selection is combined with either the FRAMED/D4 or FRAMED/SLC96 selection. CRC error analysis is only performed when this selection is combined with the FRAMED/Fe selection.

(2) LIVE— Selects live traffic analysis results. Bit error analysis is not performed; bipolar violations, framing error, and CRC error analysis are performed during the time in which the signal is present. Framing error analysis is only performed when this selection is combined with either the FRAMED/D4 or FRAMED/SLC96 selection. CRC error analysis is only performed when this selection is combined with the FRAMED/Fe selection.

THRU:

(1) OFF (default)— Selects the normal operation of the interface in which the received data is analyzed by the data receiver of the FIREBERD and transmit data is generated by the data generator of the FIREBERD.

(2) LLB— The Line Loopback selection causes the interface to act as a repeater. All data received will be echoed unchanged on the transmitter output. This setting can be used to emulate a CSU in line loopback mode. The received signal is still analyzed by the FIREBERD's data receiver. Note that the LLB selection disables the ERRINS and CODING sections of the menu; the data is not re-encoded prior to transmission.

(3) TLB— The Test Loopback selection emulates a CSU or channel bank in digital loopback. All received data is echoed on the transmitter output and the received signal is still analyzed by the FIREBERD's data receiver. ERRINS, CODING, and jitter generation (if option installed) remain active. BPVs and B8ZS coding are stripped from the received signal. The outgoing signal is re-encoded with AMI or B8ZS according to the CODING selection; BPV, LOGIC, or LOGIC & BPV errors are inserted according to the ERRINS selection. The data is jittered if the Jitter Generation option is installed and selected.

INPUT:

(1) TERM (default)— Selects normal operation in which the input is terminated by 100 ohms and will accept a T1 signal attenuated by 0 dB to 24 dB of cable attenuation.

(2) BRIDGE— This selection allows monitoring of T1 lines which are already terminated. In this mode, the input will exhibit an impedance greater than 1000 ohms, accepting signals attenuated by 0 dB to 24 dB of cable attenuation.

(3) DSX-MON— This selection conditions the receiver to operate with signals from DSX-Monitor ports. In this mode, the input accepts T1 signals resistively attenuated by 10 dB to 30 dB, and terminates the line with 100 ohms.

ERRINS:

(1) OFF (default)— Selects the normal mode of operation in which no errors are transmitted.

(2) SINGLE— This selection allows the insertion of a single error each time the soft key beneath SINGLE is pressed.

(3) RATE— This selection causes the insertion of bipolar violations at a user-selectable rate ranging from 1E-9 to 9E-3. To change the BPV insertion rate, press the RATE soft key. The cursor will be positioned under the mantissa; a new mantissa, from 1 to 9, may be entered. Once a number has been entered, the display will change to SET BPV RATE to indicate that a new rate is being entered,

and the cursor will move to the exponent. A new exponent, from 3 to 9, may be entered. The new rate is selected by pressing the ENTER key; the previously selected rate will continue to be transmitted until the ENTER key is pressed. NOTE: The synthesizer frequency must be set to 1544 kHz; any other setting causes the insertion rate to be inaccurate.

(4) BPV— Selects bipolar violations as the type of error to be inserted.

(5) LOGIC— Selects logic errors to be inserted. These errors may fall on any bit (data or framing).

(6) LOGIC & BPV— This error type emulates the type or errors which occur on repeated lines by adding or deleting a pulse after the T1 signal has been encoded with AMI or B8ZS coding. It should be noted that if B8ZS coding is selected, BPV and logic error multiplication will occur when the LOGIC & BPV error is inserted inside of a B8ZS code.

CODING:

(1) AMI (default)— This selection allows Alternate Mark Inversion (AMI) coding. AMI is encoded by transmitting a pulse of alternating polarity for every one (Mark) and no pulse for every zero (Space).

(2) B8ZS— This selection allows Bipolar with 8 Zero Substitution (B8ZS) coding, which also transmits a pulse of alternating polarity for every one and no pulse for every zero, except that strings containing eight consecutive zeros are replaced by a zero substitution code. In this case, the eight-zero sequence is replaced by 00V10V1, where 0 represents a Space, 1 represents a Mark, and V represents a bipolar violation (consecutive pulses of the same polarity). The B8ZS decoder will restore a detected B8ZS pattern to the original eight zeros.

FRAMED:

(1) OFF (default)— This selection (unframed data) performs data analysis on the full 1.544 Mb/s bandwidth of the T1 line; no framing bits are added upon transmission, and no data bits are stripped upon reception.

(2) D4— This selection allows the FIREBERD to transmit and analyze T1 signals with D4 (Superframe) framing. D4 framing occupies 8 kb/s of the 1544 kb/s bandwidth; the selected data pattern occupies the remaining 1536.kb/s. The D4 framing pattern is compatible with D1D, D2, D3, and D4 channel banks. When Live analysis mode is selected, both the Fs and Ft framing bits are examined for errors.

(3) Fe— This selection allows the FIREBERD to transmit and analyze T1 signals with Fe (Extended Superframe) framing. With Fe framed signals, the framing pattern occupies 2 kb/s, the CRC check bits occupy 2 kb/s, and a data link occupies 4 kb/s; the selected data pattern occupies the remaining 1536 kb/s. The data link is transmitted with an all-ones pattern and is examined only for the presence of a Yellow Alarm signal.

(4) SLC 96 This selection is used to transmit and analyze T1 signals with SLC 96 framing. SLC 96 framing and control channel occupy 8 kb/s of the 1544 kb/s bandwidth; the selected data pattern occupies the remaining 1536 kb/s. The transmitted framing pattern is D4 compatible. In Live Analysis mode, only the Ft framing bits are examined for errors since the Fs bits are time-shared with a control channel.

LBO:

(1) 0 dB (default)— This selection sets the primary output to the DSX level with no line build-out (0 dB attenuation).

(2) -7.5 dB— This selection provides a -7.5 dB line build-out, attenuating the primary output with 7.5 dB of simulated cable loss.

(3) -15 dB— This selection provides a -15 dB line build-out, attenuating the primary output with 15 dB of simulated cable loss.

8.11.4 FIREBERD Switches and Indicators

LOOP UP and LOOP DOWN Switches

The LOOP UP and LOOP DOWN switches will transmit loop-up and loop-down codes as described in Section 4.

MK (Mark) and SP (Space) Indicators

An input signal consisting of a continuous string of ones (Marks) or framed ones in the framed data mode will cause the MK indicator to be illuminated. Absence of an input signal for AMI code or an all-Space pattern for B8ZS code will cause the SP indicator to be illuminated. Under normal operating conditions both the SP and MK indicators should be illuminated.

FRM SYNC Indicator

The FRM SYNC indicator will be illuminated when a framing pattern is present in the received data. The framing pattern can be D1D, D2, D3 or D4 when FRAMED/D4 is selected, Fe when FRAMED/Fe is selected, or SLC 96 when FRAMED/SLC96 is selected. This indicator is functional in both Standard and Live analysis modes. The frame detection circuitry prevents false synchronization indications for unframed pseudorandom patterns.

CODE Indicator

The CODE indicator will signal the presence of B8ZS sequences on received data. AMI and B8ZS encoding are front panel menu selections; however, B8ZS decoding is automatically performed. The CODE indicator will illuminate independently of AMI coding selection if a B8ZS pattern is detected.

ALM1 Indicator

The ALM1 indicator will be illuminated when a yellow alarm condition is detected in the received framed data. When either the FRAMED/D4 or FRAMED/SLC96 selection is made, this indicator will be illuminated when 255 consecutive channel samples have bit 2 set to zero. If FRAMED/Fe is selected, the indicator will light when an alternating sequence of 1111 1111 0000 0000 is detected on the 4 kb/s data link for 16 consecutive periods.

ALM2 Indicator

The ALM2 indicator will light when an excess zero condition (16 or more consecutive zeros) is detected on the received data.

8.11.5 Data-Clock Test Points

This section describes the phase relationship between the DS1/T1 interface's data and clock signals and the FIREBERD's rear panel test points.

RCVR DATA: The signal at this test point will be high when the received data bit is a Mark and will be low when the received data bit is a Space. Framing bits are removed prior to this test point.

RCVR CLK: This test point provides a TTL signal derived from the clock recovered from the data pulses. The phase relationship between this signal and RCVR DATA is such that mid-bit data sampling occurs at the rising edge transition of the RCVR CLK signal. This test point is inactive during received framing bits.

GEN DATA: This test point provides the TTL equivalent of the transmitter data. The signal at this test point will be high when transmitting a Mark and will be low when transmitting a Space. This test point is inactive during framing bits.

GEN CLK: This test point provides a TTL signal derived from the transmitter clock. The phase relationship between this signal and GEN DATA is such that mid-bit data sampling occurs at the rising edge transition of the GEN CLK signal. This test point is inactive during framing bits.

8.11.6 Specifications

8.11.6.1 T1 Transmitter Specifications

Connectors

Connector Type: • Bantam.

Configuration: • Tip-Ring-Sleeve; Sleeve connected to ground, differential signal on Tip and Ring.

Pulse Mask

All specifications are for 0 dB line build-out and with output terminated in 100-ohm resistive load. Meets pulse masks given in CCITT recommendation G.703 and in Bell Publications CB113, CB119, CB143, PUB 41451, PUB 62411, and PUB 62508.

Pulse Amplitude: • ±3 ±0.3 volts with a maximum imbalance of ±0.15 volts.

Half Amplitude Pulse Width: • 324 ±24 ns with a maximum imbalance of ±15 ns.

Rise and Fall Times: • 100 ns maximum (10% to 90%).

Trailing Edge Overshoot: • 10% to 30% of pulse height with decay to 10% of pulse height within 400 ns.

Line Codes: • Bipolar (pseudoternary); selectable AMI or B8ZS.

Loopback Code Generation

Loop Up Code: • Repetitive "10000."
Loop Down Code: • Repetitive "100."

Line Buildout (Primary Circuit Only)

-7.5dB LBO • -7.5 dB ±1 dB attenuation at 772 kHz.
-15dB LBO • -15.0 dB ±1 dB attenuation at 772 kHz.

8.11.6.2 T1 Receiver Specifications

Connectors

Connector Type: • Bantam.

Configuration: • Tip-Ring-Sleeve; Sleeve connected to ground, differential signal on Tip and Ring.

T1 Input Circuit

Input Impedance:
• TERM or DSX-MON position 100 ohms ±5%.
• BRIDGE position 1000 ohms minimum.

Input Level: • ±3 volts (DSX-1) nominal, with 0 dB to 24 dB cable attenuation (BRIDGE, TERM), 10 dB to 30 dB resistive attenuation (DSX-MON).

Jitter Analysis Input Level:

- TERM ±3 volts (DSX-1) with 0 dB to 15 dB resistive attenuation.
- BRIDGE ±3 volts (DSX-1) with 0 dB to 24 dB cable attenuation.
- DSX-MON +3 volts (DSX-1) with 10 dB to 30 dB resistive attenuation.

Thru Data LLB Input Level:

- TERM ±3 volts (DSX-1) with 0 dB to 24 dB cable attenuation.
- BRIDGE ±3 volts (DSX-1) with 0 dB to 24 dB cable attenuation.
- DSX-MON ±3 volts (DSX -1) with 10 dB to 30 dB resistive attenuation.

Thru Data TLB Input Level:

- TERM ±3 volts (DSX-1).
- BRIDGE ±3 volts (DSX-1) with 0 dB to 24 dB cable attenuation.
- DSX-MON ±3 volts (DSX-1) with 10 dB to 30 dB resistive attenuation.

Data Rate Range:

- 1.544 Mb/s ±500 b/s minimum.

Line Code:

- Bipolar (pseudoternary), AMI with automatic detection of B8ZS coding.

Jitter Tolerance:

- Meets jitter mask given in CCITT Recommendation G.703 and in Bell publications PUB 41451 and PUB 62411.

Excess Zeros Detection:

- 16 or more sequential zeros.

8.11.6.3 Simplex Current Path

All simplex current specifications are for OUTPUT (TX) connector Tip and Ring shorted together and INPUT (RX) connector Tip and Ring shorted together.

Current:

- 60 mA nominal, 145 mA maximum.

Voltage Drop:

- 7.3 ±0.5 volts at 60 mA.

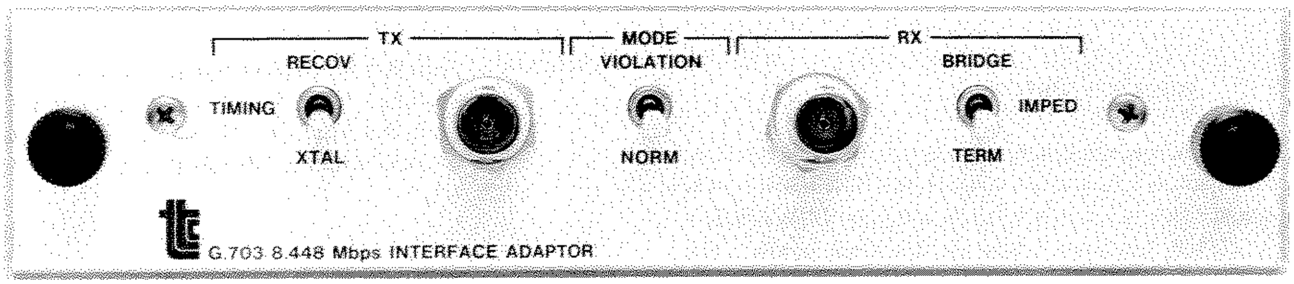
Polarity:

- Bi-directional—either pair may be positive with respect to the other pair.

Breakdown Voltage:

- ±150 volts minimum from Tip and Ring to Chassis Ground.

8.12 8448 kb/s G.703 DATA INTERFACE (Model 30524)



8.12.1 Introduction

The 8448 kb/s G.703 Data Interface allows the FIREBERD 6000 to test data communications equipment utilizing the interface specification in Section 7 of CCITT Recommendation G.703. The G.703 signals are serial, return-to-zero (RZ) pulses with high density bipolar three (HDB3) encoding. This interface will operate with the 75-ohm "preferred solution" of Recommendation G.703.

In addition to making the conversion between the TTL levels used on the FIREBERD and the G.703 signals, the interface has the following capabilities:

- It accepts degraded signals, regenerates the data, and recovers the clock timing from the data.
- It permits HDB3 coding violations in the received data to be detected by the FIREBERD.

To conform with CCITT Recommendation O.151 for a 2^{15}-1 pseudorandom pattern, all data leaving the interface is inverted with respect to the "normal." Each logical one generated by the FIREBERD is transmitted as the absence of a pulse (Space) and each logical zero is transmitted as the presence of a pulse (Mark).

8.12.2 Functional Description

There are two operating modes provided by the 8448 kb/s G.703 Data Interface. The normal mode of operation is bit error detection, in which coding violations are ignored and the received data is sent to the FIREBERD for bit error analysis.

The other method of operation is coding violation detection; circuitry within the interface detects coding violations in the received data. When coding violation detection is in use, the output of the FIREBERD is looped back to its input by the data interface and one error is inserted in the looped-back pattern for each coding violation in the incoming signal. The output of the G.703 data interface is the pattern selected on the FIREBERD front panel. This mode allows live traffic to be monitored by the data interface; the data is only checked for coding violations and is not expected to match the pattern selected on the FIREBERD front panel. A fail-safe circuit automatically breaks the loopback path when no G.703 input signal is detected.

8.12.2.1 Timing Sources

Four clock sources are available for use as the source of transmit timing: (1) a crystal oscillator located on the data interface; (2) the clock recovered from the incoming G.703 data; (3) the FIREBERD's synthesizer; or (4) an externally supplied signal input through the FIREBERD rear panel BNC connector. The selection is made by using the GEN CLK switch on the FIREBERD front panel in conjunction with the INTF SETUP menu selections.

8.12.2.2 Self-Loop

The SELF LOOP switch on the FIREBERD front panel activates a relay in the data interface which connects the G.703

line driver to the G.703 line receiver. This allows quick verification of the FIREBERD and its interface in bit error detection operation. The input and output connectors need not be removed during the test because complete isolation is provided by the relay when testing. Note that a timing source must be provided for the loop testing, and the RECOV position of the interface's TIMING switch should not be used.

8.12.3 Interface Setup

All of the functions of the 8448 kb/s G.703 Data Interface may be controlled by the switches on the FIREBERD 6000 front panel. This is accomplished by using the FIREBERD's INTF SETUP function, which is described below. The switches on the interface are disabled when the FIREBERD is in control. If desired, the interface may be controlled through its own switches by using Auxiliary Function 05. When this auxiliary function is set to INTF, the interface operates exactly as it would in a FIREBERD 1500A or 2000. See the 8448 kb/s G.703 Data Interface Operating Manual for information on operation of the interface with a FIREBERD 1500A or 2000.

When the interface is installed in the FIREBERD 6000 and is to be controlled through the FIREBERD front panel, the MENU pushbutton switch should be pressed to select the INTF SETUP function. Two selections will then appear: INT232 and 8MG703. Pressing the 8MG703 soft key selects the 8448 kb/s G.703 Data Interface. After 8MG703 has been selected, three more selections appear in the display: TIMING, MODE, and IMPED. Figure 8-12 shows the 8448 kb/s G.703 interface menu tree. Described below are the choices available under the TIMING, MODE, and IMPED selections.

TIMING:

These two soft keys select the source of transmit timing when the FIREBERD's GEN CLK switch is in the INTF position.

(1) XTAL— Selects as the transmit timing source the crystal oscillator on the interface.

(2) RECOV— Selects as the transmit timing source the clock recovered from the incoming data stream. Note that the RECOV selection should not be used with the FIREBERD in self-loop.

MODE:

These two soft keys select the operating mode of both the interface and the FIREBERD.

(1) BPV— This selection instructs the FIREBERD to detect HDB3 coding violations.

(2) NORM— This selection instructs the FIREBERD to detect bit errors.

NOTE: The NORM soft key should be selected when performing a self-loop test. If the BPV soft key is selected during a self-loop test, operation of the interface and the FIREBERD should appear the same as when the NORM soft key is selected. However, the ability of the violation circuitry to detect coding violations is not checked because no coding violations are generated.

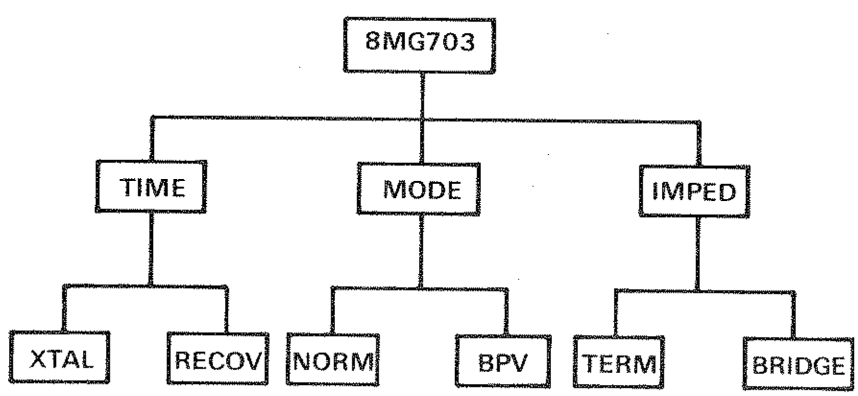


Figure 8-12
8448 kb/s G.703 Interface Menu Tree

IMPED:

These two soft keys determine the input impedance of the data interface.

(1) BRIDGE— Selects the input impedance to be greater than 1000 ohms.

(2) TERM— Selects the input impedance to be 75 ohms.

8.12.4 Interface Connectors

The 8448 kb/s G.703 Data Interface has BNC connectors for linking the interface to the circuit under test. The connectors provide bipolar unbalanced input and output with the shields connected to chassis ground and the center conductor carrying the G.703 signal. For instructions on disconnecting the RX shield from chassis ground, consult TTC's Customer Service Department.

8.12.5 MK (Mark) and SP (Space) Indicators

The FIREBERD's MK indicator will be illuminated whenever a Space is received on the input signal. The SP indicator will be illuminated whenever a Mark (pulse) is received on the input signal. Under normal operating conditions both the MK and the SP indicators should be illuminated.

8.12.6 Data-Clock Test Points

This section describes the phase relationship between the 8448 kb/s G.703 Data Interface's data and clock signals and the FIREBERD's rear panel test points.

RCVR DATA: The signal at this test point will be a TTL high when the received data bit is a Space (no pulse) and will be a TTL low when the received data bit is a Mark (pulse).

RCVR CLK: This test point provides a TTL signal derived from the clock recovered from the data pulses. The phase relationship between this signal and RCVR DATA is such that the mid-bit data sampling occurs at the rising-edge transition of the RCVR CLK signal.

GEN DATA: The signal at this test point will be a TTL high when transmitting a Space and will be a TTL low when transmitting a Mark.

GEN CLK: This test point provides a TTL signal derived from the transmitter clock. The phase relationship between this signal and GEN DATA is such that the mid-bit data sampling occurs at the rising-edge transition of the GEN CLK signal.

8.12.7 Specifications

8.12.7.1 General

Operating bit rate:
- 8448 kb/s nominal.

Coding:
- HDB3 (High Density Bipolar with 3 Zero Substitution).

Connectors:
- BNC. Tx Jack: signal on inner conductor, shield grounded. Rx Jack: Signal on inner conductor, shield grounded.

8.12.7.2 Drivers

Pulse shape:
- Conforms to Figure 16 of CCITT Recommendation G.703.

Nominal peak voltage of a Mark (pulse):
- 2.37 volts ±10% into 75 ohms.

Peak voltage of a Space (no pulse):	• 0 ± .24 volts into 75 ohms.
Nominal pulse width:	• 59 ns.
Ratio of amplitudes of positive to negative pulses at midpoint of pulse:	• 0.95 to 1.05.
Ratio of widths of positive to negative pulses at nominal half amplitudes:	• 0.95 to 1.05.

8.12.7.3 Receivers

Input Impedance, Term:	• 75 ohms with 20 dB minimum return loss.
Input Impedance, Bridge:	• 1000 ohms minimum.
Sensitivity:	• -6 dB.
Operating bit rates:	• 8448 kb/s ± 30 ppm.

8.12.7.4 Crystal Oscillator

Frequency:	• 8448 kb/s
Accuracy and Stability:	• 30 ppm, 0°C to 50°C.

Richard Trask NCR

SECTION 9
JITTER OPTIONS

This section contains information on the jitter options available with the FIREBERD 6000. The first half of the section describes the components of DS1 Jitter; the second half of this section describes the components of G.703 Jitter.

9.1 DS1 JITTER GENERATION AND MEASUREMENT

This section describes DS1 jitter generation and measurement, specifically:

- DS1 Wideband Jitter Measurement (Option 6001)
- DS1 Jitter Spectral Analysis (Option 6002)
- DS1 Jitter Generation (Option 6003)

Each of these options may be used with the DS1/D4/Fe Data Interface (Model 40460) or the DS1/T1 Data Interface (Model 40540). The three options operate simultaneously.

Jitter on a T1 line is the phase displacement in time of a T1 pulse from its ideal position. There are two parameters associated with jitter that can be measured. The first is the amplitude of the phase displacement, which varies with time. The amplitude is measured in unit intervals (UI), where one UI is equal to the amount of time associated with one T1 bit period, or 648 ns. The second parameter, measured in Hz, is the frequency at which the amplitude is changing.

The DS1 Wideband Jitter Measurement option measures jitter over a wide frequency band (10 Hz to 40 kHz). This measurement follows the guidelines set forth in CCITT Recommendation O.171. The DS1 Jitter Spectral Analysis option performs 40-band spectrum analysis on the wideband jitter; the DS1 Wideband Jitter Measurement option must be installed to use the Spectral Analysis option. The DS1 Jitter Generator option can apply a sine, square, ramp, or triangle wave jitter signal to an internal, external, or recovered T1 clock signal.

9.1.1 DS1 Wideband Jitter Measurement Option

The DS1 Wideband Jitter Measurement option receives a jittered clock signal from either the DS1/D4/Fe Data Interface (Model 40460) or the DS1/T1 Data Interface (Model 40540). The Wideband Jitter option then demodulates the jittered clock and makes the following measurements.

- Peak-to-peak jitter (1SEC JTR)
- Maximum peak-to-peak jitter (MAX JTR)
- Jitter hits count (JTR HITS)

9.1.1.1 Functional Description

The DS1 Wideband Jitter Measurement option demodulates the jittered clock by generating a voltage that is proportional in amplitude to the amplitude of the phase displacement. This voltage may then be easily measured. This full bandwidth jitter voltage is subsequently sent to two places: (1) the measurement circuits on the Wideband Jitter option; and (2) the DS1 Jitter Spectral Analysis option for further analysis.

After the demodulated jitter signal is sent to the DS1 Jitter Spectral Analysis option, an 8 kHz highpass filter may be selected, if desired. This filter allows only the high frequency components to be measured. The jitter signal, either with or without the filter, is buffered and sent to the rear panel BNC connector labeled DEMOD JITTER OUT. The jitter voltage is finally measured using a peak-to-peak measurement circuit.

The Wideband Jitter option also measures jitter hits. A jitter hit occurs when the jitter exceeds a user-selectable threshold. It is the absolute value of the demodulated jitter that is measured. Therefore, both positive jitter peaks and negative jitter peaks are compared to the peak jitter threshold.

9.1.1.2 Operation

Figure 9-1 shows the menu tree for all of the jitter options. The menu tree is accessed by pressing the MENU pushbutton switch to the JITTER position. The various DS1 Wideband Jitter Measurement modes are accessed by pressing the WDBAND soft key. Three more selections will then appear in the display: FULL, >8 kHz, and HELP. Pressing the FULL soft key causes the highpass filter to be removed from the jitter measurement path. Pressing the >8 kHz soft key causes the highpass filter to be inserted in the jitter measurement path. Pressing the HELP soft key displays

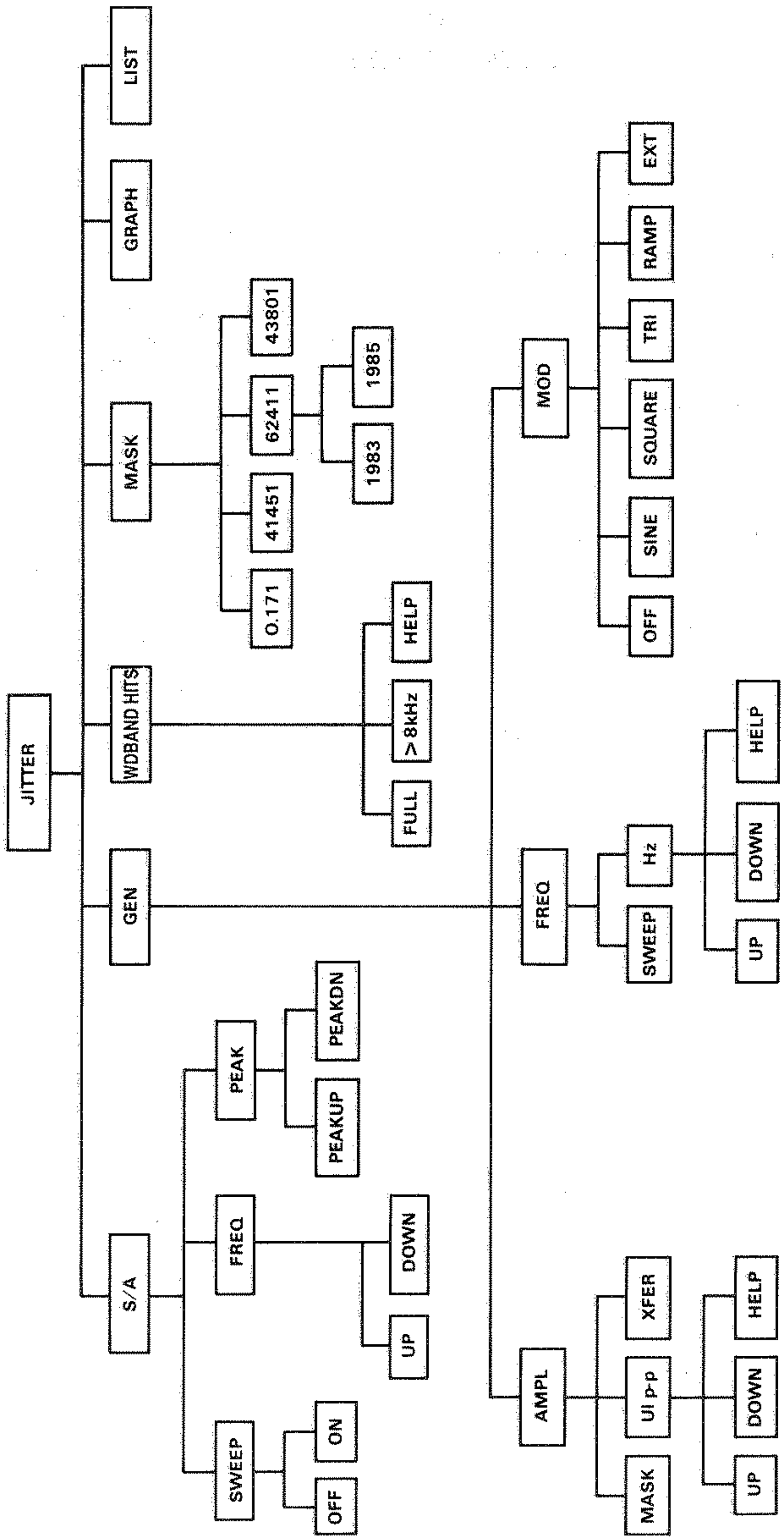


Figure 9-1
Jitter Menu Tree

the possible range for a jitter threshold. The peak jitter threshold may be entered via the keypad by typing two digits (0.1 to 6.5 UI) and pressing ENTER; there is no soft key for this function.

The jitter results—1SEC JTR, MAX JTR, and JTR HITS—are found in the SIGNAL category of results. The 1SEC JTR result is the maximum jitter measured over the last second. The MAX JTR result is the maximum of the 1SEC JTR results since the last test restart. If the DS1 Wideband Jitter Measurement option is not installed, these results will not be accessible.

9.1.1.3 Specifications

Data Rate:	• 1544 kb/s.
Bandwidth:	• -20 dB/decade below -3 dB point at 2 Hz. • -120 dB/decade above -3 dB point at 68 kHz.
Selectable High Pass Filter:	• -20 dB/decade below -3 dB point at 8 kHz.
Measurement Accuracy:	• TERM with 0-20 dB resistive attenuation. • DSX-MON with 0-30 dB resistive attenuation. ±5% ±.04 UI at 10 Hz and 1 kHz. ±7% ±.04 UI at 1 kHz and 10 kHz. ±10% ±.06 UI at 10 kHz and 40 kHz. • BRIDGE with 0-24 dB cable attenuation ±7% ±0.3 UI at 10 Hz and 40 kHz.
Range:	• 0 to 13.00 UI p-p.
Resolution:	• 0.01 UI.
Jitter Hit Threshold:	• Maximum—6.5 UI. • Resolution—0.1 UI.
JITTER OUT BNC:	• Scale—0.1 V/UI. • Range—0—1.3 V peak-to-peak. • Drive Capability—50 ohms minimum termination.

9.1.2 DS1 Jitter Spectral Analysis Option

The DS1 Jitter Spectral Analysis option consists of a board that plugs into the Wideband Jitter option and cannot be used without that option in place. The spectrum analyzer measures the maximum peak-to-peak jitter in 40 frequency bands from 10 Hz to 40 kHz and displays the result in unit intervals (UI) peak-to-peak. This option enables the following measurements.

- Jitter amplitude measured in UI peak-to-peak with a continuous sweep of 40 frequency bands.
- Continuous jitter amplitude measurement in UI peak-to-peak of 1 to 40 frequency bands.
- Percent of mask for each band.

9.1.2.1 Functional Description

The DS1 Jitter Spectral Analysis option is offered with the FIREBERD 6000 to allow the user to determine the spectral content of timing jitter in a T1 system. This is accomplished by filtering the wideband jitter signal obtained from the DS1 Wideband Jitter option into 40 discrete frequency bands. The output of each filter is then measured using a peak-to-peak measurement circuit. The Spectral Analysis option can either (1) continuously measure 1 of the 40 frequency bands, which constantly updates the jitter amplitude for that frequency, or (2) continually sweep through the 40 frequency bands. When the sweep is enabled, each jitter value stored in the 40 frequency bands is compared to the measured value of the corresponding frequency, and the maximum value is saved until a test restart occurs.

The sweep function of the Spectral Analysis option operates synchronously with the sweep function of the DS1 Jitter Generation option. The jitter generator will generate jitter at a specific frequency, the spectrum analyzer will measure that frequency band, and both options will increment to the next frequency band. This capability can be used to test equipment for bit errors or jitter attenuation characteristics. (See the Functional Description in Section 9.1.3.1 for more information.)

The time required to complete one sweep of the spectrum analyzer depends on the jitter generator sweep. With the jitter generator sweep turned off, it takes approximately 45 seconds to complete one sweep of the spectrum analyzer. With the jitter generator sweep turned on, it takes approximately 85 seconds to complete one sweep; jitter is generated for approximately 1 second before a measurement is taken.

Care should be exercised in comparing the spectral analysis results with the wideband jitter result discussed in Section 9.1.1. The Wideband Jitter option makes continuous measurements over the entire 10 Hz to 40 kHz band. The result obtained with that option is a true indication of the maximum jitter in that band. This is in contrast to the spectrum analyzer which looks at a much narrower bandwidth for each measurement. In a normal system, jitter measured in the 40 spectrum analyzer bands will add in a very complex and non-linear fashion. As a result, it is important that the wideband measurement be used in conjunction with the spectrum analyzer measurements in determining system performance.

9.1.2.2 Operation

The DS1 Spectral Analysis measurement modes are accessed in the JITTER menu tree (see Figure 9-1) by pressing the S/A soft key. At this level in the menu, the current frequency and the measured amplitude at that frequency are displayed. If the sweep is disabled, the frequency displayed is static, and the amplitude at that frequency is updated as each measurement is completed. If the sweep is enabled, the frequency displayed sweeps along with the measurement, which allows the user to know the status of the sweep at any point in time. In addition, the amplitude displayed for each frequency is the maximum amplitude measured in that band since the last test restart.

Pressing the SWEEP soft key causes the selections ON and OFF to be displayed; selecting either the ON or OFF soft key places the sweep function in the corresponding state. Pressing the FREQ soft key accesses the UP and DOWN soft key results which can be used to scroll through the 40 frequency bands. When the sweep is enabled, the amplitude displayed is the maximum value stored for that band. When the sweep is disabled, either of the UP or DOWN soft keys changes the frequency band currently being measured to the band selected by the soft key.

Pressing the PEAK soft key accesses the soft keys PEAKUP and PEAKDN, which enable the user to quickly find any peaks in the spectrum when the sweep is enabled. A peak is defined as those results that are immediately preceded by and followed by lower readings. The PEAKUP soft key will find the next higher frequency jitter peak and the PEAKDN soft key will find the next lower frequency jitter peak. Since there are no peaks when the sweep is disabled, the PEAK soft key is not visible if the sweep is off.

Two results are displayed in the SIGNAL category of results. The S/A results contain the frequency of the measurement and the amplitude being measured by the spectrum analyzer. If the sweep is enabled, both the frequency and amplitude sweep through the 40 bands, displaying the highest amplitude measured in each band. If the sweep is disabled, the frequency is displayed and the amplitude of that frequency is continually updated with each new measurement. With the sweep disabled, the frequency being measured by the spectrum analyzer can be changed from any menu by pressing SHIFT followed by the key to increment the frequency to the next higher band, or by pressing SHIFT followed by the key to decrement to the next lower frequency band.

The second available result is %MASK, which compares the measured amplitude of a frequency band to the selected mask value of that frequency. This result indicates whether the jitter amplitude is within the limits specified for a given mask; for example, 110 %MASK is 10% above the allowable jitter level and 50 %MASK is half the allowable jitter level (see Section 9.1.4). If the sweep is disabled, the %MASK corresponds to the frequency being measured. If the sweep is enabled, the %MASK corresponds to the largest %MASK of the 40 frequency bands. The 40 points can all be obtained through the printer or remote control with the jitter list command.

Pressing the LIST soft key in the JITTER menu sends a list of the jitter spectrum analyzer frequency band measurements and their corresponding %MASK values to the printer port. If the jitter spectrum analyzer sweep is turned off, only one frequency in the list is printed and the others remain blank.

Pressing the GRAPH soft key in the JITTER menu generates a graph of the DS1 Jitter Spectral Analysis results. The graphics are EPSON-compatible and can be used with TTC's PR-85 Printer. The results are graphed only when the jitter spectrum analyzer sweep is on.

9.1.2.3 Specifications

Data Rate:	• 1544 kb/s.
Frequency Points/ Measurement Bandwidths:	• See Table 9-1.
Filter Bandwidths:	• Specified at the .1 dB and 3 dB points with 36 dB octave roll-off (see Figure 9-2 and Table 9-2).
Accuracy:	• ±10% of reading ±0.05 UI.
Resolution:	• 0.01 UI.
Range:	• 01 to 12.5 UI.

Table 9-1
Frequency Points and Measurement Bandwidths

10Hz BW	33 Hz BW	100 Hz BW	333 Hz BW	1 kHz BW	3.3 kHz BW
10 Hz	100 Hz	300 Hz	1.00 kHz	3.00 kHz	10.0 kHz
20 Hz	133 Hz	400 Hz	1.33 kHz	4.00 kHz	13.3 kHz
30 Hz	166 Hz	500 Hz	1.66 kHz	5.00 kHz	16.6 kHz
40 Hz	200 Hz	600 Hz	2.00 kHz	6.00 kHz	20.0 kHz
50 Hz	233 Hz	700 Hz	2.33 kHz	7.00 kHz	23.3 kHz
60 Hz		800 Hz		8.00 kHz	26.6 kHz
70 Hz					30.0 kHz
80 Hz					33.3 kHz
					36.6 kHz
					40.0 kHz

Figure 9-2
Filter Bandwidth

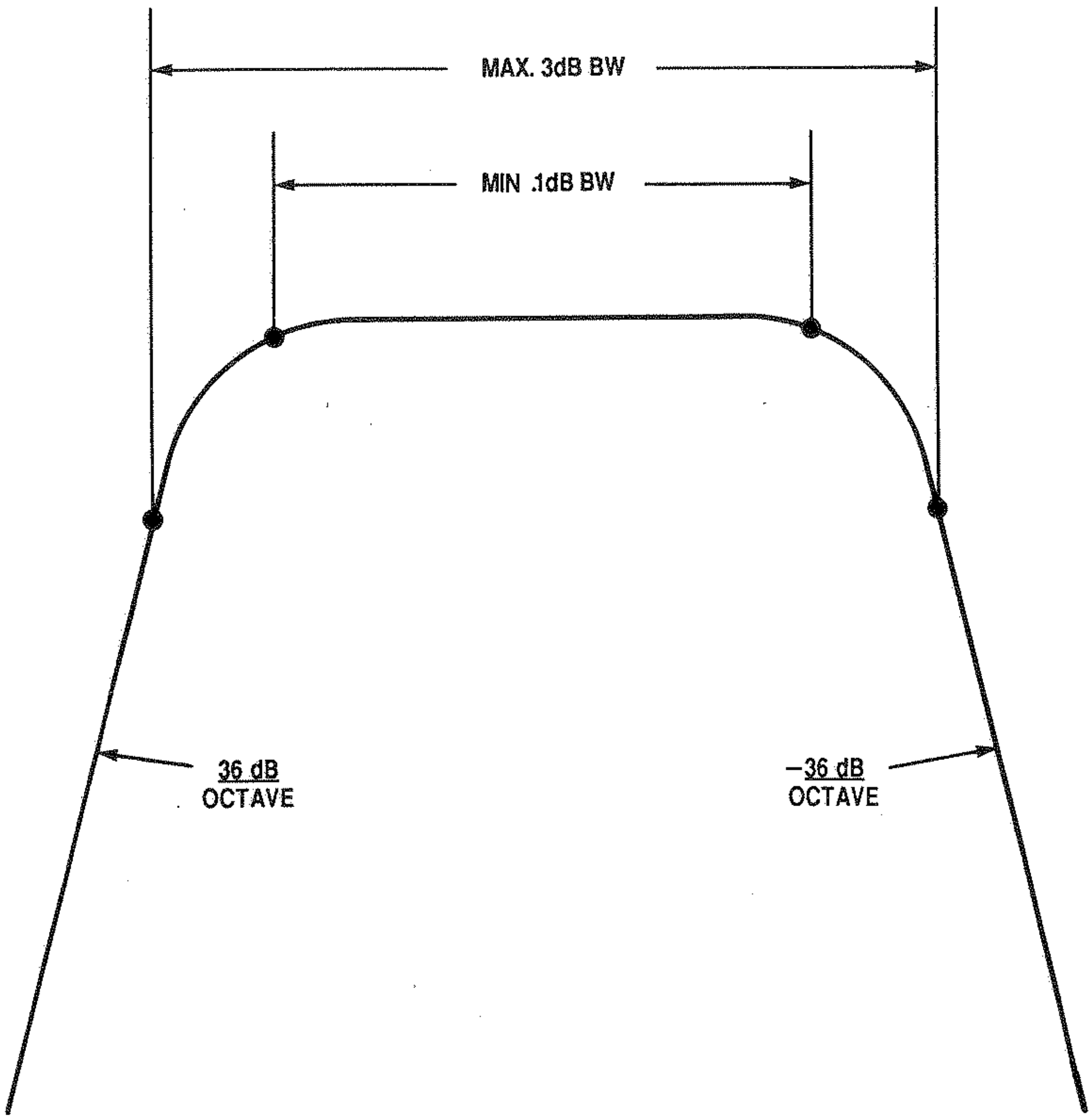


Table 9-2
Filter Bandwidths

Nominal Bandwidth	Minimum .1 dB Bandwidth	Maximum 3 dB Bandwidth
10 Hz	9.0 Hz	11.9 Hz
33 Hz	30.1 Hz	39.4 Hz
100 Hz	89.5 Hz	117 Hz
333 Hz	301 Hz	391 Hz
1 kHz	904 kHz	1.17 kHz
3.3 kHz	3.02 kHz	3.91 kHz

9.1.3 DS1 Jitter Generation Option

The DS1 Jitter Generation option can phase modulate a T1 signal using an internally generated waveform, an external waveform, or a combination of both to produce T1 jitter with the DS1/D4/Fe Data Interface (Model 40460) and the DS1/T1 Data Interface (Model 40540). Jitter can be produced on an internal clock, external clock, recovered clock, and looped-thru data. The following list summarizes the features of the DS1 Jitter Generation option.

Frequency:

- User-selectable frequency, 3-digit resolution
- Can automatically sweep the 10 Hz to 40 kHz band in 40 steps

Amplitude:

- User-selectable amplitude, 0 to 13 UI peak-to-peak .02 UI resolution
- Can automatically set amplitude to selected mask level
- Can automatically set amplitude to 50% of the selected mask level

Modulation:

- Sine
- Square
- Triangle
- Ramp
- External

Clock Sources:

- Internal
- External
- Recovered (requires Option 6001)

9.1.3.1 Functional Description

The DS1 Jitter Generation option can apply jitter to a T1 signal by phase modulating the T1 signal with another waveform. This waveform can be externally generated or internally generated by the jitter generator.

There are three clock sources which may be used with the jitter generator. When internal timing is selected, a 1.544 MHz oscillator on the jitter generator is used. (The frequency synthesizer is used to generate the frequency of the jitter modulation.) An external clock source can be used by applying the clock source to the FIREBERD's GEN CLK IN rear panel BNC connector. The third clock source which can be used is the recovered clock extracted from the DS1/T1 interface's receive input. This clock can only be used when the DS1 Wideband Jitter Measurement option is installed since the jitter generator uses as the recovered clock the dejitterized clock from the Wideband Jitter option.

There are three parameters to be selected with the DS1 Jitter Generation option: modulation type, frequency, and amplitude. In addition to external modulation, the jitter generator allows four types of internal modulation. The waveform synthesizer contained in the DS1 Jitter Generation option can generate a sine, triangle, square, or ramp wave. When any one of these waveforms is selected, it is added to the external waveform, allowing the jitter signal to be extremely versatile. The external signal can also be selected to be the only modulation signal used. If the modulation is turned off, the DS1 Jitter Generation option is no longer used to supply timing to the DS1/T1 interface.

The FIREBERD 6000's frequency synthesizer is used to generate the jitter modulation frequency. The modulation frequency can be selected with a 3-digit resolution from 10.0 Hz to 40.0 kHz. As an alternative to fixed-frequency jitter modulation, a jitter generation sweep can be turned on. This sweep will sweep through the same 40 points measured by the spectrum analyzer. The jitter generator will sweep through the 40 points, generating jitter at each frequency for approximately 1 second. If the spectral analyzer sweep is on, the jitter generator and the spectrum analyzer will sweep in unison, with jitter generation and spectral measurements occurring simultaneously at each of the 40 points.

The jitter amplitude, either with or without the jitter generator sweep enabled, can be selected manually or can be automatically referenced to the selected jitter mask. In either case, the range of the jitter amplitude is 0 UI to 13 UI peak-to-peak in .02 UI steps. The amplitude can be set to MASK, which will set the amplitude of the generated jitter to the level specified by the selected mask for the current jitter frequency. This may be used in conjunction with the jitter sweep to perform jitter tolerance tests. The jitter generator amplitude can also be set to XFER, which will set the amplitude of the generated jitter to half of the jitter specified by the mask for the current jitter frequency. This may be used in conjunction with the jitter sweep to perform jitter transfer characteristic tests.

9.1.3.2 Operation

The FIREBERD 6000's front panel GEN CLK switch selects the T1 clock source that is phase modulated by the DS1 Jitter Generation option. When the GEN CLK switch is set to the SYNTH position, the oscillator on the jitter generator is selected as the clock source, when jitter generator modulation is on. Note that the frequency synthesizer is not selected as the clock source; it is instead used to generate the jitter modulation frequency. When the GEN CLK switch is in the BNC position, the GEN CLK IN rear panel BNC connector is selected as the clock source. When the GEN CLK switch is set to the INTF position, the dejitterized, recovered T1 clock is selected. Since the DS1 Wideband Jitter Measurement option supplies the dejitterized clock, it must be installed before the Jitter Generator option can apply jitter to the recovered clock. If the Wideband Jitter option is not installed and the GEN CLK switch is set to INTF, the red indicator within the GEN CLK switch will be illuminated and no data will be transmitted.

The rest of the jitter generation functions are accessed through the JITTER menu tree (see Figure 9-1). At the top level, MOD OFF or MOD ON is displayed to indicate the status of the jitter generator (if present). Pressing the GEN soft key accesses the top level of the jitter generation menu; at this level, the frequency and amplitude displayed reflect the actual amount of jitter being generated. When a contention occurs, these actual amounts may differ from the values which the user has selected. A contention occurs when the amplitude selected is greater than the amplitude that can be generated at the selected frequency; the displayed values for frequency and amplitude will flash to indicate the contention.

> **NOTE:** At lower levels in the menu, the display will always show the frequency and amplitude values selected by the user, rather than the frequency and amplitude of the jitter actually being generated. Likewise, when a contention occurs at these lower menu levels, the user-selected values will flash to indicate the contention. To view the actual amount of jitter being generated, the user must return to the top level (GEN soft key) of the menu.

The modulation type may be selected by pressing the MOD soft key. If the modulation is set to OFF, the selected generator clock is not modulated. If the modulation is set to EXT, the external BNC connector labeled JITTER MOD IN is used as the modulation source. The SIN, SQU, TRI, and RAMP soft keys represent the available internally generated waveforms, and the waveform that is selected is added to the external input and used as the modulation waveform.

Pressing the FREQ soft key accesses the soft keys SWEEP and Hz, which are used to selected the desired frequency. If the SWEEP soft key was previously selected, the message SWEEP is displayed instead of the current frequency. Pressing the Hz soft key will turn the sweep off and allow the desired frequency to be entered; the last frequency entered is displayed, as are the soft keys UP, DOWN, and HELP.

The UP and DOWN soft keys step through the 40 frequencies corresponding to the spectrum analyzer's 40 bands, and the HELP soft key gives instructions for entering a new frequency from the keypad. If the Hz soft key was previously selected, the current jitter generator frequency is displayed and a new frequency can be entered by using the keypad and then pressing the ENTER key.

> **NOTE:** If the jitter generator sweep has been turned off and the Hz soft key has been selected, the frequency can then be entered directly from the top level (GEN soft key) of the menu.

The AMPL soft key accesses the soft keys MASK, XFER, and UI, which allow the desired amplitude to be selected. If either the MASK or XFER soft keys was previously selected, then MASK or XFER is displayed instead of the current amplitude. Pressing the UI soft key turns off the MASK or XFER function; the last amplitude entered is displayed, and soft keys labeled UP, DOWN, and HELP are displayed. The UP and DOWN soft keys increment or decrement the jitter amplitude by .02 UI, and the HELP soft key gives instructions for entering a new amplitude from the keypad. If the UI soft key was previously selected, the current jitter generator amplitude is displayed and a new amplitude can be entered by using the keypad and the pressing the ENTER key.

> **NOTE:** If the UI soft key has been selected, the amplitude can be entered directly from the top level (GEN soft key) of the menu.

9.1.3.3 Specifications

Reference Clock:	• Internal—1.544 MHz ±5 ppm crystal oscillator. • Recovered from DS1 Wideband Jitter Option. • External BNC input: GEN CLK IN.
Frequency:	• 10.0 Hz—40.0 kHz, ±0.1% (all waveforms). • 3-digit resolution.
Amplitude:	• 0 UI to 13 UI peak-to-peak. • .02 UI resolution.
Modulation Accuracy:	• Sine wave—10 Hz—40 kHz, ±5% ±.05 UI. • Square, Triangle, and Ramp waves—50 Hz—5 kHz, ±7% ±.06 UI.
Spectral Purity:	• Sine waves greater than or equal to 1.00 UI peak-to-peak; all spurious frequencies 30 dB minimum below fundamental.
External Modulation:	• BNC labeled JITTER MOD IN. • Impedance: 10 k ohms, AC coupled. • Calibration: 1.0 UI/volt. • Frequency response —±5% ±.05 UI, 10 Hz—40 kHz. —greater than or equal to 20 dB/decade roll-off above 40 kHz.
Jittered Clock Output:	• Available on GEN CLK OUT BNC.

9.1.4 Masks

The FIREBERD 6000's DS1 jitter options fully reflect three industry-standard jitter masks and partially reflect two others. The specifications in CCITT Recommendation O.171 and Bell Technical Reference Publications PUB41451, PUB43801, and PUB62411 are all T1 standards which specify jitter characteristics for T1 equipment and systems. The masks are shown in Figure 9-3, along with the sine wave limit for the DS1 Jitter Generation option.

The mask values are used by the DS1 Jitter Spectral Analysis option to calculate the %MASK in each of the frequency bands. This measurement can be used to easily determine if the jitter on a T1 line exceeds the amount of jitter allowed by the applicable mask. The mask values are also used by the DS1 Jitter Generation option to transmit the amount of jitter cited by a specific mask at the selected frequency.

The desired mask can be selected by pressing the MENU pushbutton switch to select the JITTER function; pressing the MORE key causes the MASK, GRAPH, and LIST soft-key labels to appear in the display. When the MASK soft key is pressed, the previously selected mask is displayed. To change masks, simply press the soft key associated with the desired mask.

The FIREBERD 6000's jitter options fully meet the specifications in CCITT Recommendation O.171, Bell PUB41451, and the 1983 issue of Bell PUB62411. The specifications in Bell PUB43801 and the 1985 issue of Bell PUB62411 are met where those masks are less than 13 UI and between 10 Hz and 40 kHz. Since the Jitter Generation option only operates to 13 UI, any mask that exceeds this value is truncated to 13 UI. The Spectral Analysis option does generate a proper %MASK value for these points in the mask if the jitter measured is within the option's measurement range.

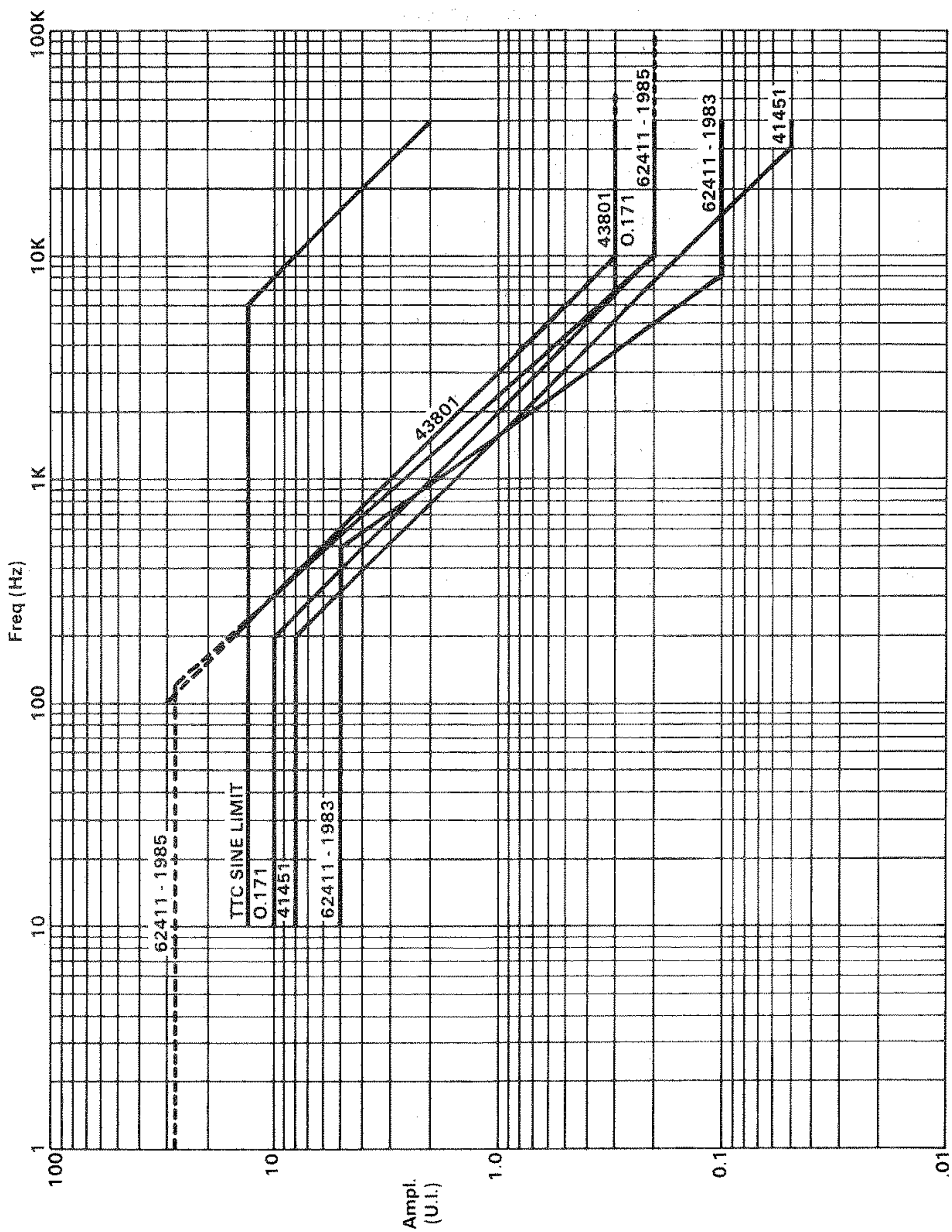


Figure 9-3
Jitter Masks

9.2 G.703 JITTER GENERATION AND MEASUREMENT

This section describes G.703 jitter generation and measurement, specifically:

- G.703 Jitter Generation and Wideband Measurement (Option 6007)
- G.703 Jitter Spectral Analysis (Option 6008)

These options are used with either the G.703 64 kb/s Data Interface (Model 30608) or the G.704 2048 kb/s Framing Interface (Model 30609). The presence of G.703 Jitter Generation and Wideband Measurement (Option 6007) is required for G.703 Jitter Spectral Analysis (Option 6008) to be installed. (Both options operate simultaneously.)

Jitter on a digital line is the displacement in time of a data pulse from its ideal position. Two parameters are used to characterize jitter. The first is the amplitude of the phase displacement, which varies over time. The amplitude is measured in unit intervals (UI), where one UI is equal to the amount of time associated with one data bit period, or 488 nanoseconds at 2048 kb/s and 15.63 microseconds at 64 kb/s. The second parameter is the frequency at which the amplitude is changing measured in Hertz (Hz).

The G.703 Jitter Generation and Wideband Measurement option measures jitter over a wide frequency band (20 Hz to 10 kHz for 64 kb/s; 20 Hz to 100 kHz for 2048 kb/s). This measurement follows the guidelines set forth in CCITT Recommendation O.171. The jitter modulator can apply a sine, square, ramp, or triangle wave jitter signal to an internal, external, or recovered reference clock signal. Discussion of the two functions of the G.703 Jitter Generation and Wideband Measurement option is split into two sections: Section 9.2.1, Jitter Wideband Measurement; and Section 9.2.3, Jitter Generation.

The G.703 Jitter Spectral Analysis option performs multiple-band spectrum analysis on the wideband jitter; this option is discussed in Section 9.2.4.

9.2.1 G.703 Jitter Wideband Measurement

The G.703 Jitter Generation Wideband Measurement option (Option 6007) receives a jittered clock signal from either the G.703 64 kb/s Data Interface (Model 30608) or the G.704 2048 kb/s Framing Interface (Model 30609). It then demodulates the jittered clock and makes the following measurements.

- Peak-to-peak jitter (1SEC JTR)
- Maximum peak-to-peak jitter (MAX JTR)
- Jitter hits count (JTR HITS)

9.2.1.1 Functional Description

The G.703 Jitter Generation and Wideband Measurement option demodulates the jittered clock by generating a voltage that is proportional in amplitude to the amplitude of the phase displacement. This signal is bandwidth-limited based upon the RANGE selection (BAND1; BAND2) and the bit rate. Once it is converted to analog voltage, the jitter signal is sent to the measurement circuitry on the G.703 Jitter Generation and Wideband Measurement option and to the G.703 Jitter Spectral Analysis option (if installed). In G.703 Jitter Generation and Wideband Measurement, peak-to-peak measurement circuitry tells the FIREBERD 6000 how may unit intervals of jitter are being received. The analog jitter signal is also buffered and sent to the rear panel BNC connector labeled DEMOD JITTER OUT.

The G.703 Jitter Generation and Wideband Measurement option also measures jitter hits. A jitter hit occurs when the instantaneous jitter exceeds a user-selectable threshold. It is the absolute value of the demodulated jitter that is measured. Therefore, both positive and negative jitter maxima are compared to the chosen jitter hit threshold.

9.2.1.2 Operation

Figure 9-4 shows the menu tree for all of the G.703 jitter options. The menu tree is accessed by pressing the MENU pushbutton switch to the JITTER position. The Wideband Jitter Measurement modes are accessed by pressing the RANGE soft key. Three more selections will then appear in the display: BAND1, BAND2, and HELP. The RANGE specified affects both the amplitude and the frequency range of the jitter measured. Table 9-3 lists the RANGE specifications; the HELP soft key also offers a condensed version of this table.

The jitter results—1SEC JTR, MAX JTR, and JTR HITS—are found in the SIGNAL category of results. The 1SEC JTR result is the maximum jitter measured over the last second. The MAX JTR result is the maximum of the 1SEC JTR results since the last test restart. The JTR HITS result is the number of jitter hits that have been counted since the last test restart. These results are not accessible if

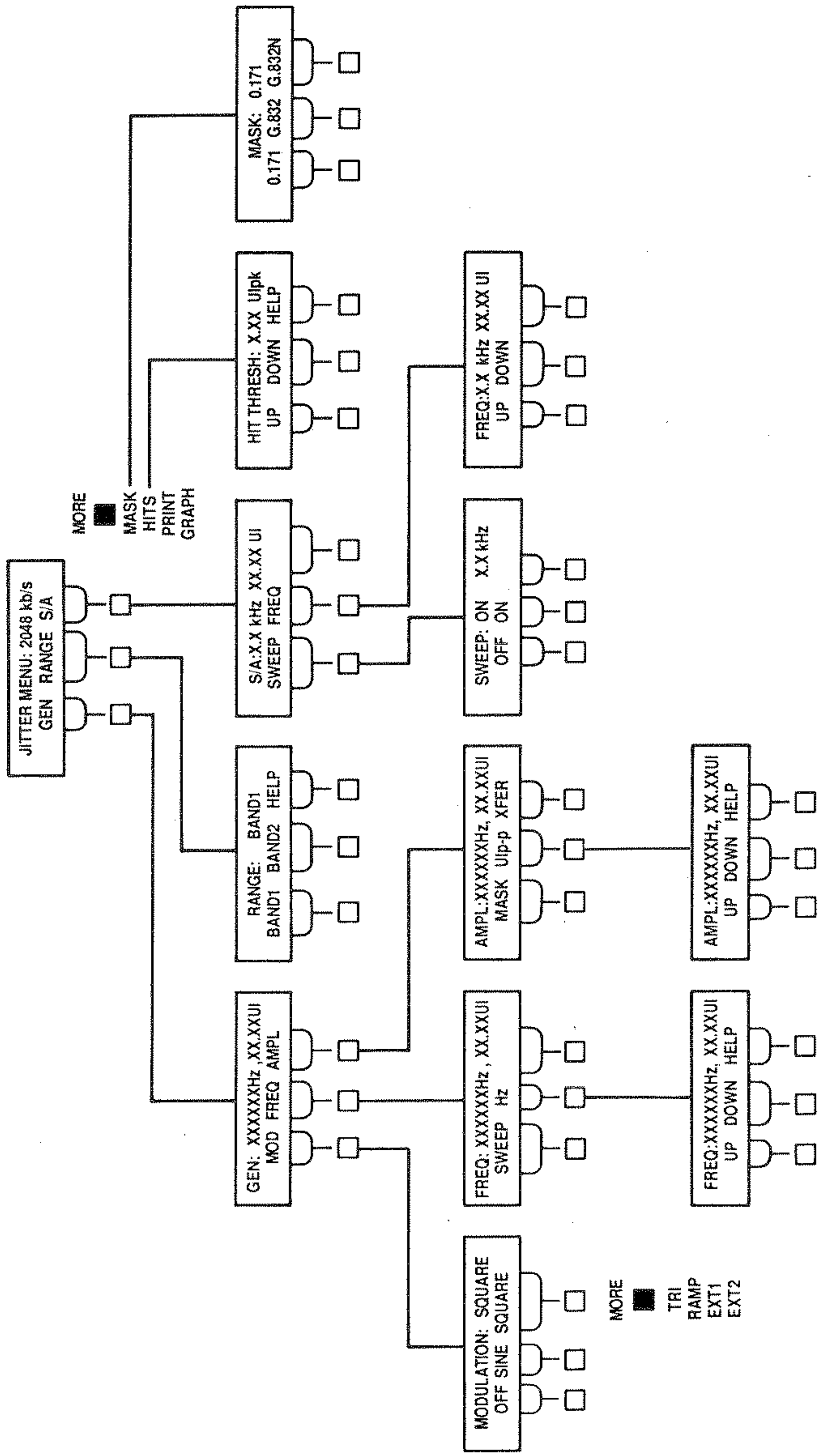


Figure 9-4
G.703 Jitter Menu Tree

the Jitter Generation and Wideband Measurement option is not installed, or if an incorrect interface is installed.

Pressing the HITS soft key in the JITTER menu allows the user to set the jitter hits threshold. (The HITS soft key is accessed by pressing the MORE soft key.) The user may enter a hits threshold from the keypad, or may scroll to the desired hit threshold using the UP and DOWN soft keys. When pressed, the HELP key displays a range of valid values for the hit threshold based on the currently selected frequency band.

9.2.1.3 Specifications

The specifications for G.703 wideband jitter measurement and G.703 jitter hits measurement are shown in Tables 9-3 and 9-4, respectively.

Table 9-3
G.703 Wideband Jitter Measurement Specifications

Interface	Band	40 db/decade High Pass Filter -3 dB Point	Passband	60 db/decade Low Pass Filter -3 dB Point	Range	Measurement Resolution	Passband Accuracy
2048 kb/s	Band 1	2 Hz	20 Hz—27 kHz	54 kHz	12.00 UI p-p	0.01 UI p-p	± 5% ± .040 UI p-p
	Band 2	2 Hz	20 Hz—100 kHz	200 kHz	1.200 UI p-p	0.005 UI p-p	± 5% ± .035 UI p-p
64 kb/s	Band 1	2 Hz	20 Hz—5 kHz	10 kHz	1.500 UI p-p	0.005 UI p-p	± 5% ± .010 UI p-p
	Band 2	2 Hz	20 Hz—10 kHz	20 kHz	0.300 UI p-p	0.005 UI p-p	± 5% ± .009 UI p-p

Interface	Data Rate Tolerance
2048 kb/s	± 50 ppm
64 kb/s	± 50 ppm

Table 9-4
G.703 Jitter Hits Measurement Specifications

Interface	Band	Range	Step Size	Accuracy
2048 kb/s	Band 1	0.1—6.0 UIp	0.10 UI	± 7% ± 0.02 UIp
	Band 2	0.05—0.60 UIp	0.05 UI	± 7% ± 0.02 UIp
64 kb/s	Band 1	0.05—0.75 UIp	0.05 UI	± 7% ± 0.005 UIp
	Band 2	0.05—0.15 UIp	0.05 UI	± 7% ± 0.005 UIp

9.2.2 Masks

The FIREBERD 6000 has a preprogrammed function which can allow the jitter generator's amplitude to be set as a function of the jitter frequency and the selected mask. (See Section 9.2.3 for jitter generation operation.) The masks found in CCITT Recommendations O.171 and G.823 specify jitter characteristics for G.703 equipment and systems. The masks are shown in Figures 9-5 and 9-6.

The mask values are used by the G.703 Jitter Spectral Analysis option (Section 9.2.4) to calculate the %MASK in each of the frequency bands. This measurement can be used to easily determine if the jitter on the digital signal exceeds the amount of jitter allowed by the applicable mask.

The desired mask can be selected by pressing the MENU pushbutton switch to select the JITTER function; pressing the MORE key causes the MASK, GRAPH, and LIST soft-key labels to appear in the display. When the MASK soft key is pressed, the previously selected mask is displayed. To change masks, simply press the soft key under the desired mask.

9.2.3 G.703 Jitter Generation

The G.703 Jitter Generation and Wideband Measurement option can phase-modulate the FIREBERD 6000 transmit clock with an internally generated waveform, an external waveform, or a combination of both to transmit jittered data from the G.703 64 kb/s Data Interface and the G.704 2048 kb/s Framing Interface. Jitter can be added to an internal clock, external clock, recovered clock, and looped-thru data. The following list summarizes the features of the G.703 Jitter Generation option.

Frequency:

- User-selectable frequency, 3-digit resolution
- Automatic sweep

Amplitude:

- User-selectable amplitude
- Can automatically set amplitude to selected mask level
- Can automatically set amplitude to 50% of the selected mask level

Modulation:

- Sine
- Square
- Triangle
- Ramp
- External

Clock Sources:

- Internal
- External
- Recovered

9.2.3.1 Functional Description

The G.703 Jitter Generation and Wideband Measurement option can apply jitter to a digital signal by phase-modulating the digital signal with another waveform. This waveform can be externally supplied or internally generated by the G.703 Jitter Generation and Wideband Measurement option.

There are three clock sources which may be used with the jitter generator. When internal timing is selected, jitter is applied to an internal reference. (The frequency synthesizer is used to set the frequency of the modulating waveform.) An external clock source can be supplied to the FIREBERD's GEN CLK IN rear panel BNC connector. The third clock source is the recovered clock from the receiver of the interface in use; this clock source is generally used when jitterizing looped data.

There are three parameters to be selected with the G.703 Jitter Generation option: modulation type, frequency, and amplitude. The waveform synthesizer on the G.703 Jitter Generation option can generate a sine, triangle, square, or ramp wave. When any one of these waveforms is selected, it is added to the external waveform, allowing the jitter signal to be extremely versatile. The external signal can also be selected to be the only modulation signal used. If the modulation is turned off, the jitterable clock is no longer the FIREBERD 6000's timing source.

The FIREBERD 6000's frequency synthesizer is used to generate the jitter modulation frequency. The modulation frequency can be selected with 3-digit resolution from 2.00 Hz to 100 kHz at 2048 kb/s, and from 2.00 Hz to 32.0 kHz at 64 kb/s. As an alternative to fixed-frequency jitter modulation, a jitter generation sweep can be used, sweeping through the 58 (37 at 64 kb/s) points listed in Table 9-3. Jitter is generated at each frequency for approximately 1 second, unless the G.703 Spectral Analysis option is installed and used in Sweep mode.

The jitter amplitude, either with or without the jitter generator sweep enabled, can be selected manually or can be automatically referenced to the selected jitter mask. The amplitude can be set to MASK, which will set the amplitude of the generated jitter to the level specified by the selected mask for the current jitter frequency. This may be used in conjunction with the jitter sweep to perform jitter tolerance

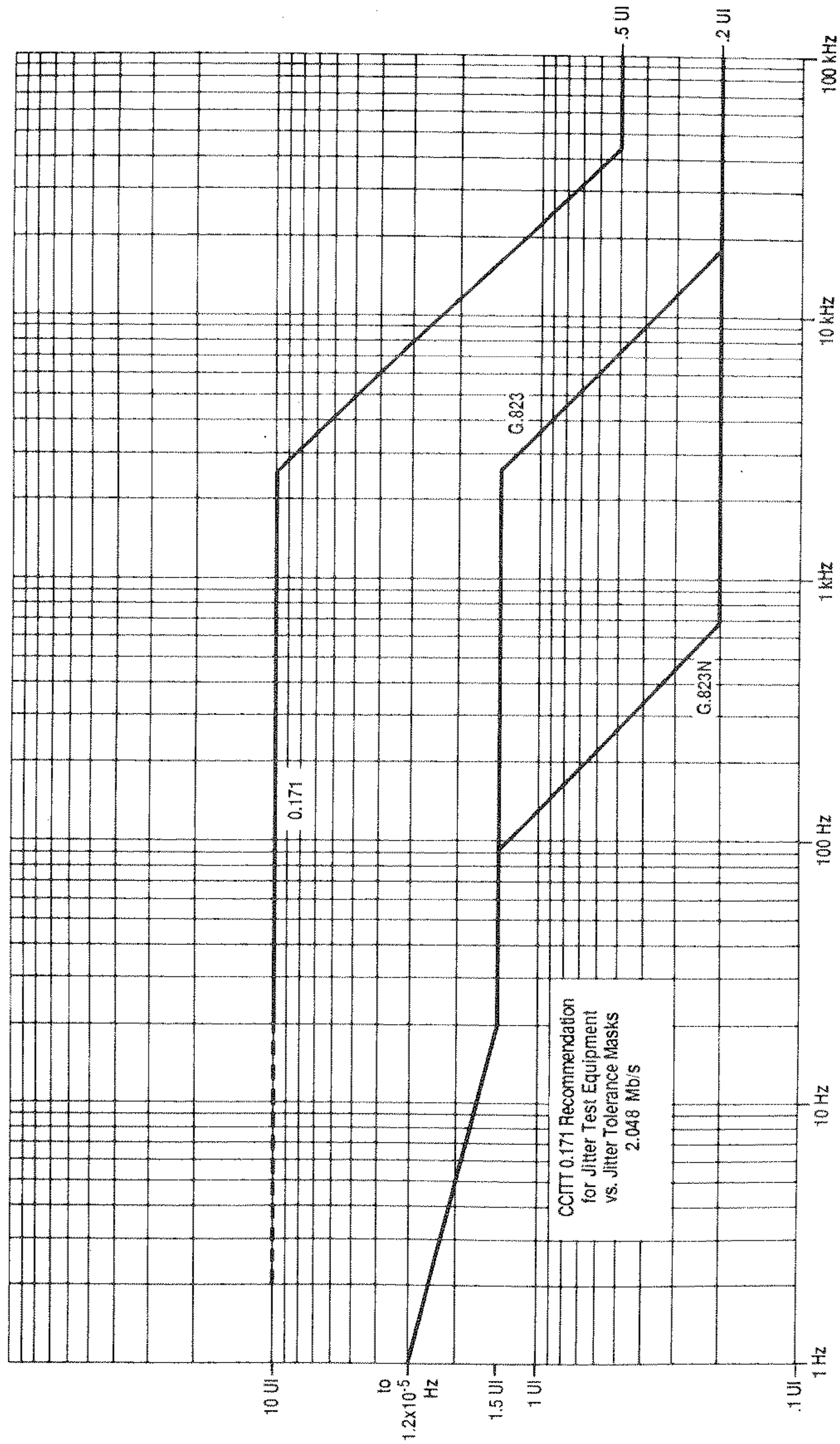


Figure 9-5
CCITT Jitter Masks

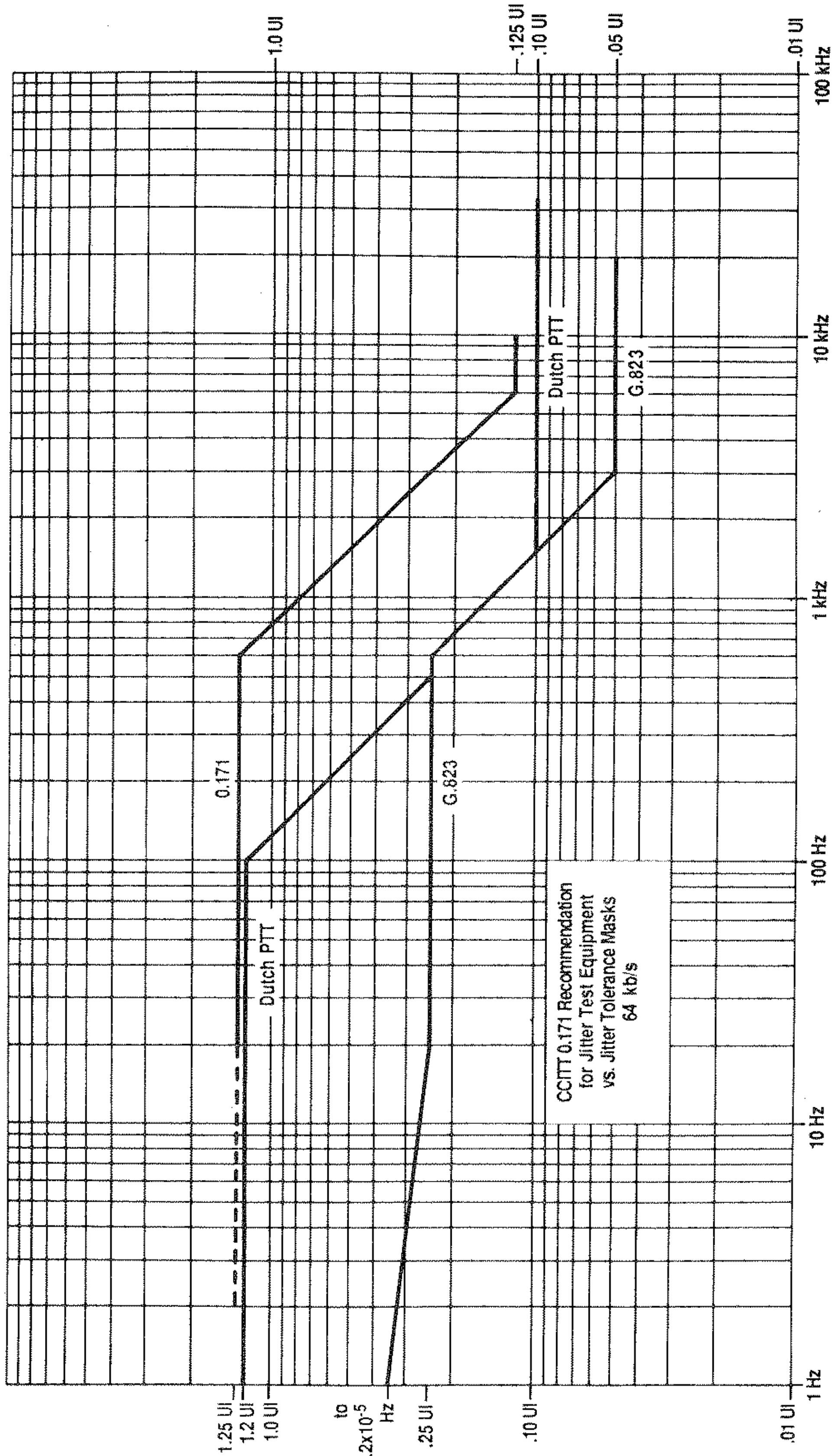


Figure 9-6
CCITT Jitter Masks

tests. The jitter generator amplitude can also be set to XFER, which will set the amplitude of the generated jitter to half of the jitter specified by the mask for the current jitter frequency. This may be used in conjunction with the jitter sweep to perform jitter transfer characteristic tests.

9.2.3.2 Operation

The FIREBERD 6000's front panel GEN CLK switch selects the clock source that is phase-modulated by the G.703 Jitter Generation and Wideband Measurement option. When the GEN CLK switch is set to the SYNTH position, an internal reference is selected for jitter modulation. Note that the frequency synthesizer is not selected as the clock source; it is instead used to generate the jitter modulation frequency. Therefore, the message GEN CLK DEFAULTS TO 2048 (64) kHz WITH JIT GEN is displayed when the SYNTH menu is selected.

When the GEN CLK switch is in the BNC position, the GEN CLK IN rear panel BNC connector is selected as the clock source.

> **NOTE:** The jitter generator expects a 2.048 MHz clock regardless of the interface in use. When selecting the BNC input as the source of generator timing for the G.703 64 kb/s Data Interface, the external source must be set to 2048 kHz when jitter generation is on and to 64 kHz when jitter generation is off.

When the GEN CLK switch is set to the INTF position, the dejitterized, recovered G.703 or G.704 clock is selected.

The rest of the jitter generation functions are accessed through the JITTER menu tree (see Figure 9-4). Pressing the GEN soft key accesses the top level of the jitter generation menu; at this level, the frequency and amplitude displayed reflect the actual amount of jitter being generated. When a contention occurs, these actual amounts may differ from the values which the user has selected. A contention occurs when the amplitude selected is greater than the amplitude that can be generated at the selected frequency; the displayed values for frequency and amplitude will flash to indicate the contention.

> **NOTE:** At lower levels in the menu, the display will always show the frequency and amplitude values selected by the user, rather than the frequency and amplitude of the jitter actually being generated. Likewise, when a contention occurs at these lower menu levels, the user-selected values will flash to indicate the contention. To view the actual amount of jitter being generated, the user must return to the top level (GEN soft key) of the menu.

The modulation type may be selected by pressing the MOD soft key. If the modulation is set to OFF, the selected generator clock is not modulated and the jitter generator is removed from the FIREBERD 6000's timing path. If the modulation is set to EXT1 or EXT2, the external BNC connector labeled JITTER MOD IN is used as the modulation source. (EXT1 selects BAND 1; EXT2 selects BAND 2.) Figures 9-7 and 9-8 show the modulation limits for each band. The SIN, SQU, TRI, and RAMP soft keys represent the available internally generated waveforms, and the waveform that is selected is added to the external input and used as the modulation waveform.

Pressing the FREQ soft key accesses the soft keys SWEEP and Hz, which are used to selected the desired frequency. If the SWEEP soft key was previously selected, the message SWEEP is displayed instead of the current frequency. Pressing the Hz soft key will turn the sweep off and allow the desired frequency to be entered; the last frequency entered is displayed, as are the soft keys UP, DOWN, and HELP.

The UP and DOWN soft keys step through the frequencies corresponding to the spectrum analyzer's bands, and the HELP soft key gives instructions for entering a new frequency from the keypad. If the Hz soft key was previously selected, the current jitter generator frequency is displayed and a new frequency can be entered by using the keypad and then pressing the ENTER key.

> **NOTE:** If the jitter generator sweep has been turned off and the Hz soft key has been selected, the frequency can then be entered directly from the top level (GEN soft key) of the menu.

The AMPL soft key accesses the soft keys MASK, UI p-p, and XFER, which allow the desired amplitude to be selected. If either the MASK or XFER soft keys was previously selected, then MASK or XFER is displayed instead of the current amplitude. Pressing the UI p-p soft key turns off the MASK or XFER function; the last amplitude entered is displayed, and soft keys labeled UP, DOWN, and HELP are displayed. The UP and DOWN soft keys increment or decrement the jitter amplitude by the minimum increment allowed at the bit rate in use, and the HELP soft key gives instructions for entering a new amplitude from the keypad. If the UI soft key was previously selected, the current jitter generator amplitude is displayed and a new amplitude can be entered by using the keypad and the pressing the ENTER key.

> **NOTE:** If the UI soft key has been selected, the amplitude can be entered directly from the top level (GEN soft key) of the menu.

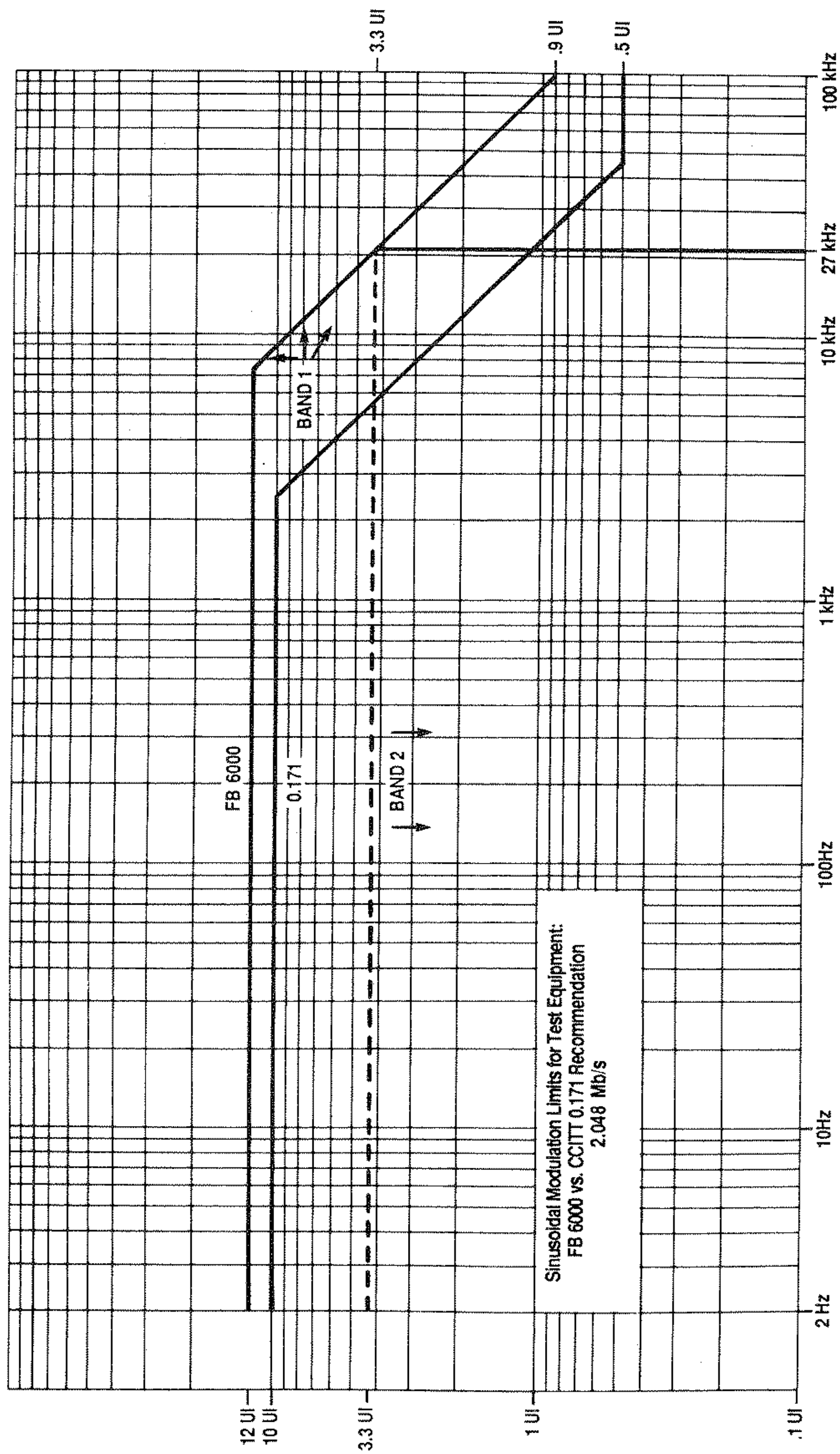


Figure 9-7
Modulation Limits— 2048 kb/s

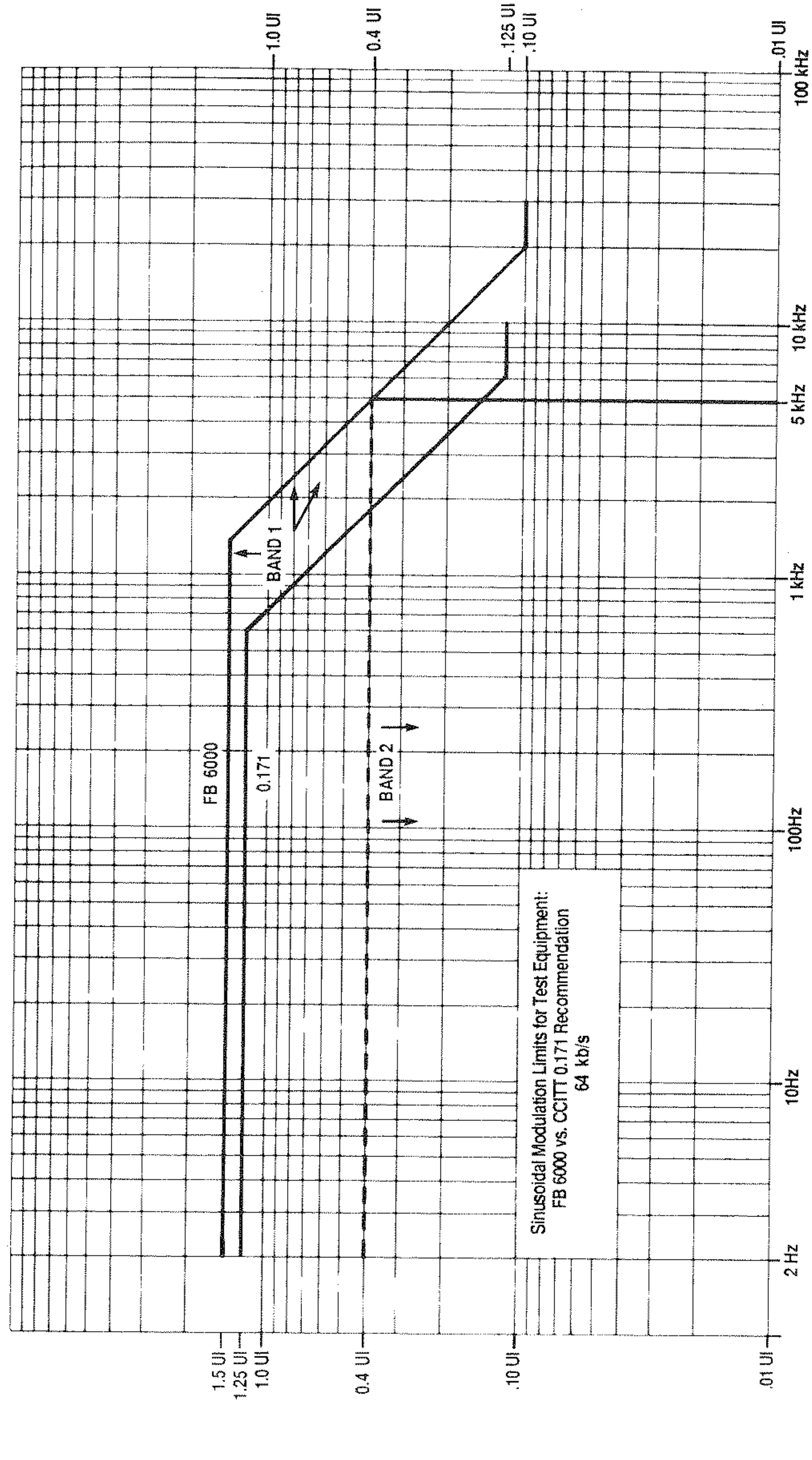


Figure 9-8
Modulation Limits—64 kb/s

9.2.3.3 Specifications

Jitter Generator Amplitude
- See Table 9-5.

Jitter Generator Internal Generator Frequency
- See Table 9-6.

External Modulation:
- BNC labeled JITTER MOD IN.
- Impedance: 10 k-ohms, ±5%; DC coupled.

Maximum Input:
- ±25 volts.

Reference Clock Sources:
- Internal: ±5 ppm, 4.096 MHz crystal oscillator.
- Recovered: Dejittered clock.
- External BNC Input: GEN CLK IN; 50 ohm (resistive termination); 1.5V p-p or greater unipolar or bipolar signal.

Jittered Clock Output (BNC):
- GEN CLK OUT, 50 ohm load minimum; TTL level; 50 +5% duty cycle square wave.

2048 kb/s Generator Sweep:
- The sinewave generator may be set up to automatically sweep through a number of frequencies with jitter amplitudes defined by one of the following jitter masks: O.171, G.823, or G.823N (see Figure 9-5).

64 kb/s Generator Sweep:
- The sinewave generator may be set up to automatically sweep through a number of frequencies with jitter amplitudes defined by one of the following jitter masks: O.171, G.823, or Dutch PTT (see Figure 9-6).

Mask Sweep:
- Jitter amplitude equals that defined by mask.

Transfer Characteristic Sweep:
- Jitter amplitude equals one-half that defined by mask.

Table 9-5
G.703 Jitter Generation Amplitude Specifications

		Sinusoidal Modulation			Non-Sinusoidal Modulation		
Interface	**1.0 UI =**	Maximum	Resolution	Accuracy	Maximum	Resolution	Accuracy
2048 kb/s	488 ns.	12.00 UI p-p	0.02 UI p-p	±5% ± 0.05 UI p-p	10.00 UI p-p	0.02 UI p-p	±7% ± 0.05 UI p-p
64 kb/s	15.63 microsecs.	1.500 UI p-p	0.005 UI p-p	±5% ± 0.013 UI p-p	1.250 UI p-p	0.005 UI p-p	±7% ± 0.013 UI p-p

Table 9-6
G.703 Jitter Generator Internal Generator Frequency Specifications

Interface	Sinusoidal Modulation Range	Non-Sinusoidal Modulation Range	Resolution	Accuracy
2048 kb/s	2.0 Hz—100 kHz	50.0 Hz—5.00 kHz	3 significant digits	±0.1% of setting
64 kb/s	2.0 Hz—32.0 kHz	50.0 Hz—1.00 kHz	3 significant digits	±0.1% of setting

9.2.4 G.703 Jitter Spectral Analysis Option

The G.703 Jitter Spectral Analysis option (Option 6008) consists of a board that plugs into the G.703 Jitter Generation and Wideband Measurement option. At 2048 kb/s, the spectrum analyzer measures the maximum peak-to-peak jitter in 58 frequency bands from 10 Hz to 100 kHz and displays the result in unit intervals (UI). At 64 kb/s, the spectrum analyzer measures the maximum peak-to-peak jitter in 37 frequency bands from 10 Hz to 30 kHz and displays the result in UI.

The G.703 Jitter Spectral Analysis option enables the following measurements.

- Jitter amplitude measured in UI peak-to-peak with a continuous sweep of 58 (37 at 64 kb/s) frequency bands.
- Continuous jitter amplitude measurement in UI peak-to-peak at one frequency.
- Percent of mask for each band.

The G.703 Jitter Spectral Analysis option can only be used with the G.703 Jitter Generation and Wideband Measurement option.

9.2.4.1 Functional Description

The G.703 Jitter Spectral Analysis option is offered with the FIREBERD 6000 to allow the user to determine the frequency content of timing jitter in a digital system. This is accomplished by filtering the wideband jitter signal obtained from the G.703 Jitter Generation and Wideband Measurement option into 58 (37 at 64 kb/s) discrete frequency bands. The output of each filter in turn goes to a peak-to-peak measurement circuit. The G.703 Jitter Spectral Analysis option can either (1) continuously monitor one of the frequency bands and measure the jitter amplitude for that band, or (2) continually sweep through the frequency bands. When the sweep is enabled, the amplitude stored and displayed for each frequency band is compared to the current measurement at the corresponding frequency, and the maximum value is saved until a test restart occurs.

The sweep function of the G.703 Jitter Spectral Analysis option operates synchronously with the generator sweep function of the G.703 Jitter Generation and Wideband Measurement option. The G.703 jitter generator will generate jitter at a specific frequency, the spectrum analyzer will measure that frequency band, and both options will increment to the next frequency band. This capability can be used to test equipment for bit errors or jitter attenuation characteristics. (See the Functional Description in Section 9.2.3.1 for more information.)

The time required to complete one sweep of the spectrum analyzer is approximately 45 to 50 seconds with jitter generation disabled, and approximately 2 to 2 1/2 minutes with jitter generation enabled.

Care should be exercised in comparing the spectral analysis results with the wideband jitter result discussed in Section 9.2.1. The Wideband Jitter option makes continuous measurements over the entire frequency range for 64 kb/s and 2048 kb/s. The result obtained with that option is a true indication of the overall maximum jitter in that band. This is in contrast to the spectrum analyzer which looks at a much narrower bandwidth for each measurement. Real-world jitter is likely to be non-sinusoidal, containing frequency components that do not add directly. As a result, it is important that the wideband measurement be used in conjunction with the spectrum analyzer measurements in determining system performance.

Since the Spectral Analysis Option (6008) uses the signal from the G.703 Jitter Generation and Wideband Measurement Option (6007), the RANGE selection affects the amount of jitter that can be measured by Option 6008. In both BAND1 and BAND2, however, the Spectrum Analysis functions cover the full frequency range for the interface in use.

9.2.4.2 Operation

The G.703 Jitter Spectral Analysis measurement modes are accessed in the JITTER menu tree (see Figure 9-4) by pressing the S/A soft key. At this level in the menu, the current frequency and the measured amplitude at that frequency are displayed. If the sweep is disabled, the frequency that is displayed is the only one for which measurements are taken. The display is updated each time the amplitude measurement is completed. If the sweep is enabled, the frequency displayed sweeps along with the measurement, which allows the user to know the status of the sweep at any point in time. In addition, the amplitude displayed for each frequency is the maximum amplitude measured in that band since the last test restart.

Pressing the SWEEP soft key causes the selections ON and OFF to be displayed; selecting either the ON or OFF soft key places the sweep function in the corresponding state. Pressing the FREQ soft key accesses the soft keys UP and DOWN, which can be used to scroll through the frequency bands. When the sweep is enabled, the amplitude displayed is the maximum value stored for that band. When the sweep is disabled, either of the UP or DOWN soft keys changes the frequency band currently being measured to the band selected by the soft key.

The following results are available under the ANALYSIS RESULTS function of the SIGNAL category for G.703 Jitter Spectral Analysis:

1. Maximum % of Mask (%MASK)

   Each time the jitter spectrum analyzer takes a reading, the ratio of the measured jitter amplitude to the reference jitter mask's value at this point is calculated. If the spectrum analyzer is sweeping, then the maximum value of that ratio since the beginning of the test is displayed as a percentage, and a value less than 100% indicates that during the test no spectrum analyzer reading exceeded the reference mask. If the spectrum analyzer is not sweeping, then the ratio of the last spectrum analyzer reading to the reference mask at that frequency is displayed as a percentage.

2. S/A X.XX k

   The amplitude of the jitter at the frequency currently measured by the spectrum analyzer. If the spectrum analyzer sweep is enabled, this result sweeps also; if the sweep is disabled, the frequency being measured can be scrolled up or down using either the SHIFT key followed by the key, or the SHIFT key followed by the key, respectively.

Pressing the LIST soft key in the JITTER menu sends a list of the jitter spectrum analyzer frequency band measurements and their corresponding %MASK values to the printer port. If the jitter spectrum analyzer sweep is turned off, only one frequency in the list is printed and the others remain blank.

Pressing the GRAPH soft key in the JITTER menu generates a graph of the G.703 Jitter Spectral Analysis results. The graphics are Epson-compatible and can be used with TTC's PR-85 Printer. The results are graphed only when the jitter spectrum analyzer sweep is on.

9.2.4.3 Specifications

Frequency Points/ Measurement Bandwidths:	• See Table 9-7.
Filter Bandwidths:	• See Figure 9-2 and Table 9-2.
Range:	
2048 kb/s	• BAND 1—Up to 12.00 UI p-p. • BAND 2—Up to 1.200 UI p-p.
64 kb/s	• BAND 1—Up to 1.500 UI p-p. • BAND 2—Up to 0.300 UI p-p.
Resolution:	
2048 kb/s	• BAND 1—0.00 to 2.00 UI p-p in 0.01 UI p-p steps; 2.00 to 12.00 UI p-p in 0.05 UI p-p steps. • BAND 2—0.000 to 0.500 UI p-p in 0.005 UI p-p steps; 0.500 to 1.200 UI p-p in 0.025 UI p-p steps.
64 kb/s	• BAND 1—0.000 to 0.250 UI p-p in 0.005 UI p-p steps; 0.250 to 1.500 UI p-p in 0.025 UI p-p steps. • BAND 2—0.000 to 0.050 UI p-p in 0.005 UI p-p steps; 0.050 to 0.300 UI p-p in 0.025 UI p-p steps.
Accuracy:	
2048 kb/s	• BAND 1—±10% ±0.08 UI p-p. • BAND 2—±10% ±0.05 UI p-p.
64 kb/s	• BAND 1—±10% ±0.02 UI p-p. • BAND 2—±10% ±0.013 UI p-p.

Table 9-7
Frequency Points and Measurement Bandwidths

10 Hz BW	33 Hz BW	100 Hz BW	333 Hz BW	1 kHz BW	3.3 kHz BW
10 Hz	100 Hz	300 Hz	1.00 kHz	3.00 kHz	10.0 kHz
20 Hz	133 Hz	400 Hz	1.33 kHz	4.00 kHz	13.3 kHz
30 Hz	166 Hz	500 Hz	1.66 kHz	5.00 kHz	16.6 kHz
40 Hz	200 Hz	600 Hz	2.00 kHz	6.00 kHz	20.0 kHz
50 Hz	233 Hz	700 Hz	2.33 kHz	7.00 kHz	23.3 kHz
60 Hz		800 Hz		8.00 kHz	26.6 kHz
70 Hz					30.0 kHz*
80 Hz					33.3 kHz
					36.6 kHz
					40.0 kHz
					43.3 kHz
					46.6 kHz
					50.0 kHz
					53.3 kHz
					56.6 kHz
					60.0 kHz
					63.3 kHz
					66.6 kHz
					70.0 kHz
					73.3 kHz
					76.6 kHz
					80.0 kHz
					83.3 kHz
					86.6 kHz
					90.0 kHz
					93.3 kHz
					96.6 kHz
					100.0 kHz

*Stop here at 64 kb/s.

SECTION 10
SPECIFICATIONS

10.1 MODES OF OPERATION

Emulation:	• Emulate DTE mode (for connection to DCE). • Emulate DCE mode (for connection to DTE).
System Configuration:	• Full Duplex mode. • Single Transmit mode. • Self-Loop mode.
Timing Modes:	• Synchronous Timing. • Asynchronous Timing. • Recovered Timing (optional).

10.2 GENERATOR

10.2.1 Generator Timing Systems

Timing Modes:	• Synchronous (1x bit rate clock generated for bit rates from 50 to 15,000,000 b/s). • Asynchronous (16x bit rate clock used by USART for bit rates from 50 to 20,000 b/s). • Recovered (1x bit rate clock generated for bit rates from 50 to 520,000 b/s).
Timing Sources:	• Internal frequency synthesizer. • GEN CLK IN rear panel BNC connector. • Data interface.
Indicator:	• LED within the GEN CLK switch is illuminated when no generator clock signal is present.

10.2.1.1 Frequency Synthesizer

Frequency Range:	• 50.00 Hz to 15.000 MHz (16x bit rate clock generated in the 16x Asynchronous timing mode for bit rates from 50 to 20,000 b/s).
Resolution:	• 5 significant digits (for frequencies that begin with 10 through 15). • 4 significant digits (all other frequencies).
Accuracy and Stability:	• ±5 ppm (±1 ppm optional). • ±5 ppm/year (±1 ppm/year optional).

10.2.1.2 GEN CLK IN Rear Panel BNC Connector

Input Configuration:	• Outer conductor—ground. • Inner conductor—signal.
Input DC Impedance:	• 1000 ohms.
Input AC Impedance:	• 50 ohms.
Input Signal Range:	• 1.5 volts p-p to 25 volts p-p.

10.2.1.3 GEN CLK OUT Rear Panel BNC Connector

Output Configuration:	• Outer Conductor—ground. • Inner Conductor—signal.
Output Load:	• 50 ohms minimum.
Output Signal Levels:	• TTL Levels - 2.0 volts minimum high level, 0.4 volts maximum low level (50-ohm load).

10.2.2 Data Generator

Fixed Patterns:	• Mark. • 1:1 (Mark and Space alternate). • User-programmable, 3- to 24-bit repeating pattern.
Pseudorandom Patterns:	• 63 (2^6-1). • 511 (2^9-1). • 2047 (2^{11}-1). • 2^{15}-1. • 2^{20}-1. • 2^{23}-1. • QRSS.
Messages:	• FOX Message (in Baudot, BCDIC, ASCII or EBCDIC depending on code level selected). • Three user-programmable messages each up to 255 characters in length.
Character Format (Asynchronous Timing mode):	• Code Level—5, 6, 7, 8 bits. • Parity—odd, even, none. • Stop Bits—1, 1.5, 2 bits.

Data Inversion:

- Available by Auxiliary Function for transmitted data.

Error Insertion:

- Single error or fixed 10^{-3} bit error rate in generated data only.

Full-Duplex Bit Rates:

- Messages and/or Asychronous timing mode—50 to 20,000 b/s.
- Synchronous timing mode—50 to 15,000,000 b/s.

10.3 RECEIVER

10.3.1 Receiver Timing Systems

Timing Modes:

- Synchronous (1x bit rate clock received through data interface for bit rates from 50 to 15,000,00 b/s).
- Asynchronous (16x bit rate clock internally provided for USART for bit rates from 50 to 20,000 b/s).
- Recovered (1x bit rate clock recovered from data transitions for bit rates from 50 to 520,000 b/s).

Timing Sources:

- Data interface.
- Clock Recovery option.

Indicators:

- NO CLK backlit label is illuminated when receiver clock is not present.
- CLK INV backlit label is illuminated when the clock-data phasing at the input of data interface is the opposite of that required by the applicable interface standard.

10.3.2 Data Error Analysis

Analysis Modes:

- Single.
- Continuous.

Indicators:

- Receiver Inputs:
  —MK indicator is illuminated when a Mark is received by the FIREBERD.
  —SP indicator is illuminated when a Space is received by the FIREBERD.
  —SYNC indicator is illuminated when pattern sync is achieved.
- DATA INV backlit indicator is illuminated when the data received by the FIREBERD is inverted from what is expected.
- SYNC LOST LED (latching with pushbutton reset) is illuminated when a sync loss occurs.

Sync Acquisition Criteria (Synchronous, Recovered timing modes):

- Fixed pattern data—30 consecutive bits with no errors.
- Pseudorandom pattern data—30 + n consecutive bits with no errors for a 2^n-1 pattern.

Sync Acquisition Criteria (Asynchronous timing mode):

- Fixed pattern data—10 consecutive characters with no errors.
- Pseudorandum pattern data—10 consecutive characters with no errors.
- Messages—10 consecutive characters with no errors.

Sync Loss Criteria (Synchronous, Recovered timing modes):

- Medium Sync Loss Threshold 250 bit errors in less than 1000 bits of data.
- Low Sync Loss Threshold 100 bit errors in less than 1000 bits of data.
- High Sync Loss Threshold 20,000 bit errors in less than 100,000 bits of data.

Sync Loss Criteria (Asynchronous timing mode):

- Low and Medium Sync Loss Thresholds–30 character errors in less than 60 received characters.
- High Sync Loss Threshold–20,000 bit errors in less than 100,000 received bits.

10.3.2.1 Error Analysis

Test Results Available: (with appropriate data interface)

- Bit Errors.
- Bit Error Rate (BER).
- Average Bit Error Rate.
- Character Errors.
- Blocks.
- Block Errors.
- Average Block Error Rate.
- Clock Slips.

10.3.2.2 Time-Related Results

Test Results Available: (with appropriate data interface)

- Error Analysis Seconds.
- Errored Error Analysis Seconds.
- Error-Free Error Analysis Seconds.
- Elapsed Seconds.
- Time.
- Date.

10.3.2.3 Performance Analysis

Test Results Available: (with appropriate data interface)

- % Active Seconds
- % Available Seconds
- % Degraded Minutes
- % Error-Free Seconds
- % Severely Errored Seconds
- % Severely Violated Seconds
- % Sync Seconds
- % Violation-Free Seconds
- Available Seconds
- Degraded Minutes
- Error-Free Seconds
- Errored Seconds
- Severely Errored Seconds
- Signal Loss Seconds

- Severely Violated Seconds
- Sync Loss Seconds
- Unavailable Seconds
- Violation-Free Seconds

10.3.2.4 BER Test Intervals

- 10^4, 10^5, 10^6, 10^7, 10^8, 10^9, or 10^{10} bits.
- Timed Tests Intervals—1 second to 24 hours, 1 second resolution.

10.3.2.5 Block Lengths

- 10^2 to 10^6 bits, 1-bit resolution.

10.3.3 Signal Analysis

10.3.3.1 Frequency Measurements

Frequency Range:

- 50 Hz to 16 MHz.

Resolution:

- less than 1,000 Hz - 0.001 Hz.
- 1,000 Hz to 9,999.99 Hz - 0.01 Hz.
- 10,000.0 Hz to 99,999.0 Hz - 0.1 Hz.
- greater than 100,000 Hz - 1 Hz.

Accuracy:

- ± 5 ppm (± 1 ppm optional).

10.3.3.2 Delay Measurements

Start of Measurement Signal Sources:

- DTR.
- DSR.
- RTS.
- RLSD.
- CTS (emulate DCE only).
- Generator Data.
- Generator Pattern Sync test point.
- Delay Start test point.

End of Measurement Signal Sources:

- DTR.
- DSR.
- RTS.
- CTS (emulate DTE only).
- RLSD.
- Receiver Data.
- Receiver Pattern Sync test point.
- Delay Stop test point.

Edge Selection:

- Rising (off to on) or falling (on to off) edge selectable for both start and end of measurement signals (except pattern sync test points).

Measurement Range:	• 0 to 9,999.9 milliseconds.
Resolution and Accuracy:	• ±0.1 millisecond.

10.3.4 T-Carrier Analysis

Test Results Available: (with appropriate data interface)

- Bipolar Violations
- Average Violation Rate
- Violation Rate
- Violation Free Seconds
- % Violation Free Seconds
- Received Code -B8ZS, AMI.
- Frame Errors
- Average Frame Error Rate
- Frame Error Rate
- Frame Sync Losses
- CRC Errors
- CRC Error Rate
- Average CRC Errors
- Frame Word Errors
- Average Frame Word Error Rate
- Frame Word Error Rate
- 1SEC CRC

10.3.5 Alarm

Test Results Available: (with appropriate data interface)

- Sync Losses
- Data Losses
- Clock Losses
- Signal Losses
- Yellow Alarm Seconds
- Excess Zero Seconds
- Received Clock-Data Phase Changes
- Power Losses
- AIS SEC

10.4 CLOCK RECOVERY SYSTEM
(With the Clock Recovery Option Installed)

Bit Rates:	• 50 b/s to 520 kb/s.
Clock Recovery Acquisition/ Tracking Range:	• ±1% of selected bit rate typical.

10.5 PROGRAMMABILITY

10.5.1 User-Defined Messages

Number of Programmable Messages:	• Three (USER1, USER2, USER3).

Message Length:
- 1 to 255 characters.

Entry Format:
- One hexadecimal character pair per transmitted character.

Output Format:
- 5, 6, 7, or 8 level code.

10.5.2 Front Panel Programs

Number of Front Panel Programs:
- 10.

Functions Under User Program Control:
- Front panel switch settings, keypad entries, auxiliary functions, etc.

Access:
- Program entry and program recall via the RECALL/STORE function of the MENU switch.

10.6 NON-VOLATILE MEMORY

Information Stored:
- Current front panel switch settings, keypad entries, auxiliary functions.
- Three user-defined messages.
- 10 front panel programs.
- Time and date of last power-down.
- Results from before power-down.

Memory Back-up Battery Life:
- Typically greater than 7 years.

10.7 REMOTE CONTROL CAPABILITY

Remote Control Access:
- RS-232 Printer/Remote Control Interface.
- Optional IEEE-488 Interface.

Controllable Functions:
- Front panel switch settings.
- Keypad entries.
- Auxiliary functions.
- User-defined messages.

10.8 DATA INTERFACES

10.8.1 Built-In RS-232 Data Interface

Connectors:
- Two 25-pin D subminiature female connectors.
- One connector for DTE emulation labeled TO DCE.
- One connector for DCE emulation labeled TO DTE.

Signal Format:
- Bipolar, unbalanced.

Data Bit Rates:
- 50 to 20,000 b/s per EIA RS-232 and CCITT V.28.

10.8.2 External Data Interface

External Data Interface Slot:
- Accepts any FIREBERD data interface.

10.9 REAR PANEL TEST POINTS

Output Test Points:
- Generator Clock.
- Generator Data.
- Generator Pattern Sync.
- Receiver Clock.
- Receiver Data.
- Receiver Pattern Sync.
- Error.
- Sync.
- Test Point Z.
- Signal Ground.

Logic Low Output:
- 0.4 volts maximum at 12 mA or less.

Logic High Output:
- 2.4 volts minimum at 3 mA or less.

Input Test Points:
- External Delay Start.
- External Delay Stop.

Logic Low Input:
- 0.8 volts maximum.

Logic High Input:
- 2.0 volts minimum.

Input Impedance:
- 2000 ohms minimum.

10.10 REAL TIME CLOCK

Display Clock Functions:
- Hours (24-hour format).
- Minutes.
- Seconds.
- Month.
- Day.
- Year.

Printed Clock Functions:
- Hours.
- Minutes.
- Seconds.
- Month.
- Day.
- Year.

Accuracy:
- Typically better than 1 second per day.

10.11 DISPLAY

Display Type:
- Vacuum Fluorescent Display.

Display Size:
- 80 characters—40 characters x 2 lines.

Character Font:
- 5 x 7 dot matrix and cursor.

10.12 AUDIO OUTPUT

Audio Indicator:
- Speaker.

Audio Level Control:
- Volume control—off, minimum to maximum.

10.13 POWER REQUIREMENTS

Voltage:
- Two user selectable ranges: 90-135 volts ac, 195-250 volts ac.

Frequency:
- 48 to 66 Hz.

Power:
- 110 volt-amperes maximum.

10.14 ENVIRONMENTAL SPECIFICATIONS

Operating Temperature Range:
- 0°C (+32°F) to +50°C (+124°F).

Storage Temperature Range:
- -30°C (-22°F) to +75°C (+167°F).

10.15 DIMENSIONS AND WEIGHT

FIREBERD 6000

Size:
- 6" H x 12" W x 12" D.

Weight:
- 15.8 lbs with all options, a data interface, and the IEEE-488 Remote Control Interface installed.

FIREBERD MC6000

Size:
- 6.5" H x 14.5" W x 14" D.

Weight:
- 19.3 lbs with all options, a data interface, and the IEEE-488 Remote Control Interface installed.

FIREBERD 6000R

Size:
- 6" H x 12" W x 12" D.

Weight:
- 12.0 lbs with all options, a data interface, and the IEEE-488 Remote Control Interface installed.

SECTION 11
OPTIONS AND ACCESSORIES

11.1 INTRODUCTION

This section describes some of the options and accessories available for use with the FIREBERD 6000. Specifically described are the Metal Case and Remote Control options and such accessories as the printers, rack mounts, and carrying cases. This section also includes, for ordering purposes, a list of all accessories available (including cables and data interfaces) with their corresponding model numbers. Detailed information is not provided on the data interfaces since they are covered in Section 8 of this manual.

11.2 OPTIONS

Various hardware and software options are available for the FIREBERD 6000. Two of these, the Metal Case option and the Remote Control option, are described below. The other available options are discussed in detail elsewhere in this manual. Section 11.2.3 lists these options and their model numbers.

11.2.1 FIREBERD MC6000 (Metal Case Option)

The FIREBERD MC6000 is the ruggedized version of the standard FIREBERD 6000. Performance characteristics, front and rear panel formats, and internal electronic sub-assemblies are identical.

The FIREBERD MC6000 housing is of metal construction and quite rugged. The unit comes with a front snap-on cover. With the cover in place, the instrument is completely protected and can be carried and handled like a piece of luggage. The manual or two extra interface modules can be stored in the snap-on back pouch.

The FIREBERD MC6000 is 6 ½" high (including the feet), 14 ½" wide and 14" deep (including the cover). The unit weighs approximately 19 pounds, 3 ounces with interface, all options, front cover, and power cord.

11.2.2 FIREBERD 6000R (Remote Control Communications Analyzer)

The FIREBERD 6000R has all of the capability of the FIREBERD 6000, but it will operate only under remote control. It is packaged in the FIREBERD 6000 plastic case but has a blank front panel with only a power switch and an indicator that lights while the FIREBERD is being remotely controlled. It weighs 12 pounds with all options, a data interface, and the IEEE-488 Remote Control Interface installed.

11.2.3 Options List

The following is a list of other available options and their part numbers. Listed in parentheses next to each option is the location in this manual of a description of the option.

OPTION NUMBERS	DESCRIPTIONS
6001	DS1 Wideband Jitter Measurement (Section 9)
6002	DS1 Jitter Spectral Analysis (Section 9)
6003	DS1 Jitter Generation
6004	Clock Recovery (Section 5.6)
6005	IEEE-488 Remote Control/Printer Interface (Section 7.6)
6006	Precision Time Base (1 ppm) (Section 5.3.5)

11.3 ACCESSORIES

Various accessories for use with the FIREBERD 6000 are described below. Also included are instructions for those accessories requiring installation.

11.3.1 PR-85 Printer

The PR-85 is an impact, dot matrix, graphic printer. It will provide 80-column printouts as well as bit-mapped histograms and jitter graphics. The printer connects to the

RS-232 Printer/Controller Interface through a male-to-male printer cable. It can produce draft or near-letter-quality (NLQ) characters by pressing one of three switches on the PR-85 control panel.

For more information on the PR-85 printer, see the PR-85 Operating Manual.

11.3.2 PR-2000 Thermal Printer

The PR-2000 is a quiet, non-impact, alphanumeric thermal printer. It is capable of printing the full printable ASCII character set with up to 20 characters per line. The characters are input in a serial asynchronous format with start, stop, and parity bits. This small portable unit may be operated on a bench top or may be rack mounted along with the FIREBERD in the optional RM-1500A or RM-MC Rack Mount units. A cable is included with each printer allowing it to directly interface with the FIREBERD RS-232 Printer/ Controller Interface at 2400 baud. For more information on the PR-2000 Thermal Printer, see the PR-2000 Operating Manual.

11.3.3 ISU-2000 Interface Switching Unit

The Interface Switching Unit (ISU) allows the user to change the FIREBERD data interface without physically removing and inserting the interface. The ISU is a rack-mountable device capable of accommodating up to four data interfaces and electronically selecting one data interface for use with the FIREBERD.

Intended to be rack mounted either directly above or directly below the FIREBERD, the Interface Switching Unit is connected to the FIREBERD by a ribbon cable attached to a special data interface (included). Switching between data interfaces can be accomplished by using pushbutton switches mounted on the ISU or remotely via contact closures. Indicators are provided on the ISU indicating which data interface is on line and whether the unit is under local or remote control.

The Interface Switching Unit will accommodate any of the FIREBERD 1500Aand 2000-compatible interfaces that are also used with the FIREBERD 6000. The ISU can be mounted with the interface facing the front of the rack (front access) or the rear of the rack (rear access). A BNC connector is mounted facing the front of the rack for the application of an external clock signal to the FIREBERD. The ISU can operate at 100/120/220/240 volts ac (50/60 Hz) and occupies 5 ¼" of rack height. For additional information on the ISU, refer to the ISU-2000 Operating Manual.

11.3.4 ISU Flush Door Accessory (Model 10518)

The Interface Switching Unit can be equipped with an optional Flush Door Accessory. The accessory recesses the ISU panel approximately 4 ½" behind the rack mount surface and provides a smoke gray plexiglass door. The unit conceals the interface modules and cables while still allowing access to the interface module front panels.

11.3.5 Interface Extender (Model 10770)

The Interface Extender is an accessory to all FIREBERD mainframes housed in a metal case. The Interface Extender, which allows front panel access to the data interface module and its controls, connects to the FIREBERD via a shielded ribbon cable attached to a special data interface (included). The Model 10770 Interface Extender mounts under the FIREBERD mainframe. A Rack Mount Adaptor (Model 10773) is available for mounting the Interface Extender in a standard 19" rack.

11.3.6 FIREBERD 6000/6000R Rack Mount (Model RM-1500A)

The RM-1500A allows the standard FIREBERD 6000 (plastic case) or the FIREBERD 6000R and the PR-2000 Thermal Printer to be mounted in a standard 19" equipment rack. The assembly requires 7" of vertical rack space. The Rack Mount provides a power switch for the Thermal Printer and an AC receptacle to provide ac power to both the FIREBERD and the PR-2000 Thermal Printer.

WARNING

To minimize shock hazard, the Rack Mount chassis must be connected to an electrical ground. The Rack Mount is equipped with a three-conductor AC power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adaptor with grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet.

The following sections provide instructions for mounting the FIREBERD and the PR-2000 Printer in the RM-1500A Rack Mount. If the FIREBERD has a swing-around handle, this handle must be removed before mounting into the Rack Mount; the user may either return the FIREBERD to TTC for handle removal or use the following handle removal instructions. If the FIREBERD does not have a handle, proceed directly to the assembly instructions.

FIREBERD Handle Removal
(All Metal, Black Side Arms and Cross Bar)

(1) Disconnect the AC power cord from the FIREBERD.

(2) Remove the left and right pushbutton and spring on each side (insert small screwdriver and pry gently). Remove the screw and washer from both sides. This will allow complete removal of handle and ratchet mechanism. The FIREBERD is now ready for rack mount assembly.

Assembly Instructions

(1) Install the printer as follows:*

(a) Insert the PR-2000 through the Rack Mount Panel from the front.

(b) Unlatch and slide the printer mechanism forward, exposing the printer mounting ears. Install four #4 x 3/16" lg. pan head screws into the holes of the mounting ears then return the printer mechanism to its operating position (closed).

(c) Install the printer support bracket at the rear of the printer by removing the two #3 screws at the top rear of the PR-2000. Attach the support bracket to the printer and chassis using four #4-40 x 3/16" lg. screws and lock washers.

* If a printer is not to be installed into the Rack Mount unit, a blank-off plate is available to cover the Printer Mounting hole.

(2) Install FIREBERD as follows:

(a) Make sure the FIREBERD does not have the handle or side handle ratchet installed. The sides of the FIREBERD must be free of all handle components so that it will fit into the rack adaptor.

(b) Place the FIREBERD on the shelf, front panel facing forward, and carefully manipulate the front of the case through the opening. It should protrude through the front panel about ¼ inch.

(c) Lift the rear of the FIREBERD and insert the two ¼" hex x 3/16" lg. standoffs in the rear feet and align with two holes in the shelf. Install two #6 x 3/16" lg. screws and two lock washers through the bottom of the shelf into the standoffs.

(d) Install the two "Z" hold-down brackets at the rear of the instrument using the #4 hardware provided with the rack adaptor.

(e) Plug the FIREBERD and the printer into the 115 VAC receptacle. The printer should be plugged into the receptacle that is controlled by the front panel switch.

(f) Fold and store excess FIREBERD and printer line cord under the printer. The bracket is designed to allow cable storage.

(3) Connect the cable supplied with the printer from the 25-pin "D" type connector on the rear of the printer to the RS-232 printer connector on the FIREBERD.

(4) The RM-1500A unit should now be ready for rack installation. The unit will mount in a rack by its front panel without further angle brackets or supports.

11.3.7 FIREBERD MC6000 Rack Mount (Model RM-MC)

The RM-MC allows the FIREBERD MC6000 and the PR-2000 Thermal Printer to be mounted in a standard 19" equipment rack. This assembly requires 7" of vertical rack space. The Rack Mount provides a power switch for the Thermal Printer and an AC receptacle to provide ac power to both the FIREBERD and the PR-2000 Thermal Printer.

WARNING

To minimize shock hazard, the Rack Mount chassis must be connected to an electrical ground. The Rack Mount is equipped with a three-conductor AC power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three contact or two contact adaptor with grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet.

The following sections provide instructions for mounting the FIREBERD and the PR-2000 Printer in the RM-MC Rack Mount. If the FIREBERD has a swing-around handle, this handle must be removed before mounting into the Rack Mount; the user may either return the FIREBERD to TTC for handle removal or use the following handle removal instructions. If the FIREBERD does not have a handle, proceed directly to the assembly instructions.

FIREBERD Handle Removal (Metal Case Units)

(1) Disconnect the AC power cord from the FIREBERD.

(2) Remove the left and right push button and spring on each side (insert small screw driver and pry gently). Remove the screw and washer from both sides. This will allow complete removal of handle and ratchet mechanism. The FIREBERD is now ready for rack mount assembly.

Assembly Instructions

(1) Install the printer as follows:*

(a) Insert the PR-2000 through the Rack Mount Panel from the front.

(b) Unlatch and slide the printer mechanism forward, exposing the printer mounting ears. Install four #4 x 3/16" lg. pan head screws into the holes of the mounting ears then return the printer mechanism to its operating position (closed).

* If a printer is not to be installed into the Rack Mount unit, a blank-off plate is available to cover the Printer Mounting hole.

(2) Install FIREBERD as follows:

(a) Make sure that the FIREBERD does not have the handle installed. The sides of the FIREBERD must be free of all handle components in order to fit into the rack adaptor.

(b) Place the FIREBERD on the shelf, front panel facing forward, and carefully manipulate the front of the case through the opening. It should protude through the front panel until the lip of the bezel fits solidly.

(c) Install the two "Z" hold-down brackets at the rear of the instrument using the #4 hardware provided with the rack adaptor.

(d) Plug the FIREBERD and the printer into the AC receptacle. The printer should be plugged into the receptacle that is controlled by the front panel switch.

(e) Fold and store excess FIREBERD and printer line cord under the printer.

(3) Connect the cable supplied with the printer from the 25-pin D connector on the rear of the printer to the RS-232 printer connector on the FIREBERD.

(4) The RM-MC unit should now be ready for rack installation. The unit will mount in a rack by its front panel without further angle brackets or supports.

11.3.8 Shipping Case—For FIREBERD 6000 and 6000R (Model 10176)

The shipping case holds a standard FIREBERD (plastic case), a PR-2000 Thermal Printer, five interface modules, accessory cables, and this manual. The rigid ABS molded case has a foam-padded interior with cavities to hold the FIREBERD and its accessories. The case is rugged and water resistant, and has stainless steel draw latches and a molded handle. Case dimensions are 26 ½" x 19" x 11 ½".

11.3.9 Shipping Case—For FIREBERD MC6000 (Model 40527)

This shipping case holds the FIREBERD MC6000 (metal version), a PR-2000 Thermal Printer, five interface modules, accessory cables, and this manual. The rigid ABS molded case has a foam-padded interior with cavities to hold the FIREBERD MC6000 and its accessories. The case is rugged and water-resistant, and has stainless steel draw latches and a molded handle.

11.3.10 Soft Carrying Case (Model 10170)

The FIREBERD Soft Carrying Case is constructed of canvas with dense foam inserts surrounding all sides, top, and bottom. The dimensions are 19 ½" wide x 9 ½" deep x 16 ⅛" high. The case is navy blue and has an I.D. pocket on the top cover. The top cover is hinged and secured with

Velcro fasteners. The case is carried by a handle that supports across the bottom and up both sides. Additionally, there is a padded, adjustable, snap-on shoulder strap.

The carrying case holds one standard FIREBERD (plastic case), a PR-2000 Thermal Printer, one manual, and three interface modules in addition to the associated cables and line cords. The carrying case will also hold one FIREBERD MC6000 (metal case), one manual, two interface modules, and several cables. Empty, the case weighs 6 ¼ lbs.

11.3.11 PR-85 Soft Carrying Case

The PR-85 Soft Carrying Case is constructed of canvas with dense foam inserts surrounding all sides, top, and bottom. The dimensions of the case are 20" wide x 8 ½" deep x 17 ½" high. The top cover is hinged and secured with Velcro fasteners. The case is carried by a handle that supports the bottom and both sides of the case. The carrying case includes a backpouch used to hold the operating manual, printer paper, and printer cable. Empty, the case weighs 3 ¼ pounds.

11.3.12 ISU-6000 Interface Switching Unit

The ISU-6000 Interface Switching Unit (ISU) is a rack-mountable product capable of accommodating multiple data interface modules and electronically setting one interface for use with the FIREBERD 6000. Using this device, the user can operate a FIREBERD 6000 without handling interfaces or moving cables. Switching between the installed interfaces is controlled by the FIREBERD 6000's Interface Setup menu.

Single-Unit Configuration (Four Interfaces)

The ISU-6000 may be configured to accommodate four or eight interfaces. The components for each configuration are listed below:

- One Interface Shelf (Model 10805)
- One Single Cable Interface Adaptor (Model 40678)
- One Flush Door (Model 10518) (optional)

Dual-Unit Configuration (Eight Interfaces)

- Two Interface Shelves (Model 10805)
- One Dual Cable Interface Adaptor (Model 40681)
- Two Flush Doors (Model 10518) (optional)

11.4 ORDERING INFORMATION

The following is a list of accessories available from TTC at the time this manual was printed; model numbers are listed for ordering purposes. Contact TTC for an up-to-date list.

Description	Model Number
RACK MOUNTS	
Rack Mount for FIREBERD 6000 (Plastic Case) and Printer	RM-1500A
Rack Mount for FIREBERD MC6000 and Printer	RM-MC
Rack Mount for FIREBERD 6000R	RM-1500A
INTERFACE SWITCHING UNIT (ISU) ISU-2000	
Interface Switching Unit Flush Door	10518
INTERFACE EXTENDER (for FIREBERD metal case)	10770
Rack Mount Adaptor	10773
PRINTERS	
PR-2000 ASCII Thermal Printer (20-column) with cable	PR-2000
PR-2000 Printer Paper (12 rolls)	10217
PR-85 ASCII and Graphics Printer (80-column) with cable	PR-85
PR-85 Soft Carrying Case	40522
PR-85 Printer Paper (2400 sheets)	10651
PR-85 Printer Repacement Ribbon	10653
PR-85 Printer Replacement Print Head	10671

Description	Model Number
MISCELLANEOUS	
Extra Manual	ML10607
Soft Carrying Case (for both FIREBERD plastic and metal case)	10170
Hard Shipping Case (for FIREBERD plastic case)	10176
Hard Shipping Case (for FIREBERD metal case)	40572
Remote Adaptor (For RS-232 and IEEE-488 Remote Control)	30379
Transmit Line Build Out	10557
DATA INTERFACE MODULES	
RS-232 Sync DTE/DCE Interface	40236
RS-232 Sync/Isoch DTE Interface	40232
RS-232/V.24/MIL-188C DTE/DCE Character Interface	40392
V.35/306 DTE/DCE Interface	40202
RS-449 (422/423) DTE/DCE Interface	40200
WECO 303 Interface (cable included)	40182
DS1/T1 (D4 Framed/Unframed) Interface	40405
DS1/T1 (Unframed only) Interface with APS	40365
CCITT G.703 64 kb/s (co-directional) Interface	40323
CCITT G.703 2.048 Mb/s Interface	40380
MIL-188C/MIL-188-114 Unbalanced Interface	40226
MIL-188-114 Balanced Interface	40298
Lab Interface Bal/Unbal, Polar/Bipolar (TTL Compatible)	40204
DS1C/DS2 Interface	30447
DS0/DS0A Interface	30481
DS1/D4/Fe Interface	40460
64 kb/s G.703 Data Interface	30608
2048 kb/s G.704 Framing Interface	30609
CABLES	
RS-232/V.24 male-to-male cable (6')	10213
RS-232/V.24 male-to-male cable (10')	10418
V.35/306 male-to-male cable (6')	10214
V.35/306 male-to-male cable (10')	10419
RS-449/Military male-to-male cable (6')	10215
RS-449/Military male-to-male cable (10')	10417
WECO 310 plug to WECO 310 plug cable (10')	10420
WECO 310 plug to alligator clips cable (10')	10558
WECO 310 plug to 15-pin adaptor cable (10')	30375
WECO 310 plug to bantam plug cable (4')	10599
WECO 310 plug to bantam plug cable (10')	10559
Bantam plug to alligator clips cable (4')	10648
Dual bantam plug to 15-pin adaptor cable (10')	30503
Military male 37-pin D to male 25-pin D adaptor cable (6')	10496
Military male 37-pin D to female 25-pin D adaptor cable (6')	10538
RS-449 DTE to X.21 DTE Adaptor Cable	10562
OIU adaptor cable, 9-pin, male-to-male	20309
Bantam plug to bantam plug cable	10615
Replacement printer cable (for PR-2000)	30265
Replacement printer cable (for PR-85)	30511
BREAKOUT BOXES	
Breakout Box for RS-232C, V.24/V.28, MIL-188C	Model 25
Breakout Box for V.35, Bell 306	Model 34
Breakout Box for RS-449, V.10/V.11, MIL-188-114	Model 37

SECTION 12
MAINTENANCE AND SERVICE

12.1 INTRODUCTION

This section contains information on maintenance and service for the FIREBERD 6000. Specifically, it includes steps to take should the user experience difficulty operating the FIREBERD, maintenance procedures for the fan screen, and a description of TTC's warranty and repair procedures.

12.2 MAINTENANCE

12.2.1 In Case of Difficulty

If the unit fails to operate and no front or rear panel indicators illuminate, check the following:

AC power cord and AC supply
AC fuse and fuse size

If some indicators light but the unit fails to operate with the built-in RS-232 interface, there are three checks that can be made: (1) determine whether the interface in use is the correct one for the desired application; (2) verify that the interface is properly inserted in the interface slot; or (3) insert another interface (suitable for the application) in the event that the original interface itself is not operating properly. Power to the FIREBERD should always be off before removing or inserting interface modules. The interface cable and connections to the FIREBERD should also be checked.

Follow the Self-Test Procedure in Section 3 as an aid to localizing the problem. If the unit cannot be made to operate properly, call the TTC Customer Service Department for applications assistance.

12.2.2 Fan Screen

A fan mounted on the rear panel of the FIREBERD allows proper cooling and ventilation of the internal components. The fan is always in operation while the FIREBERD itself is on; the fan cannot be operated independently. The fan is protected by a screen which is attached to the outside of the rear panel for easy maintenance. The screen should be checked and cleaned periodically to ensure proper cooling operation. Before removing the screen for cleaning, remove power to the FIREBERD and allow fan to stop. Remove the four screws which attach the screen to the rear panel. The screen may be cleaned with compressed air or, if necessary, with a cleaning solvent. Reattach the screen by replacing the four screws which hold it in place.

12.3 SERVICE

12.3.1 Warranty Policy

All equipment manufactured by Telecommunications Techniques Corporation (TTC) is warranted against defects in material and workmanship. This warranty applies only to the original purchaser and is non-transferable unless express written authorization of the warranty transfer is granted by TTC.

FIREBERD mainframes (Models 6000, MC6000, 6000R) will be repaired or replaced (at our option) at no charge for a period of three (3) years after original receipt by the customer. Data interfaces, cables, breakout boxes, accessories, and all equipment other than FIREBERD mainframes will be repaired or replaced (at our option) at no charge for a period of one (1) year after original receipt by the customer.

Liability under this warranty extends only to the replacement value of the equipment. This warranty is void under the following conditions:

1) Equipment has been altered or repaired without specific authorization by TTC.
2) Equipment is installed or operated other than in accordance with instructions contained in TTC literature and operating manuals.

No other warranty is expressed or implied. TTC is not liable for consequential damages.

12.3.2 In-Warranty Service

Equipment in warranty must be returned to the factory with shipping prepaid. The equipment should be packed and shipped in accordance with the instructions contained in Section 12.3.4 of this manual. Defective units will be repaired or replaced (at our option) depending on severity of defect. Before returning any equipment, the customer must obtain a Return Authorization (RA) number by contacting the TTC Customer Service Department. The RA number should then appear on all paperwork and be clearly marked on the outside of the equipment container.

After the equipment is repaired by TTC, it will be tested to applicable specifications, burned-in for at least 24 hours, retested, and returned to the customer with shipping prepaid. A brief description of the work performed and the materials used will be provided on the Equipment Repair Report furnished with the returned equipment.

12.3.3 Out-of-Warranty Service

The procedure for repairing out-of-warranty equipment is the same as that used for equipment still in warranty. However, there is a minimum charge of $100.00 applied to each request for out-of-warranty service. The $100.00 minimum charge guarantees the customer an estimate of the repair costs and is used as credit against actual materials and labor costs should the equipment be repaired. The customer will be billed for parts plus standard labor rates in effect at the time of repair. The customer will also be required to furnish a purchase order number before repair work can be started. A description of the labor and materials used will be provided in the Equipment Repair Report.

12.3.4 Equipment Return Instructions

To all equipment returned for repair, the customer should attach a tag that includes the following information.

1) Owner's name and address.
2) A list of the equipment being returned and the applicable serial number(s).
3) A detailed description of the problem or service requested.
4) The name and telephone number of the person to contact regarding questions about the repair.
5) The Return Authorization (RA) number.

If a FIREBERD mainframe is being returned, it is recommended that all switches be left in the positions they were in when the problem occurred. The interface module in use at the time of the failure should also be returned.

If possible, the customer should return the equipment using the original shipping container and material. If the original container is not available, the unit should be carefully packed so that it will not be damaged in transit. TTC is not liable for any damage that may occur during shipping. The customer should clearly mark the TTC-issued RA number on the outside of the package and ship it prepaid and insured to TTC.

APPENDIX A
FIREBERD 6000 ON-LINE HELP DIRECTORY

All commands to the FIREBERD consist of an ASCII command name followed by optional ASCII parameter selections and a statement terminator. A valid statement terminator is a carriage return, linefeed, or any combination thereof.

HELP!	Print a list of all valid command names.
HELP (command name)	Print the PARAMETER SYNTAX for a command.
HELP AUX	Print a list of all available AUX functions.
PAGE1 or HELP or ?	Print this page.
PAGE 2	Print additional HELP for command entry.
PAGE 3	Print HELP for front panel switch commands.
PAGE 4	Print HELP for special front panel commands.
PAGE 5	Print HELP for remote-control-only commands.
PAGE 6	Print HELP for BERD-BASIC programming.
PAGE 7	Print HELP for built-in BERD-BASIC programs.
(command name) (parameter)	Set the new state of a command.
(command)	Print the current state of a command.

The following characters have special meaning to the FIREBERD:

<BREAK>	(Three times slowly) Enter Auto-Baud mode. Type spaces (“ ”) repeatedly (~5 Hz) until auto-baud achieved, the <ESCAPE>.
control h	BACK SPACE delete the previously entered character.
control x	CANCEL cancel the current input line.
control c	Clear the input line, clear the print FIFO, abort any loop codes, and break the program execution.
control s	X-OFF suspend all printer outputs until X-ON.
control q	X-ON resume all printer outputs from X-OFF.
“*”	Recall the help/status macro.
“&n”	Recall user macro #n (where n = 0 to 9).
“;”	Separate multiple comands on the same line.
“,” or “~”	Separate multiple parameter selections of a command.
“#nn/”	Select command/parameter #nn as listed by the NUMBER command. (“/” is optional if the character that follows is not numeric.)
“{...}”	Surrounds comments to be ignored by the FIREBERD.
“_”	Repeat the previous command.
“.”	Follows an abbreviated command or parameter name.

Front panel switch manipulation commands include:

ANA MOD	—select analysis mode.
ANA RES 1 and 2	—select left and right display results, respectively.
AUX nn	—select auxiliary function nn.
CHA FOR	—Select async character format.
DAT	—select generator data pattern.
ERR INS	—select error insertion rate.
GEN CLK	—select generator clock source.
INT SET	—select data interface set-up.
JIT	—select jitter set-up.
PRI EVE	—select print event.
PRI	—select printer power or results/controls.
REC/STO	—recall/store front panel program.
RES	—restart test.
RTS/DTR	—select interface signals (also RLS/DSR or LOOUP/LOODN).
SEL LOO	—select self-loop mode.
SYN FRE	—select synthesizer frequency.
TES INT	— select the test interval length.
TIM MOD	— select the timing mode.

Special front panel switch commands perform the same function as the normal front panel switch commands but with a simplified command entry format. They include:

CLEAR FIFO	—clear the printer FIFO.
CONTROLS	—generate a controls print.
CUSTOM	—select the custom printout status.
ERROR	—insert a single error in the TX data.
FAST/SLOW	—select fast/slow RS-232 printer mode.
FORMAT/UNFORMAT	—select formatted/unformatted printer mode.
HELLO	—print the software revision level.
LONG	—select long results print mode.
OCT TIM	—select octet timing mode for 64 kb/s G.703 Data Interface
RESULTS	—generate a results print.
STANDARD	—select the standard results print.
STATUS	—select the customized status messages.
TERM 232	—select the RS-232 printer line terminator.
TERM 488	—select the IEEE-488 printer line terminator.
TIME/DATE	—set or display the time/date.
WIDTH	—select the printer width.

The "remote-control-only" commands provide access to functions not available via the front panel. They include:

AUDIO	—select the audio level override.
BEEP	—sound the beeper once.
CLS	—clear the terminal screen.
DEVICE CLEAR	—initialize the FIREBERD to its power-up state (also BYE).
DISPLAY	—select the front panel display switch mode.
ECHO/PROMPT	—select the echo/prompt function status.
ENTER/END	—disable/re-enable contention error messages.
HOLD/REL	—hold/release all printer outputs.
ISU	—control the Interface Switching Unit.
LEDS	—print state of front panel LEDs.
LOCAL or /	—return the FIREBERD to local mode.
LPRINT	—print a literal string.
MACRO	—define or display macros.
PLAIN ENGLISH	—select plain english or hex user message prints.
PRINT or ?	—print the result or variable value.
SELF TEST	—print the results of the automatic self-test.
TERMINAL or "."	—set the FIREBERD up to talk to a dumb terminal.
TPZ	—control rear-panel test point "Z".
USER	—enter a user message in ASCII.

FIREBERD 6000 ON-LINE HELP DIRECTORY

The FIREBERD accepts the following BERD-BASIC commands:

nnnn (command)	—load remote control command as line number nnnn.
nnnn	—delete program line number nnnn.
BREAK	—select program action on error.
CHAIN	—chain execution to a program in permanent storage.
COMMON	—preserve all variables through the next CHAIN.
DIR	—print the names of all files in permanent storage.
GOSUB/RETURN	—goto and return from subroutine, respectively.
GOTO	—transfer program execution to the specified line.
IF (....THEN)	—goto specified line if condition is true.
INPUT	—enter line from terminal into user macro.
KILL	—delete a program from permanent storage.
LET	—(optional) assign a new value to a variable.
LIST	—list the currently loaded program.
LOAD/SAVE	—load/save a program from/to permanent storage.
NEW	—clear the current program in preparation for a new one.
RUN/CONT	—run/continue the current program.
STOP/END	—stop the program execution at the specified line.
WAIT	—wait for sync or for the specified number of seconds.

The built-in BERD-BASIC programs provide additional capabilities not otherwise available through simple remote control commands. Note that these programs may modify the user macros. They include:

PROG or ^	—run the main interactive menu.
PROG AUX	—configure AUX functions.
PROG FRONT PANEL	—configure the front panel functions
PROG INTERFACE	—configure the interface set-up
PROG JITTER	—configure the jitter set-up.
PROG PRINTER	—configure the printer functions.

APPENDIX B
SAMPLE IEEE-488 PROGRAM

This appendix provides a computer program written for use on a Hewlett Packard 85 computer.

SAMPLE PROGRAM #1: IEEE-488/GPIB-PC Controller Program

This program is for use with the National Instruments GPIB-PCII and BASIC language interface for the IBM PC. Lines 1-99 must come from the DECL.BAS file included in the National Instruments package.

```
100 REM ****** GPIB-PC / BASIC PROGRAM TO CONTROL FB6000 *******
110 REM
120 REM LINES 1—99 MUST COME FROM DECL.BAS SUPPLIED WITH YOUR
130 REM GPIB-PC SOFTWARE PACKAGE
140 REM
150 REM READ GPIB-PC DOCUMENTATION FOR FURTHER INFORMATION
160 REM
170 REM THIS PROGRAM ASSUMES FB6000 IS ADDRESS 1 ON IEEE-488 BUS
180 REM
190 REM ******************** INITIALIZATION ******************
200 DIM C$[255]
210 CLS:KEY OFF:LOCATE 25,1
220 PRINT " PRESS ANY KEY TO ENTER COMMAND MODE ----Q COMMAND QUITS"
230 LOCATE 1,1
240 DEV$ = "DEV1" 'ASSUMES DEVICE ADDRESS 1
250 CALL IBFIND(DEV$, DEV%)
260 IF DEV% 0 THEN PRINT DEV$;" not found in GPIB-PC configuration";GOTO 460
270 GOTO 380
280 REM
290 REM ******* ENTER USER COMMAND **********
300 PRINT DEV$;" ";MSG$;
310 LINE INPUT MSG2$
320 MSG$ = MSG$ + MSG2$
330 IF MSG$ = "q" OR MSG$ = "Q" THEN 460
340 MSG$ = MSG$ + CHR$(13) + CHR$(10) 'APPEND CR LF TO TERMINATE CMD
350 CALL IBWRT (DEV%,MSG$) 'WRITE ASCII STRING TO FB6000
360 RETURN
370 REM
380 REM ****** POLL CONTINUOUSLY ********
390 MSG$ = INKEY$ "IF LEN(MSG$) 0 then GOSUB 290 'CHECK KEYBOARD
400 CALL IBRSP(DEV%, STA%) 'SERIAL POLL THE FIREBERD
410 IF (IBSTA% AND &H4000) THEN 450
420 IF (STA% AND !) 0 THEN PRINT "SYNTAX ERROR"
430 IF STA% 0 THEN C$=SPACE$(255):CALL IBRD(DEV%,C$):PRINT LEFT$(C$,IBCNT%);
440 GOTO 380
450 PRINT DEV$;" TIMEOUT—ERR = ";IBERR%;
460 KEY ON:END
```

SAMPLE PROGRAMS 2-3: IEE-488/HP-85 Controller Programs

These programs are for use with the Hewlett-Packard HP-85 computer equipped with an HP-IB interface and IO-ROM.

```
10 ! PROGRAM NAME “SRQ488”
20 ! DOES INTERRUPT DRIVEN I/O
30 ! ON IEEE-488 BUS
40 !
50 DIM A$[99],B$[99]
60 ON TIMEOUT 7 GOTO 450
70 SET TIMEOUT 7;1200
80 CLEAR
90 DISP “SRQ DRIVEN IEEE-488 CONTROLLER
100 DISP “ PROGRAM”
110 DISP
120 DISP “BE SURE THAT AUX 39, SRQ MODE”
130 DISP “IS SET TO DAT”
140 DISP
150 DISP “PRESS k1 TO ISSUE A COMMAND
160 DESP “PRESS k2 to CHANGE ADDRESS”
170 DISP
180 GOSUB 510
190 ! GET ANY CHR FROM BEFORE
200 ! SRQ ENABLED
210 ENTER 700+I USING “#%,%K”; A$
220 DISP A$
230 ! ENABLE INTERRUPTS
240 ON INTR 7 GOSUB 390
250 ENABLE INTR 7;8
260 ON KEY# 1 GOSUB 300
270 ON KEY# 2 GOSUB 510
280 GOTO 280
290 !
300 ! ** OUTPUT COMMAND **
310 DISP
320 DISP “COMMAND“
330 INPUT B$
340 OUTPUT 700+I ;B$
350 OUTPUT 700+I ;“/”
360 RETURN
370 !
380 ! INTERRUPT SERVICE ROUTINE
390 S#SPOLL(700+I)
400 ENTER 700+I USING “#%,%K”; A$
410 DISP A$
420 ! CLEAR HP-85 INTERRUPTI
430 STATUS 7,1 ; S
440 ENABLE INTR 7;8 ^ RETURN
450 ! ** HANDLE BUS TIMEOUT **
460 ABORTIO 7
470 DISP “BUS TIMEOUT—RESET”
480 BEEP
490 WAIT 1500
500 GOTO 230
510 ! GET NEW DEVICE ADDRESS
520 DISP “ENTER ADDRESS OF DEVICE”
530 INPUT I
540 RETURN
```

```
10 ! PROGRAM NAME “EZ488”
20 ! DESIGNED TO PERFORM I/O
30 ! VIA IEEE-488 BUS
40 !
50 !
60 ! ** INITIALIZATION
70 CLEAR
80 DIM I$[99],0$[99]
90 DISP “MENU”
100 DISP “————————”
110 DISP “1) DEPRESS k1”
120 DISP “ TO SEND A COMMAND”
130 DISP “2) DEPRESS k2”
140 DISP “ TO SELECT ADDRESS”
160 ON KEY# 2 GOTO 70
170 DISP “————————”
190 DISP “OF YOUR INSTRUMENT”
200 INPUT A
210 IF A32 THEN 260
220 GOTO 70
230 !
240 !
250 ! *
260 CL
```

```
10 ! PROGRAM NAME "EZ488"
20 ! DESIGNED TO PERFORM I/O
30 ! VIA IEEE-488 BUS
40 !
50 !
60 ! ** INITIALIZATION
70 CLEAR
80 DIM I$[99],0$[99]
90 DISP "MENU"
100 DISP "————————"
110 DISP "1) DEPRESS k1"
120 DISP " TO SEND A COMMAND"
130 DISP "2) DEPRESS k2"
140 DISP " TO SELECT ADDRESS"
160 ON KEY# 2 GOTO 70
170 DISP "————————"
190 DISP "OF YOUR INSTRUMENT"
200 INPUT A
210 IF A32 THEN 260
220 GOTO 70
230 !
240 !
250 ! ** WAIT FOR STATUS 0
260 CLEAR
270 GOSUB 590
280 ON TIMEOUT 7 GOSUB 620
290 SET TIMEOUT 7;500
300 !
310 !
330 ! ITS STATUS
340 S=SPOLL (700+A)
350 !
360 ! IS DATA AVAILABLE (dav)
370 IF BINAND(S,128) 0 THEN GOSUB 510
380 GOTO 280
390 !
400 !
410 ! *** SUBROUTINES ***
420 !
430 ! ** SEND COMMANDS TO BUS
440 DISP "ENTER COMMAND"
450 INPUT 0$
460 OUTPUT 700+A ;0$
470 GOSUB 590
480 RETURN
490 !
500 !
510 ! READ DATA UNTIL EOI
520 ENTER 700+A USING "#%,%K"; I$
530 DISP I$
540 RETURN
550 !
560 !
570 DISP "TIME OUT ON BUS"
580 DISP "+ + + + + + + + + + + + + + + + + + + + + + +"
590 DISP "WAITING FOR A PRINT"
600 DISP "FROM ADDRESS";A
610 DISP
620 ABORTIO 7
630 RETURN
+ + + + + + + + + + + + + + +"
```

APPENDIX C.
HEX CONVERSION TABLE

HEX	BAUDOT		BCDIC		ASCII	EBCDIC
	LTRS	FIGS	UPPER	LOWER		
00	Blank	Blank	Space	Space	NUL (Blank)	NUL (Null)
01	E	3	=	1	SOH (Start of Header)	SOH (Start of Header)
02	LF	LF	<	2	STX (Start of Text)	STX (Start of Text)
03	A	–	:	3	EXT (End of Text)	EXT (End of Text)
04	Space	Space	:	4	EOT (End of Transmission)	PF (Punch Off)
05	S	' or BELL	%	5	ENQ (Enquiry)	HT (Horizontal Tab)
06	I	8	'	6	ACK (Acknowledge)	LC (Lower Case)
07	U	7	>	7	BEL (Bell)	DEL (Delete)
08	CR	CR	*	8	BS (Backspace)	
09	D	WRU or $	(	9	HT (Horizontal Tabulation)	RLF
0A	R	4	)	0	LF (Line Feed)	SMM (Start Manual Message)
0B	J	BELL or '	"	#	VT (Vertical Tabulation)	VT (Vertical Tab)
0C	N	,	DC2	DC2	FF (Form Feed)	FF (Form Feed)
0D	F	!	RS	RS	CR (Carriage Return)	CR (Carriage Return)
0E	C	:	UPPER	UPPER	SO (Shift Out)	SO (Shift Out)
0F	K	(	EOT	EOT	SI (Shift In)	SI (Shift In)
10	T	5	CAN	@	DLE (Data Link Escape)	DLE (Data Link Escape)
11	Z	+ or "	?	/	DC1 (Device Control 1)	DC1 (Device Control 1)
12	L	)	S	s	DC2 (Device Control 2)	DC2 (Device Control 2)
13	W	2	T	t	DC3 (Device Control 3)	DC3 (Device Control 3)
14	H	#	U	u	DC4 (Device Control 4)	RES (Restore)
15	Y	6	V	v	NAK (Negative Acknowledge)	NL (New Line)
16	P	0	W	w	SYN (Synchronization)	BS (Backspace)
17	Q	1	X	x	ETB (End of Text Block)	IL (Idle)
18	O	9	Y	y	CAN (Cancel)	CAN (Cancel)
19	B	?	Z	z	EM (End of Medium)	EM (End of Medium)
1A	G	&			SUB (Substitute)	CC (Cursor Control)
1B	FIGS	FIGS	,	.	ESC (Escape)	CU1 (Customer Use 1)
1C	M	.	BEL	BEL	FS (File Separator)	IFS (Interchange File Sep.)
1D	X	/	LF	LF	GS (Group Separator)	IGS (Interchange Group Sep.)
1E	V	= or ;	ETB	ETB	RS (Record Separator)	IRS (Interchange Record Sep.)
1F	LTRS	LTRS	DC3	DC3	US (Unit Separator)	IUS (Interchange Unit Sep.)

HEX	BAUDOT		BCDIC		ASCII	EBCDIC
	LTRS	FIGS	UPPER	LOWER		
20	Blank	Blank	–	—	SP	DS (Digit Select)
21	E	3	J	j	!	SOS (Start of Significance)
22	LF	LF	K	k	"	FS (Field Separator)
23	A	–	L	l	#	
24	Space	Space	M	m	$	BYP (Bypass)
25	S	' or BELL	N	n	%	LF (Line Feed)
26	I	8	O	o	&	ETB (End Transmission Block)
27	U	7	P	p	' (Single Closing Quote)	ESC (Escape)
28	CR	CR	Q	q	(	
29	D	WRU or $	R	r	)	
2A	R	4			*	SM (Set Mode)
2B	J	BELL or '	!	$	+	CU2 (Customer Use 2)
2C	N	,	DC4	DC4	, (Comma)	
2D	F	!	CR	CR	– (Hyphen)	ENQ (Enquiry)
2E	C	:	BS	BS	. (Period)	ACK (Acknowledge)
2F	K	(	DLE	DLE	/	BEL (Bell)
30	T	5	+	&	0	
31	Z	+ or "	A	a	1	
32	L	)	B	b	2	SYN (Synchronous Idle)
33	W	2	C	c	3	
34	H	#	D	d	4	PN (Punch On)
35	Y	6	E	e	5	RS (Reader Stop)
36	P	0	F	f	6	UC (Upper Case)
37	Q	1	G	g	7	EOT (End of Transmission)
38	O	9	H	h	8	
39	B	?	I	i	9	
3A	G	&			:	
3B	FIGS	FIGS	.	.	;	CU3 (Customer Use 3)
3C	M	.	DC1	DC1	< (Less Than)	DC4 (Device Control 4)
3D	X	/	HT	HT	=	NAK (Negative Acknowledge)
3E	V	= or ;	LOWER	LOWER	> (Greater Than)	
3F	LTRS	LTRS	DEL	DEL	?	SUB (Substitute)

APPENDIX C. HEX CONVERSION TABLE

<table>
<tr><th rowspan="2">HEX</th><th colspan="2">BAUDOT</th><th colspan="2">BCDIC</th><th rowspan="2">ASCII</th><th rowspan="2">EBCDIC</th></tr>
<tr><th>LTRS</th><th>FIGS</th><th>UPPER</th><th>LOWER</th></tr>
<tr><td>40</td><td>Blank</td><td>Blank</td><td>Space</td><td>Space</td><td>@</td><td>SP (Space)</td></tr>
<tr><td>41</td><td>E</td><td>3</td><td>=</td><td>1</td><td>A</td><td></td></tr>
<tr><td>42</td><td>LF</td><td>LF</td><td><</td><td>2</td><td>B</td><td></td></tr>
<tr><td>43</td><td>A</td><td>–</td><td>;</td><td>3</td><td>C</td><td></td></tr>
<tr><td>44</td><td>Space</td><td>Space</td><td>:</td><td>4</td><td>D</td><td></td></tr>
<tr><td>45</td><td>S</td><td>' or BELL</td><td>%</td><td>5</td><td>E</td><td></td></tr>
<tr><td>46</td><td>I</td><td>8</td><td>'</td><td>6</td><td>F</td><td></td></tr>
<tr><td>47</td><td>U</td><td>7</td><td>></td><td>7</td><td>G</td><td></td></tr>
<tr><td>48</td><td>CR</td><td>CR</td><td>*</td><td>8</td><td>H</td><td></td></tr>
<tr><td>49</td><td>D</td><td>WRU or $</td><td>(</td><td>9</td><td>I</td><td></td></tr>
<tr><td>4A</td><td>R</td><td>4</td><td>)</td><td>0</td><td>J</td><td>¢</td></tr>
<tr><td>4B</td><td>J</td><td>BELL or '</td><td>"</td><td>#</td><td>K</td><td>. (Period)</td></tr>
<tr><td>4C</td><td>N</td><td>,</td><td>DC2</td><td>DC2</td><td>L</td><td>< (Less Than)</td></tr>
<tr><td>4D</td><td>F</td><td>!</td><td>RS</td><td>RS</td><td>M</td><td>(</td></tr>
<tr><td>4E</td><td>C</td><td>:</td><td>UPPER</td><td>UPPER</td><td>N</td><td>+</td></tr>
<tr><td>4F</td><td>K</td><td>(</td><td>EOT</td><td>EOT</td><td>O</td><td>| (Logical OR)</td></tr>
<tr><td>50</td><td>T</td><td>5</td><td>CAN</td><td>@</td><td>P</td><td>&</td></tr>
<tr><td>51</td><td>Z</td><td>+ or "</td><td>?</td><td>/</td><td>Q</td><td></td></tr>
<tr><td>52</td><td>L</td><td>)</td><td>S</td><td>s</td><td>R</td><td></td></tr>
<tr><td>53</td><td>W</td><td>2</td><td>T</td><td>t</td><td>S</td><td></td></tr>
<tr><td>54</td><td>H</td><td>#</td><td>U</td><td>u</td><td>T</td><td></td></tr>
<tr><td>55</td><td>Y</td><td>6</td><td>V</td><td>v</td><td>U</td><td></td></tr>
<tr><td>56</td><td>P</td><td>0</td><td>W</td><td>w</td><td>V</td><td></td></tr>
<tr><td>57</td><td>Q</td><td>1</td><td>X</td><td>x</td><td>W</td><td></td></tr>
<tr><td>58</td><td>O</td><td>9</td><td>Y</td><td>y</td><td>X</td><td></td></tr>
<tr><td>59</td><td>B</td><td>?</td><td>Z</td><td>z</td><td>Y</td><td></td></tr>
<tr><td>5A</td><td>G</td><td>&</td><td></td><td></td><td>Z</td><td>!</td></tr>
<tr><td>5B</td><td>FIGS</td><td>FIGS</td><td>.</td><td>.</td><td>[(Opening Bracket)</td><td>$</td></tr>
<tr><td>5C</td><td>M</td><td>.</td><td>BEL</td><td>BEL</td><td>\ (Reverse Slant)</td><td>*</td></tr>
<tr><td>5D</td><td>X</td><td>/</td><td>LF</td><td>LF</td><td>] (Closing Bracket)</td><td>)</td></tr>
<tr><td>5E</td><td>V</td><td>= or ;</td><td>ETB</td><td>ETB</td><td>^ (Circumflex)</td><td>;</td></tr>
<tr><td>5F</td><td>LTRS</td><td>LTRS</td><td>DC3</td><td>DC3</td><td>(Underline)</td><td>¬ (Logical NOT)</td></tr>
</table>

<table>
<tr><th rowspan="2">HEX</th><th colspan="2">BAUDOT</th><th colspan="2">BCDIC</th><th rowspan="2">ASCII</th><th rowspan="2">EBCDIC</th></tr>
<tr><th>LTRS</th><th>FIGS</th><th>UPPER</th><th>LOWER</th></tr>
<tr><td>60</td><td>Blank</td><td>Blank</td><td>–</td><td></td><td>` (Opening Single Quote)</td><td>– (Hyphen)</td></tr>
<tr><td>61</td><td>E</td><td>3</td><td>J</td><td>j</td><td>a</td><td>/</td></tr>
<tr><td>62</td><td>LF</td><td>LF</td><td>K</td><td>k</td><td>b</td><td></td></tr>
<tr><td>63</td><td>A</td><td>–</td><td>L</td><td>l</td><td>c</td><td></td></tr>
<tr><td>64</td><td>Space</td><td>Space</td><td>M</td><td>m</td><td>d</td><td></td></tr>
<tr><td>65</td><td>S</td><td>' or BELL</td><td>N</td><td>n</td><td>e</td><td></td></tr>
<tr><td>66</td><td>I</td><td>8</td><td>O</td><td>o</td><td>f</td><td></td></tr>
<tr><td>67</td><td>U</td><td>7</td><td>P</td><td>p</td><td>g</td><td></td></tr>
<tr><td>68</td><td>CR</td><td>CR</td><td>Q</td><td>q</td><td>h</td><td></td></tr>
<tr><td>69</td><td>D</td><td>WRU or $</td><td>R</td><td>r</td><td>i</td><td></td></tr>
<tr><td>6A</td><td>R</td><td>4</td><td>,</td><td></td><td>j</td><td>| (Vertical Line)</td></tr>
<tr><td>6B</td><td>J</td><td>BELL or '</td><td>!</td><td>$</td><td>k</td><td>, (Comma)</td></tr>
<tr><td>6C</td><td>N</td><td>,</td><td>DC4</td><td>DC4</td><td>l</td><td>%</td></tr>
<tr><td>6D</td><td>F</td><td>!</td><td>CR</td><td>CR</td><td>m</td><td>_ (Underline)</td></tr>
<tr><td>6E</td><td>C</td><td>:</td><td>BS</td><td>BS</td><td>n</td><td>> (Greater Than)</td></tr>
<tr><td>6F</td><td>K</td><td>(</td><td>DLE</td><td>DLE</td><td>o</td><td>?</td></tr>
<tr><td>70</td><td>T</td><td>5</td><td>+</td><td>&</td><td>p</td><td></td></tr>
<tr><td>71</td><td>Z</td><td>+ or "</td><td>A</td><td>a</td><td>q</td><td></td></tr>
<tr><td>72</td><td>L</td><td>)</td><td>B</td><td>b</td><td>r</td><td></td></tr>
<tr><td>73</td><td>W</td><td>2</td><td>C</td><td>c</td><td>s</td><td></td></tr>
<tr><td>74</td><td>H</td><td>#</td><td>D</td><td>d</td><td>t</td><td></td></tr>
<tr><td>75</td><td>Y</td><td>6</td><td>E</td><td>e</td><td>u</td><td></td></tr>
<tr><td>76</td><td>P</td><td>0</td><td>F</td><td>f</td><td>v</td><td></td></tr>
<tr><td>77</td><td>Q</td><td>1</td><td>G</td><td>g</td><td>w</td><td></td></tr>
<tr><td>78</td><td>O</td><td>9</td><td>H</td><td>h</td><td>x</td><td></td></tr>
<tr><td>79</td><td>B</td><td>?</td><td>I</td><td>i</td><td>y</td><td>' (Opening Quote)</td></tr>
<tr><td>7A</td><td>G</td><td>&</td><td></td><td></td><td>z</td><td>:</td></tr>
<tr><td>7B</td><td>FIGS</td><td>FIGS</td><td>.</td><td>.</td><td>{ (Opening Brace)</td><td>#</td></tr>
<tr><td>7C</td><td>M</td><td>.</td><td>DC1</td><td>DC1</td><td>| (Vertical Line)</td><td>@</td></tr>
<tr><td>7D</td><td>X</td><td>/</td><td>HT</td><td>HT</td><td>} (Closing Brace)</td><td>'</td></tr>
<tr><td>7E</td><td>V</td><td>= or ;</td><td>LOWER</td><td>LOWER</td><td>~ (Overline Tilde)</td><td>=</td></tr>
<tr><td>7F</td><td>LTRS</td><td>LTRS</td><td>DEL</td><td>DEL</td><td>DEL (Delete/Rubout)</td><td>"</td></tr>
</table>

APPENDIX C. HEX CONVERSION TABLE

HEX	BAUDOT LTRS	BAUDOT FIGS	BCDIC UPPER	BCDIC LOWER	ASCII	EBCDIC
80	Blank	Blank	Space	Space	NUL (Blank)	
81	E	3	=	1	SOH (Start of Header)	a
82	LF	LF	<	2	STX (Start of Text)	b
83	A	—	;	3	EXT (End of Text)	c
84	Space	Space	:	4	EOT (End of Transmission)	d
85	S	; or BELL	%	5	ENQ (Enquiry)	e
86	I	8	'	6	ACK (Acknowledge)	f
87	U	7	>	7	BEL (Bell)	g
88	CR	CR	*	8	BS (Backspace)	h
89	D	WRU or $	(	9	HT (Horizontal Tabulation)	i
8A	R	4	)	0	LF (ne Feed)	
8B	J	BELL or '	"	#	VT (ertical Tabulation)	
8C	N	.	DC2	DC2	FF (Form Feed)	
8D	F	!	RS	RS	CR (Carriage Return)	
8E	C	:	UPPER	UPPER	SO (Shift Out)	
8F	K	(	EOT	EOT	SI (Shift In)	
90	T	5	CAN	@	DLE (Data Link Escape)	
91	Z	+ or "	?	/	DC1 (Device Control 1)	j
92	L	)	S	s	DC2 (Device Control 2)	k
93	W	2	T	t	DC3 (Device Control 3)	l
94	H	#	U	u	DC4 (Device Control 4)	m
95	Y	6	V	v	NAK (Negative Acknowledge)	n
96	P	0	W	w	SYN (Synchronization)	o
17	Q	1	X	x	ETB (End of Text Block)	p
98	O	9	Y	y	CAN (Cancel)	q
99	B	?	Z	z	EM (End of Medium)	r
9A	G	&			SUB (Substitute)	
9B	FIGS	FIGS	.	,	ESC (Escape)	
9C	M	.	BEL	BEL	FS (File Separator)	
9D	X	/	LF	LF	GS (Group Separator)	
9E	V	= or ;	ETB	ETB	RS (Record Separator)	
9F	LTRS	LTRS	DC3	DC3	US (Unit Separator)	

HEX	BAUDOT LTRS	BAUDOT FIGS	BCDIC UPPER	BCDIC LOWER	ASCII	EBCDIC
A0	Blank	Blank	–	—	SP (Space)	
A1	E	3	J	j	!	~
A2	LF	LF	K	k	"	s
A3	A	-	L	l	#	t
A4	Space	Space	M	m	$	u
A5	S	' or BELL	N	n	%	v
A6	I	8	O	o	&	w
A7	U	7	P	p	' (Single Closing Quote)	x
A8	CR	CR	Q	q	(	y
A9	D	WRU or $	R	r	)	z
AA	R	4			*	
AB	J	BELL or '	!	$	+	
AC	N	,	DC4	DC4	, (Comma)	
AD	F	!	CR	CR	- (Hyphen)	
AE	C	:	BS	BS	. (Period)	
AF	K	(	DLE	DLE	/	
B0	T	5	+	&	0	
B1	Z	+ or "	A	a	1	
B2	L	)	B	b	2	
B3	W	2	C	c	3	
B4	H	#	D	d	4	
B5	Y	6	E	e	5	
B6	P	0	F	f	6	
B7	Q	1	G	g	7	
B8	O	9	H	h	8	
B9	B	?	I	i	9	
BA	G	&			:	
BB	FIGS	FIGS	.	.	;	
BC	M	.	DC1	DC1	< (Less Than)	
BD	X	/	HT	HT	=	
BE	V	= or ;	LOWER	LOWER	> (Greater Than)	
BF	LTRS	LTRS	DEL	DEL	?	

HEX	BAUDOT LTRS	BAUDOT FIGS	BCDIC UPPER	BCDIC LOWER	ASCII	EBCDIC
C0	Blank	Blank	Space	Space	@	{
C1	E	3	=	1	A	A
C2	LF	LF	<	2	B	B
C3	A	–	;	3	C	C
C4	Space	Space	:	4	D	D
C5	S	' or BELL	%	5	E	E
C6	I	8	'	6	F	F
C7	U	7	>	7	G	G
C8	CR	CR	*	8	H	H
C9	D	WRU or $	(	9	I	I
CA	R	4	)	0	J	
CB	J	BELL or '	"	#	K	
CC	N	,	DC2	DC2	L	
CD	F	!	RS	RS	M	
CE	C	:	UPPER	UPPER	N	
CF	K	(	EOT	EOT	O	
D0	T	5	CAN	@	P	}
D1	Z	+ or "	?	/	Q	J
D2	L	)	S	s	R	K
D3	W	2	T	t	S	L
D4	H	#	U	u	T	M
D5	Y	6	V	v	U	N
D6	P	0	W	w	V	O
D7	Q	1	X	x	W	P
D8	O	9	Y	y	X	Q
D9	B	?	Z	z	Y	R
DA	G	&			Z	
DB	FIGS	FIGS	,	,	| (Opening Bracket)	
DC	M	.	BEL	BEL	\ (Reverse Slant)	
DD	X	/	LF	LF	| (Closing Bracket)	
DE	V	= or ;	ETB	ETB	^ (Circumflex)	
DF	LTRS	LTRS	DC3	DC3	__ (Underline)	

HEX	BAUDOT LTRS	BAUDOT FIGS	BCDIC UPPER	BCDIC LOWER	ASCII	EBCDIC
E0	Blank	Blank	–	—	` (Opening Single Quote)	/ (Reverse Slash)
E1	E	3	J	j	a	
E2	LF	LF	K	k	b	S
E3	A	–	L	l	c	T
E4	Space	Space	M	m	d	U
E5	S	; or BELL	N	n	e	V
E6	I	8	O	o	f	W
E7	U	7	P	p	g	X
E8	CR	CR	Q	q	h	Y
E9	D	WRU or $	R	r	i	Z
EA	R	4	'		j	
EB	J	BELL or '	!	$	k	
EC	N	,	DC4	DC4	l	
ED	F	!	CR	CR	m	__ (Underline)
EE	C	:	BS	BS	n	
EF	K	(	DLE	DLE	o	
F0	T	5	+	&	p	0
F1	Z	+ or "	A	a	q	1
F2	L	)	B	b	r	2
F3	W	2	C	c	s	3
F4	H	#	D	d	t	4
F5	Y	6	E	e	u	5
F6	P	0	F	f	v	6
F7	Q	1	G	g	w	7
F8	O	9	H	h	x	8
F9	B	?	I	i	y	9
FA	G	&			z	
FB	FIGS	FIGS	.	.	{ (Opening Brace)	
FC	M	.	DC1	DC1	¦ (Vertical Line)	
FD	X	/	HT	HT	} (Closing Brace)	
FE	V	= or ;	LOWER	LOWER	~ (Overline Tilde)	
FF	LTRS	LTRS	DEL	DEL	DEL (Delete/Rubout)	

APPENDIX D
DISCUSSION OF G.821

This appendix discusses the concept of available time versus unavailable time as specified in CCITT Recommendation G.821. This discussion is provided to familiarize users with the results that are provided in the Performance category.

CCITT Recommendation G.821 defines available and unavailable time as follows:

> "A period of unavailable time begins when the bit error rate (BER) in each second is worse than 10^{-3} for a period of 10 consecutive seconds. These 10 seconds are considered to be unavailable time. The period of unavailable time terminates when the BER in each second is better than 10^{-3} for a period of 10 consecutive seconds. These 10 seconds are considered to be available time."

Available and unavailable time are measured in seconds—available seconds and unavailable seconds, respectively. All seconds after initial pattern synchronization must fall into one of the two categories (total available seconds + total unavailable seconds = total seconds after initial pattern synchronization.)

After initial pattern synchronization, seconds are considered to be available time; the available seconds begin counting (seconds before initial pattern synchronization are not included in performance analysis). These seconds continue to be counted until 10 consecutive seconds, each with a BER worse than 10^{-3}, occur. A sliding window, 10 seconds in length, is used to detect this transition from available time and vice versa.

As an example, assume a test begins and continues to run for 25 seconds and each of those 25 seconds has a BER better than or equal to 10^{-3}. After initial pattern synchronization, seconds are considered to be available time, so the available seconds count at this point is 25. In the 26th

sec 20	sec 21	sec 22	sec 23	sec 24	sec 25	sec 26	sec 27	sec 28	sec 29
BER <=	BER <=	BER <=	BER <=	BER <=	BER <=	BER >	BER >	BER >	BER <=

Sliding Window After 29th Test Second

Still in Available Time

second, the BER becomes worse than 10^{-3}. The same for the 27th and 28th seconds. In the 29th second, the BER drops back to better than or equal to 10^{-3}. All 29 seconds are a part of available time and are, therefore, counted as available seconds.

Even though there were 3 consecutive seconds (the 26th, 27th, and 28th) which each had a BER worse than 10^{-3}, 10 such consecutive seconds are required to make the transition to unavailable time. Those 3 individual seconds are still in available time and they are counted as available seconds.

The 3 seconds with a BER worse than 10^{-3} are also included in the count of severely errored seconds, which are those seconds with a BER worse than 10^{-3} that occur in available time. A signal loss second or a second in which pattern synchronization is lost is also considered to be a second with a BER worse than 10^{-3}. Therefore, the current test result values for available seconds count = 29; the severely errored seconds (SES) count = 3, and the unavailable seconds count = 0.

The same test continues to run and remains in available time. In the 80th second, the BER for that second is worse than 10^{-3}. The BER for the 81st, 82nd, 83rd, 84th, and 85th seconds is also worse than 10^{-3}. In the 86th second, pattern synchronization is lost. This also continues for the 87th and 88th seconds. We now have 9 consecutive seconds each of which has a BER worse than 10^{-3}. As each of these seconds occurs, we are still in available time, so they are counted as available seconds and severely errored seconds. The transition has not been made from available time to unavailable time.

sec 79 BER <=	sec 80 BER >	sec 81 BER >	sec 82 BER >	sec 83 BER >	sec 84 BER >	sec 85 BER >	sec 86 BER >	sec 87 BER >	sec 88 BER >

Sliding Window After 88th Test Second

Still in Available Time

The 89th second also has a BER worse than 10^{-3}. At this point, the available seconds count = 89, the SES count = 13, and the unavailable seconds count = 0. However, the sliding window now contains 10 consecutive seconds each of which has a BER worse than 10^{-3}. A transition is made to unavailable time.

sec 80 BER >	sec 81 BER >	sec 82 BER >	sec 83 BER >	sec 84 BER >	sec 85 BER >	sec 86 BER >	sec 87 BER >	sec 88 BER >	sec 89 BER >

Sliding Window After 89th Test Second

Transition to Unavailable Time

Those 10 seconds which had been counted as available seconds are deducted from the available seconds count and are added to the unavailable seconds count; the available seconds count becomes 79, and the unavailable seconds count become 10. Those same 10 seconds were also included in the SES count. However, SES is limited to only those seconds in available time which have a BER worse than 10^{-3}; therefore, those last consecutive 10 seconds must also be deducted from the SES count (the SES count is updated to 3).

Once the transition occurs from available time to unavailable time, all seconds are counted as unavailable seconds until 10 consecutive seconds occur each with a BER better than 10^{-3}. As the sample test continues, the 90th through 150th seconds each have a BER worse than or equal to 10^{-3}. We are still in unavailable time, so these seconds are counted as unavailable seconds; now the total available seconds count = 79 and the total unavailable seconds count = 71.

Beginning with the 151st second, the BER for that second falls below 10^{-3}. It is still counted as an unavailable second since we are still in unavailable time and the transition has not been made to available time. A BER better than 10^{-3} also occurs for the 152nd, 153rd, 154th, 155th, 156th, 157th, 158th, 159th, and 160th seconds. Since there are now 10 consecutive seconds with a BER better than 10^{-3}, the transition is made from unavailable time to available time.

sec 151 BER <	sec 152 BER <	sec 153 BER <	sec 154 BER <	sec 155 BER <	sec 156 BER <	sec 157 BER <	sec 158 BER <	sec 159 BER <	sec 160 BER <

Sliding Window After 160th Test Second

Transition to Available Time

As each of these 10 seconds occurred, it was added to the unavailable seconds count (unavailable seconds = 81, available seconds = 79, and SES = 3). Now that those consecutive seconds have triggered the transition to available time, they are deducted from the unavailable seconds count and added to the available seconds count. Now the unavailable seconds count = 71 and the available seconds count = 89.

The monitoring of available and unavailable time continues for the duration of the test.

Degraded minutes is an error analysis result that is affected by available and unavailable time. Degraded minutes is a count of the number of minutes during which an average BER worse than 10^{-6} occurs. The 1-minute intervals are derived by removing unavailable seconds and severely errored seconds (SES) from the total test time and then consecutively grouping the remaining seconds into blocks of 60. The average BER is calculated for the block of 60 seconds and, if it is worse than 10^{-6}, the block is counted as a degraded minute.

In the transition from available time to unavailable time, the degraded minutes result is unaffected. This is because a switch to unavailable time requires 10 consecutive seconds each with a BER worse than 10^{-3}. Any second in available time with a BER worse than 10^{-3} is considered to be a severely errored second and, therefore, not included in the accumulation of seconds used to calculate degraded minutes.

Moving from unavailable time to available time may affect the degraded minutes count. While in unavailable time, 10 consecutive seconds each with a BER better than 10^{-3} are required for the transition to available time. When this happens, those 10 seconds are subtracted from the unavailable seconds count and are added to the available seconds count. Since these seconds are now considered to be a part of available time and they are not severely errored seconds, they are included in the calculation of degraded minutes.