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User Manual

Tektronix

ST2400
2.4 Gb/s SONET Test Set

070-9781-05

This document supports firmware version 3.0 and above

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Table Of Contents

General Safety Summary ix
Preface xii

Getting Started

Product Description 1-1
Ordering Information 1-2
Factory Installed Options 1-2
Bellcore CLEI and CPR Product Codes 1-3
Overview, SONET 1-4
Features and Capabilities 1-4
Accessories 1-6
Standard 1-6
Optional 1-6
Interface Cables 1-6
First-Time Operation 1-8

Functional Overview

Front Panel Controls, Indicators and Connectors 2-1
Display, Display Controls and Indicators 2-2
Setup Menu System 2-2
Transmitter Description 2-3
Transmitter Connectors 2-4
Transmitter Status Indicators 2-4
Mode Key 2-4
Tributary and Input Select Keys, Transmitter 2-5
OVHD Key, Transmitter 2-5
Alarm Key, Transmitter 2-6
Error Key, Transmitter 2-6
Receiver Description 2-7
Receiver Connectors 2-7
Receiver Status Indicators 2-8
View History Key 2-8
Drop Select Key. Receiver 2-9
Tributary Select Key, Receiver 2-9
OVHD Key, Receiver 2-9
Measurement Controls & Indicators 2-9
Remote Indicators 2-9
Rear Panel Description 2-10
SYNC Output 2-10
Laser Lockout, Remote Interlock 2-10
Rear Panel Connectors 2-11

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Applications and Use **2-12**
Passive Monitoring 2-12
Active Analysis 2-13
Active Through Mode Analysis 2-13

Reference

Functional Verification **3-1**
Setup Menu System **3-1**
Report/ Test Time Menu System 3-4
Auxiliary Setup Menu System 3-5
General Menus & Displays **3-7**
Menu & Measurement Refinements 3-7
Option Not Installed 3-7
Error Log Display 3-7
Transmitter Menus & Displays **3-8**
TX Source Mode 3-8
External Clock Synchronization 3-8
PRBS Mapping 3-9
Input Select, Transmitter 3-11
Tributary Select, Transmitter 3-11
Illegal Mode 3-12
Alarm Generation Menus - SONET 3-13
Overhead Menus (SONET), Transmitter 3-15
Editing M1 Byte 3-16
Error Generation Menus (SONET) 3-17
B2 Error Inject 3-18
Inject Random BER on one Selectable Channel 3-19
Receiver Menus & Displays **3-20**
Error Measurements, Receiver 3-20
Overhead Displays, Receiver 3-21
ASCII Synchonization Messages - S1 byte 3-22
Automatic Protection Switching (APS) 3-22
Receiver Drop Select 3-23
Receiver Tributary Select 3-23
Virtual Front Panel (VFP) **3-24**

Appendices

Specifications, SONET **A-1**
Incoming Inspection Test **B-1**
SDH for Reference **D-1**
SONET Glossary and Standards **G-1**
Index **I-1**

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General Safety Summary

Review the following safety precautions to avoid injury and prevent damage to this product or any equipment connected to it. To avoid potential hazards, use this product only as specified.

Only qualified personnel should perform service procedures.

While using this product, you may need to access other parts of the system. Read the *General Safety Summary* in other system manuals for warnings and cautions related to operating the system.

Injury Precautions

Use Proper Power Cord

To avoid fire hazard, use only the power cord specified for this product.

Avoid Electric Overload

To avoid electric shock or fire hazard, do not apply a voltage to a terminal that is outside the range specified for that terminal.

Ground the product

This product is grounded through the grounding conductor of the power cord. To avoid electric shock, the grounding conductor must be connected to earth ground. Before making connections to the input or output terminals of the product, ensure that the product is properly grounded.

Do not operate without covers

To avoid electric shock or fire hazard, do not operate this product with covers or panels removed.

Use Proper Fuse

To avoid fire hazard, use only the fuse type and rating specified for this product.

Do not operate in Wet/Damp Conditions

To avoid electric shock, do not operate this product in wet or damp conditions.

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Do not operate in Explosive Atmosphere

To avoid injury or fire hazard, do not operate this product in an explosive atmosphere.

Wear Eye Protection

To avoid eye injury, wear eye protections if there is a possibility of exposure to high-intensity rays.

Product Damage Precautions

⚠ CAUTION!

Signal levels greater than –10dBm (negative 10dBm) may damage the Optical Input devices. Always pad the input level to less than –10dBm.

Always use 15 dB of attenuation when connecting the ST2400 Transmitter output to its receiver input. Failure to do so will damage the optical detector.

Use Proper Power Source

Do not operate this product from a power source that applies more than the voltage specified.

Provide Proper Ventilation

To prevent product overheating, provide proper ventilation.

Do not operate with suspected failures

If you suspect there is damage to this product, have it inspected by qualified service personnel.

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Safety Terms and Symbols

Terms in this manual

These terms may appear in this manual:

Icon	Label	Meaning
⚠	WARNING!	Warning statements identify conditions or practices that could result in injury or loss of life.
⚠	CAUTION!	Caution statements identify conditions or practices that could result in damage to this produce or other property.

DANGER indicates an injury hazard immediately accessible as you read the marking.

WARNING indicates an injury hazard not immediately accessible as you read the marking.

CAUTION indicates a hazard to property including the product.

Symbols on the Product

The following symbols may appear on the product:



DANGER
High Voltage



Protective Ground
(Earth) Terminal



ATTENTION
Refer to Manual



Double Insulated

Certifications and Compliances

CSA Certified Power Cords

CSA Certification includes the products and power cords appropriate for use in the North American power network. All other power cords supplied are approved for the country of use.

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Preface

This manual describes how to use the Tektronix ST2400 SONET Test Set. This manual is your primary source of information about how the ST2400 SONET Test Set functions.

How This Manual is Organized

This manual is divided into four sections: *Getting Started*, *Operating Basics*, *Reference*, and *Appendices*.

- *Getting Started* provides an overview of the ST2400 SONET Test Set and describes first-time operation.
- *Operating Basics* explains the basic principles of operating the ST2400. The Operating Basics section also includes sample ST2400 applications.
- *Reference* provides explanations of how to perform detailed tasks.
- The *Appendices* provide a listing of specifications, default factory setting, an incoming inspection test, and other useful information.

Conventions

This manual uses the following conventions:

- The names of front-panel controls and menus appear in all upper case letter, for example, TRANSMIT and HELP.
- Names appear in the same case in this manual as they appear on the display of the ST2400, for example, Test Duration and USER DEFINED.
- Within a procedure, a specific button to be pressed or a parameter to be selected appears in boldface print.

Related Manuals

The following documents are available for the ST2400 SONET Test Set:

- *ST2400 SD/SONET Programmer Manual* (Tektronix part number 071-0121-00) describes how to control the ST2400 using an instrument controller.
- *ST2400 SONET/SDH Test Set Service Manual* (Tektronix part number 071-0106-00) provides information on maintaining and servicing your instrument to the module level.

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Getting Started

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Getting Started

This chapter describes the **ST2400 2.4 Gb/s SDH/SONET Test Set** and provides a list of standard and optional accessories for both the SDH and SONET option and for each of the three configurations: TRANSCEIVER, TRANSMIT-ONLY, and RECEIVE-ONLY.

Product Description

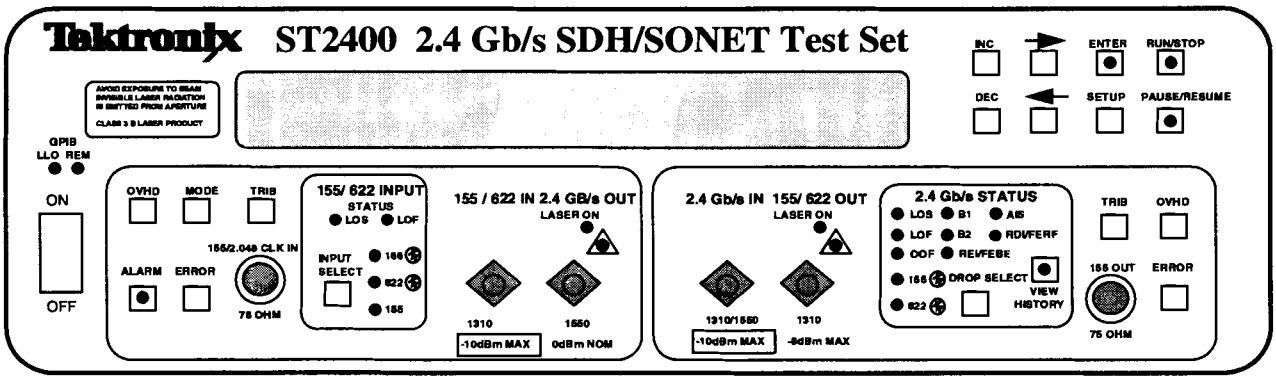


Figure 1-1. ST2400 2.4 Gb/s SDH/SONET Test Set Front Panel

The **ST2400 2.4 Gb/s SDH/SONET Test Set** provides line and section signal generation and analysis for the 2.4 Gb/s SDH STM-16 or SONET OC-48 standards. The ST2400 is a versatile unit that can be ordered in one of three configurations: TRANSCEIVER, TRANSMIT-ONLY, or RECEIVE-ONLY. The front panel design (Figure 1–1) is the same for both the SDH and SONET functions.

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Use the following order numbers:

ST2400 STM-16/OC-48 Ordering Information

Nomenclature	Description
ST2400	SDH/SONET Transceiver Base Unit.
	Optical Line Interfaces for 2.488 Gbit/s (FC connectors are standard)
Opt. 11	Receive Only with 2.4 Gb/s Wideband Optics
Opt. 12	Transmit Only with 1310 nm Tx Long Reach 2.4 Gb/s Optics
Opt. 13	1310 nm Intermediate Reach Laser
Opt. 15	1550 Long Reach Laser
Opt. 17	1310/ 1550 Laser (1310 Intermediate/ 1550 Long Reach)
	Accessories
Opt. 1A	15 dBm FC-PC Attenuator for 2.4 Gb/s Rx
Opt. 1M	Rack Mount
Opt. 3C	Replace FC connectors with SC connectors
Opt. 4C	Replace FC connectors with ST connectors
Opt. A1	220V, Euro Plug
Opt. A2	240V, UK Plug
Opt. A3	240V, Aust Plug
Opt. A5	220V, Swiss Plug
016-1494-00	Transit Case
HC411	DPU-11 printer

Factory Installed Options

Nomenclature	Description
ST2400	
ST24F11	Add wideband Rx function to Tx Only Unit
ST24F12	Add 1310 nm Tx function to Rx Only Unit
ST24F15	Add 1550 nm Tx function to Rx Only Unit
ST24F17	Add dual switchable optics to Transceiver

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Bellcore CLEI and CPR Product Codes

The ST2400 has been assigned the following Bellcore COMMON LANGUAGE Product Codes:

CLEI	Receive-Only Test Set (Both Frequencies):	STNQACG6AA
CPR	Receive-Only Test Set (Both Frequencies):	674835
CLEI	Transmitter-Only Test Set (Both Frequencies):	STNQACJ6AA
CPR	Transmitter-Only Test Set (Both Frequencies):	674846
CLEI	Transceiver Test Set (Both Frequencies):	STNQACH6AA
CPR	Transceiver Test Set (Both Frequencies):	674845

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Overview, SONET

The ST2400 transceiver version can transmit and receive OC-48 signals. The transmitter section can internally generate a 2.4 Gb/s signal or multiplex the higher-rate signal from OC-3 or OC-12 signal inputs. The receiver section receives an OC-48 signal, demultiplexes it, and can drop out either the OC-3 or OC-12 signal as required.

The transmit-only version can generate and transmit the OC-48 signal from an internal source, or multiplex the higher-rate signal from either OC-3 or OC-12 signal inputs.

The receive-only version can receive and demultiplex the OC-48 signal and drop either the OC-3 or OC-12 signal to an auxiliary test set, as required.

The **ST2400 2.4 Gb/s SDH/SONET Test Set** is designed to integrate directly with the ST112 SONET Transmission Test Set, OC-3, or OC-12 Transmission Analyzers for DS1 through OC-48 testing. The ST2400 unit operates with many other OC-3 and OC-12 test sets that accept 155 or 622 Mb/s optical signals and the 155 Mb/s CMI electrical signal, such as the Tektronix CTS 710, ST103A, and ST103.

ST2400 2.4 Gb/s SDH/SONET Test Set Features and Capabilities:

- OC-48 SONET Section and Line Testing
  B1 and B2 Error Measurement
  Section and Line Alarm Detection
  Line Layer Alarm and Error Generation
- STS1, STS3c PRBS Mappings
- External Clock Input (2 Mbps/ 2 Mhz)
- User-selectable power failure recovery mode
- Truly portable—25 pounds (11.4 kilograms) maximum weight
- A simple menu system
- Interface Access at 155 Mb/s or 622 Mb/s
- Easily software switched between SONET and SDH
- Integrates with the ST112 for complete "all-rate" SONET analysis
- Wide optical range:
  3 dBm to –2 dBm Output Power
  –29 dBm to –10 dBm Receiver Sensitivity
- Through Mode with Overhead Editing, Error, and Alarm Injection
- Direct user download of software updates

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- GR-253-CORE and CCITT/ITU G.708, G.709 framing
- Complete Remote Control
  - RS-232 and GPIB ports, and standard printer interfaces
  - VT100 Virtual Front Panel Functions
- Standard tributary interfaces
  - STS-3 155 electrical
  - OC-3 155 optical
  - OC-12 622 optical
- Interface to STE, LTE and other test equipment

The ST2400 meets the needs of development, network design, and service engineers by providing the capabilities for:

- System interrogation and conformance testing
- Manufacturing Production Testing
- Network Integrity testing
- Network Performance monitoring
- Network Troubleshooting

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Accessories

Some accessories are included with the **ST2400 2.4 Gb/s SDH/SONET Test Set**. If you wish to purchase optional accessory contact your local Tektronix Representative.

Standard

User Manual; Certificate of Traceable Calibration; Front Cover; Power Cord

Optional

Interface Cables, RS-232-C, GPIB, Centronics

RS-232-C

012-1379-00	9-pin female to 9-pin male
012-1298-00	9-pin female to 25-pin male
012-1398-00	9 in. RS-232-C to plotter/printer

GPIB

012-0991-00	2m, double-shielded
012-0991-01	1m, double-shielded
012-0991-02	4m, double-shielded
012-1282-00	0.5 m, GPIB

Centronics

012-1233-00	3 m, 4693 to Terminal
012-1214-00	8 ft. Male Centronics to PC 25-Pin D
012-1284-00	9 ft. male to male

Interface Cables, used for CE Certification

1M-BM-SB142-BM	BNC to BNC (50 OHM) 1 meter length
1M-BM-4233-BM	BNC to BNC (75 OHM) 1 meter length
H1740-1	Printer Cable, 8 feet
8004570	DB25 Male to Female, 6 feet
8004569	DB9 Male to Female 6 feet
CIB24-1M	GPIB 1EEE-488 1 meter length
CIB24X	GPIB Adapter

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Adapters, SMA

015-0369-00	SMA male to N
015-0572-00	SMA male to BNC male
015-0554-00	SMA male to BNC female
015-1009-00	SMA male to N female
015-0553-00	Threaded female to male slip-on connector
015-0549-00	Male to female connector (Used permanently installed to prolong life of instrument connector)
020-1693-00	SMA Kit

Attenuator, Optical

Recommended:
AMP 06-0033 FC Style Build Out Attenuator 15 dB Fixed Value
or equivalent.

Option 1A provides an attentuator.

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First Time Operation

Unpacking

Unpack the **ST2400 2.4 Gb/s SDH/SONET Test Set** and place the unit on a hard firm surface.

ST2400 Installation

Before using the ST2400 verify that it is properly set up and powered on, as follows:

1. Remove the unit from its shipping carton and place it on a hard firm surface.
2. Verify that the operating environment is within the limits detailed under the Environmental Requirement section in this manual.
3. Allow approximately 2 inches (5 cm) clearance for cooling on the top and rear of the unit. The two rear panel fans draw air into the ST2400 which is exhausted through the top vents.
4. Wire the unit for a chosen application. Never exceed the maximum optical power limits (–10dBm) listed on the front panel. Always cover the unused OC connectors.

⚠ CAUTION!

Signal levels greater than –10dBm (negative 10dBm) may damage the Optical Input devices. Always pad the input level to less than –10dBm.

Always use 15 dB of attenuation when connecting the ST2400 Transmitter output to its receiver input. Failure to do so will damage the optical detector.

1. Verify that the rear panel key lock is in the desired position.
2. Plug the unit into the appropriate AC Power source as follows:

Table 1-1. Power Requirements

AC Voltage	Voltage Range	Frequency Range	Maximum Power
110 VAC	90 VAC - 132 VAC	48 - 62 Hz	200 Watts
220 VAC	180 VAC - 250 VAC	48 - 62 Hz	200 Watts

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Operating Basics

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Functional Overview

This section describes **ST2400 2.4 Gb/s SDH/SONET Test Set** controls, indicators, connectors, display elements, and menu structures. It includes separate sections that detail receiver and transmitter specifics, and general sections that apply to both.

Front Panel Controls, Indicators, and Connectors

Figure 2-1 shows a complete view of the front panel.

WARNING! Always avoid exposure to the laser beam. Before power is applied to the **ST2400 2.4 Gb/s SDH/SONET Test Set** be sure that all laser outputs are either covered with the screw cap provided or connected to the appropriate circuit.

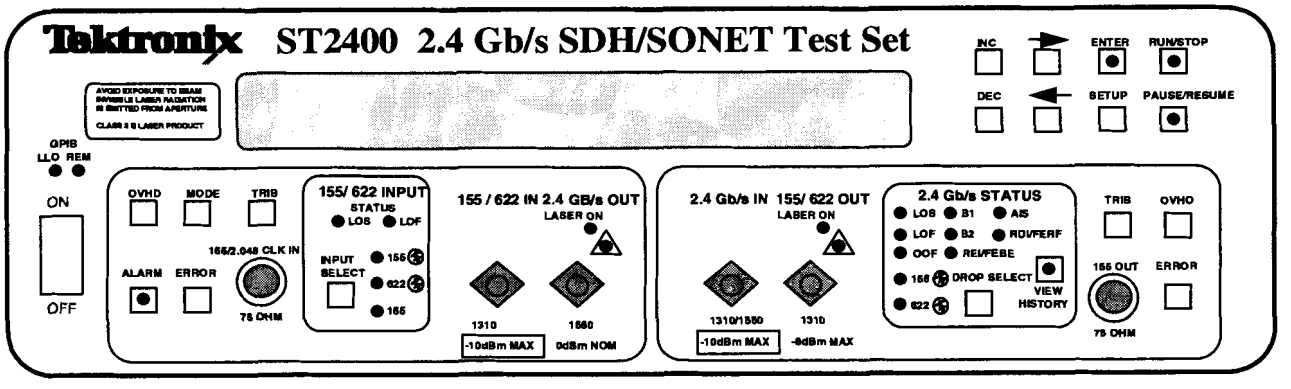


Figure 2-1. ST2400 Front Panel

The front panel can be divided into functional sections:

- Display and Display Controls
- Transmitter Controls and Connectors (Left-side of front panel)
- Receiver Controls and Connectors (Right-side of front panel)

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Display, Display Controls, and Indicators

The figure shows the **ST2400 2.4 Gb/s SDH/SONET Test Set** display and display controls. The display is a two-line by twenty-four character back-lit super twisted Nematic LCD (liquid crystal display) that provides a sharp image and increased viewing angle in all directions.

The LCD display is used to present main menus, submenus, and test results. The right and left arrows are used to position the LCD cursor. The INC (increment) and DEC (decrement) keys are used to change values. The ENTER key is used to insert the selected value.

The ENTER key houses a red LED indicator that flashes whenever an action is requested or required. It will continue to flash until the ENTER key is pressed, entering a new value or executing the function.



Figure 2-2. ST2400 LCD Display

Setup Menu System

The SETUP key is located below the ENTER key on the front panel. Pressing the SETUP key at any time will start the menu sequence. Each additional press, represented by the black arrow, will access the next menu. The number of main menus is mode dependent. Some main menus have submenus, omitted in this chapter, but detailed in *Chapter 3- Reference*. The SETUP menus are arranged in a continuous loop. Press any other key to exit the setup mode.

⚠ WARNING!

Before activating the 2.4 Gb/s LASER its output must be connected to a circuit.

⚠ CAUTION!

Signal levels greater than –10dBm (negative 10dBm) may damage the Optical Input devices. Always pad the input level to less than –10dBm.

Always use 15 dB of attenuation when connecting the ST2400 Transmitter output to its receiver input. Failure to do so will damage the optical detector.

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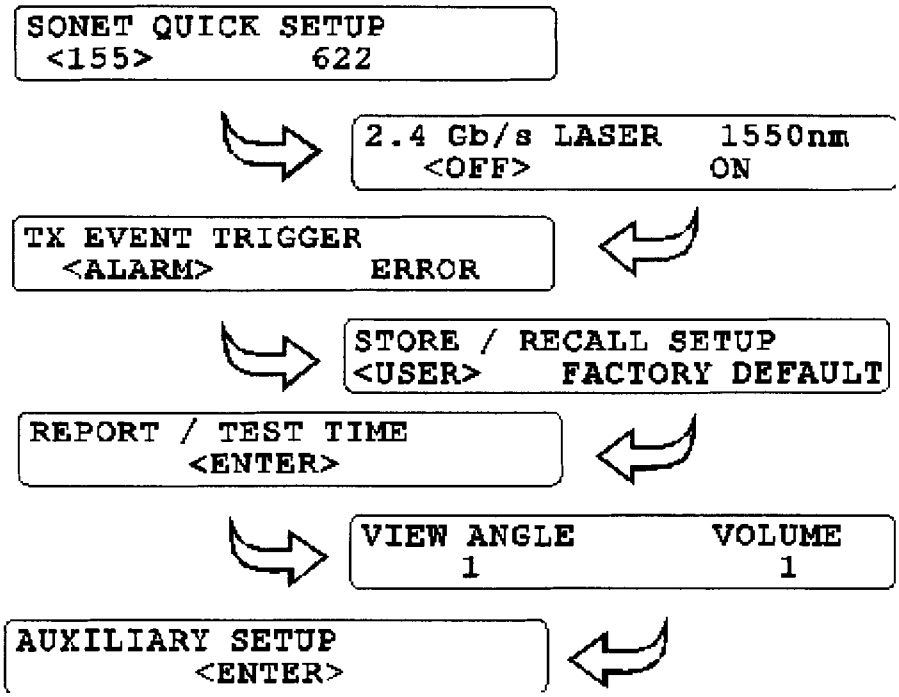


Figure 2-3. Examples of SONET Setup Main Menus

Transmitter Description

This section describes the transmitter inputs, outputs, controls and indicators. The figure below shows the **ST2400 2.4 Gb/s SDH/SONET Test Set** transmitter front panel area, located on the left side of the front panel.

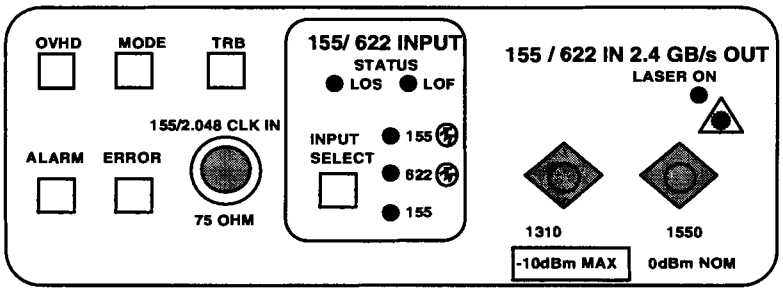


Figure 2-4. Transmitter Front Panel

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Transmitter Connectors

There can be three connectors on the transmitter front panel—one electrical CMI (Code Mark Inversion) and two optical. The CMI electrical carrier connector is an industry standard BNC that is marked **155/2.048 CLK IN**. It provides a 75 ohm load impedance and direct coupling (DC) for the 155 Mb/s SONET electrical signal. It also provides 2 Mb/ 2 Mhz inputs external timing synchronization.

On the right side of the transmitter section are two industry standard FC/PC optical connectors—one input and one output. ST and SC connectors are available as an option. The input optical connector is marked **155/622 IN**; it accepts either OC-3 or OC-12 signals. The output optical connector is marked **2.4 Gb/s OUT**; it outputs an OC-48 signal. Both are equipped with screw caps to protect the optics from airborne contamination, such as dust. Optical devices can be cleaned by using compressed air or with a Microtip Medium Swab dipped in isopropyl alcohol that has greater than 70 percent alcohol. Fiber optic cables should also be cleaned before connection with a lint free wipe and isopropyl alcohol.

⚠ WARNING!

Before activating the 2.4 Gb/s LASER its output must be connected to a circuit.

CAUTION!

Always use 15 dB of attenuation when connecting the ST2400 transmitter output to its receiver input. Failure to do so will damage the optical detector.

Transmitter Status Indicators

The **155/622 INPUT STATUS** section has five LED indicators—three yellow and two red. The SELECT key is used to choose between the two optical inputs and one electrical. When the input is external, the yellow LEDs indicate which input has been chosen.

The two red indicators are labeled LOS (Loss Of Signal) and LOF (Loss Of Frame). They monitor the 155 and 622 inputs for those alarm conditions. Both LEDs are off when the appropriate incoming signal is present. They are disabled when the unit is internally generating a 2.4 Gb/s or is in the through mode (see the *Mode Key* section).

Mode Key

Pressing the MODE key will access the transmitter input selection menu. It is used to choose one of the three data sources that will produce the 2.4 Gb/s output signal and select the wavelength when a dual wavelength transmitter option is installed. The three choices are: EXT, an external input tributary from the transmitter front panel; INT, an internally generated 2.4 Gb/s signal; and THRU, a through input from the receiver section.

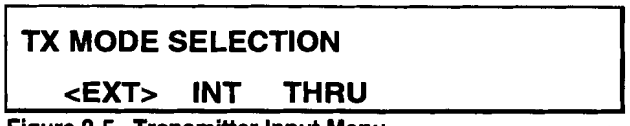


Figure 2-5. Transmitter Input Menu

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The EXT input can be 155 Mb/s optical (OC-3), 622 Mb/s optical (OC-12), or 155 Mb/s CMI electrical signal. The appropriate yellow status LED will indicate the input signal.The EXT sub-menu choices are: EXT TX MAPPING STRUCTURE and EXT TX STS1 or STS3c TEST PATT.

The INT mode generates an unequipped SONET 2.4 Gb/s (OC-48) signal with valid transport overhead bytes that can be modified. The INT sub-menu choices are: EXTERNAL SYNC INPUT, INT TX MAPPING STRUCTURE, and INT STS1 or STS3c TEST PATT.

The transceiver THRU mode will output a modified 2.4 Gb/s SONET signal that entered the receiver section from an external source before modification. All three yellow status LEDs will be off when the ST2400 is in the THRU (Through) mode. The THRU sub-menu choice is THRU MODE MAPPING.

The transceiver WAVELENGTH menu will only be present when the dual wavelength option is installed. Use the arrow keys to move the cursor to either 1310nm or 1550nm and the enter key to select the value.

Tributary and Input Select Keys, Transmitter

The transmitter TRIB key is used with the INPUT SELECT key to configure input groupings. OC-48 has sixteen OC-3 channel groups or four OC-12 channel groups.

OVHD Key, Transmitter

The transmitter OVHD (Overhead) key provides access to the section and line overhead bytes in the first STS-1 of the OC-48 frame. The figure below shows the menu used to access the E1 byte. A field change occurs when an arrow key is used to move the cursor from PASS to SET. The field change shows the current value of the particular overhead byte being viewed. Greater detail is provided in *Chapter 3- Reference*.

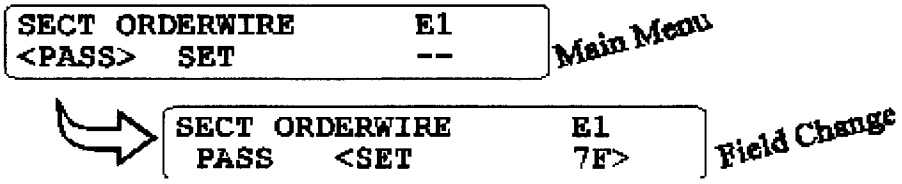


Figure 2-6. Overhead Menu Access

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Alarm Key, Transmitter

The transmitter alarm key is used to inject any of the alarms in one of four modes: continuous, timed, burst, or repeat at specific intervals. The alarm displays and menus are detailed in the next chapter. The red LED indicator in the alarm key will be illuminated whenever an alarm is active.

Error Key, Transmitter

The transmitter error key is used to generate specific error conditions that are detailed in *Chapter 3 - Reference*.

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Receiver Description

This section describes the **ST2400 2.4 Gb/s SDH/SONET Test Set** receiver front panel inputs, outputs, controls, and indicators, located on the right side of the front panel.

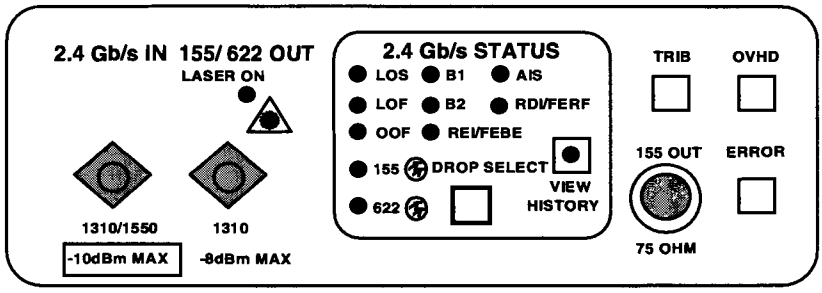


Figure 2-7. Receiver Front Panel

Receiver Connectors

There are three connectors on the receiver front panel—one electrical CMI (Code Mark Inversion) and two optical. The CMI electrical signal connector is an industry standard BNC that is marked **155 OUT**. It provides the 75 ohm load impedance and direct coupling (DC) for the SONET electrical signal.

The two industry standard FC/PC optical connectors are on the left side of the receiver section, one input and one output. ST or SC connectors are available as options. The input optical connector, **2.4 Gb/s IN**, accepts the OC-48 signal. The output optical connector, **155/622 OUT**, outputs OC-3 and OC-12 tributary signals. Both are equipped with screw caps to protect the optics from airborne contamination, such as dust. Optical devices can be cleaned by using compressed air or with a Microtip Medium Swab dipped in isopropyl alcohol that has greater than 70 percent alcohol. All fiber optic cables should also be cleaned before connection with a lint free wipe and isopropyl alcohol.

⚠ WARNING!

Before activating the 2.4 Gb/s LASER its output must be connected to a circuit.

⚠ CAUTION!

Always use 15 dB of attenuation when connecting the ST2400 transmitter output to its receiver input. Failure to do so will damage the optical detector.

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Receiver Status Indicators

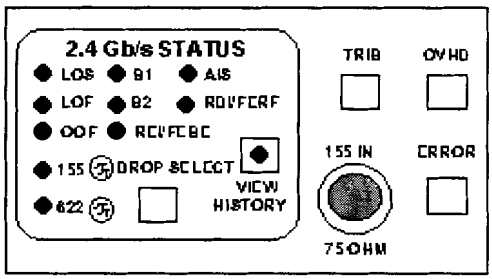


Figure 2-8. Receiver Status Indicators

The status indicators include the alarms and errors detailed below. The appropriate LED indicator will light for a minimum of 200 milliseconds when a corresponding alarm or error is detected. Detected errors and alarms are stored as historical data.

The receiver LOS (Loss Of Signal) alarm indicates that the 2.4 Gb/s signal has been off for more than 2 microseconds. The LOS alarm will be asserted no later than 127 microseconds after receiving the low signal (all zero) condition.

The receiver LOF (Loss Of Frame) alarm indicates that more than 3 milliseconds of an *out of frame* condition has occurred.

The OOF (Out Of Frame) alarm indicates that more than 4 consecutive frames of the 2.4 Gb/s signal has had frame alignment errors.

The B1 and B2 LEDs indicate that section or line (respectively) parity errors were detected.

The REI/FEBE (Remote Error Indication or Far End Block Error) indicates that a non-zero value in the Line FEBE byte was detected.

The RDI/FERF (Remote Defect Indication or Far End Receive Failure) alarm indicates that bits 6, 7, and 8 of the K2 byte have been a binary 110, respectively, for five or more consecutive frames.

The AIS (Alarm Indication Signal) indicates that bits 6, 7, and 8 of the K2 byte have been a binary 111, respectively, for five or more consecutive frames.

The 155 and 622 LEDs function in conjunction with the DROP SELECT key to indicate which optical drop rate has been selected. Both LEDs are off when the 155 Mb/s electrical drop is selected.

View History Key

The VIEW HISTORY key reviews past alarms and errors. A history status bit is set, and the status LED built into the key is lit whenever an alarm or error is detected during the run mode. Pressing this key will display the history status of the alarm and error LED indicators instead of the current status. Releasing this key will return to the current status display within 200 milliseconds. History is cleared when a new test cycle starts.

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Drop Select Key, Receiver

The DROP SELECT key is used to select one of three drops from the 2.4 Gb/s (OC-48) signal. The 155 Mb/s signal (OC-3) can be either electrical or optical. The 622 Mb/s (OC-12) signal is always optical. The Tributary Select Key will then be used to choose a tributary.

Tributary Select Key, Receiver

The receiver TRIB key is used to choose the drop side tributary. One of sixteen 155 Mb/s (OC-3) tributaries or one of four 622 Mb/s (OC-12) tributaries can be selected from the 2.4 Gb/s (OC-48) signal. The Drop Select Key was used to choose either the OC-3 or OC-12 drop.

OVHD Key, Receiver

The receiver OVHD (Overhead) key permits viewing of the section and line overhead bytes of the first STS-1 in the OC-48 frame, including APS (Automatic Protection Switching). Some of these bytes may be used to perform testing—review the *OVHD Key, Transmitter* section previously presented in this chapter.

Measurement Controls and Indicators

The **ST2400 2.4 Gb/s SDH/SONET Test Set** Measurement Controls and indicators are located at the top right-side of the front panel. The RUN/STOP key provides duration control over the test cycle. RUN clears all counters, clears history data, and starts the test cycle. STOP halts the test cycle without effecting counter values. The green LED indicator, inside the key, is on during the RUN cycle. A stopped test can be restarted using the pause-run-resume sequence, saving stored history data.

The PAUSE/RESUME key permits a temporary stop of the test cycle. The red LED indicator is on when the test cycle is in the pause mode. Pressing the key, once again, extinguishes the LED and resumes the test. All counters are suspended in the PAUSE mode and continue from that point when the test cycle is resumed (RESUME).

Remote Indicators

The two GPIB front panel LED status indicators are located on the left-side of the front panel. The Remote Operation (REM) LED indicates that the ST2400 is being controlled through its GPIB connection or is in ST112 Dual Mode—functioning as a slave unit. The REM LED is off when the unit is in the local mode or is being controlled by an RS-232C connection. Except in the ST112 Dual Mode, front panel control is restored when the SETUP key is pressed.

In the Local Lockout (LLO) mode, the **ST2400 2.4 Gb/s SDH/SONET Test Set** front panel is disabled by a remote controller that is using GPIB access commands. Front panel control can only be restored by the appropriate GPIB command or by a power initialization cycle. Power initialization should only be used when the ST2400 is not being remotely operated.

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Rear Panel Description

This section describes the rear panel controls and connectors.

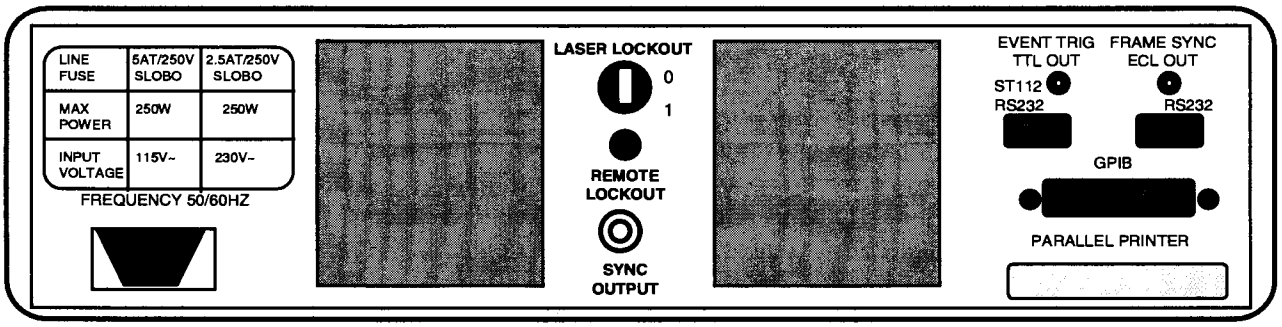


Figure 2-9. Rear Panel - ST2400

The AC power module is located in the lower left-hand corner of the rear panel. It has a removable fuse panel that can be opened with a small flat blade screw driver after the AC Line Cord has been unplugged. The AC power supply automatically detects and switches to accept either 115 (90 to 130 VAC or 230 (180 to 250) VAC inputs. A 5AT fuse is used with either AC source voltage.

⚠ **WARNING!** Always disconnect the AC Power Cord before opening the fuse panel or disconnecting the rear panel AC interlock.

SYNC Output

SYNC Output (Clock Trigger) is an AC-coupled output. The voltage level is 500 mV peak-to-peak minimum. This output needs a 50-Ohm termination to work properly. This output is used to trigger a oscilloscope to measure the eye diagram of an OC-48/STM-16 signal.

Laser Lockout, Remote Interlock

LASER LOCKOUT is a safety device. The key switch disables the Transmitter's 2.4 Gb/s laser output when its turned to the 0 (zero) position. The laser output can only be turned on when the key is in the 1 (one) position.

REMOTE INTERLOCK is a bantam plug normally closed connection internally wired in series with the laser lockout key switch. It can be used with additional hardware to disable the Transmitter 2.4 Gb/s laser output.

NOTE: The Transmitter 2.4 Gb/s Laser output cannot be enabled unless:

- The Laser Lockout key switch is set to the on (1) position.
- The Remote Interlock, which is normally enabled, is either not used or externally enabled.
- The Laser output is software enabled.

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⚠ WARNING!

Before activating the 2.4 Gb/s LASER its output must be connected to a circuit.

⚠ CAUTION!

Always use 15 dB of attenuation when connecting the ST2400 Transmitter output to its receiver input. Failure to do so will damage the optical detector.

Rear Panel Connectors

There are two BNC, two 9-pin RS-232, one GPIB, and one parallel printer.

Event Trigger and Frame Sync signals are accessible through individual BNC connectors shown in and located on the upper right rear panel. Either can be connected to an event counter or used to trigger an oscilloscope.

- The Event Trigger is a TTL output that is generated by any one of the following Transmitter programmed alarm or error conditions (AIS, FERF, LOS, and frame errors—including LOF), or by changing an overhead byte value. The event trigger signal is a minimum of 2.4 Vpeak, with a pulse width of 25 ns ±10%, and leads the event by less than 1µs.
- The Frame Sync has an ECL output that is generated by the transmitted framing bytes, A1 and A2. The frame sync signal is a minimum of 600 mvpp, with a pulse width of 25 ns ±10%. The pulse repetition rate is equal to the 125µs frame rate.

The two DB-9 receptacles are RS-232C 9-pin serial interface connectors. One is marked for use with the Tektronix ST112. It can be used with a VT-100 terminal or PC running VT-100 terminal emulation software. The ST112 is only supported in the SONET configuration or mode. The other is marked RS232 it can be used for remote operations or with a serial printer.

The GPIB receptacle is an IEEE-488.2 standard connector provided for remote operation.

The DB-25 receptacle is a Centronics parallel printer interface.

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Applications and Use

This section provides three common examples of telecommunication network applications. It details how the **ST2400 2.4 Gb/s SDH/SONET Test Set** can be used for:

- Passive Monitoring (Receive-Only)
- Active Analysis
- Active Throughput Analysis

Common **ST2400 2.4 Gb/s SDH/SONET Test Set** applications such as field service troubleshooting, engineering analysis, production testing and maintenance will be similar.

Passive Monitoring

The passive monitoring application monitors the 2.4 Gb/s signal. It uses a passive coupler to connect and disconnect the ST2400 without disrupting live traffic.

This setup is used for non-intrusive network monitoring applications. It is perfect for LEC/IXC (local exchange carrier / inter-exchange carrier) cross-boundary or other long-term, passive performance monitoring. It does not allow optical line error injection testing.

This installation splits the STM-16 optical signal through a passive coupler, which can be mounted in an optical cross-connect bay or other convenient location. Since there is no active regeneration of the optical line, the system under test must have adequate margin to accommodate the coupler insertion loss. Measurements are made with the ST2400, as required.

The CTS850, ST112, or another SDH/SONET tributary test set can be used with the ST2400 to expand its test capabilities. The ST2400 Receive-Only model is particularly economical for passive monitoring applications.

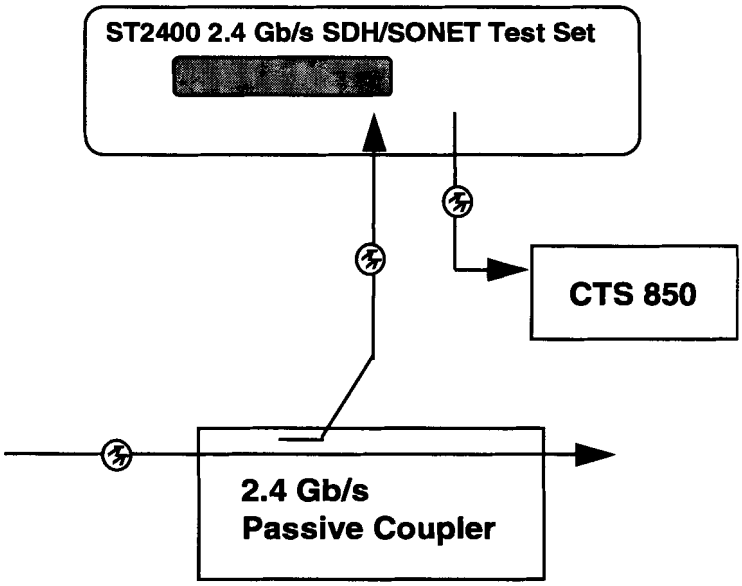


Figure 2-10. ST2400 Passive Monitoring

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Active Analysis

The Active Analysis application inserts the ST2400 into an active signal path. This configuration is suitable for test or maintenance operation where live traffic is not being carried over the network, network element, or unit under test.

In this application, the CTS750 test set can provide the 155 Mb/s or 622 Mb/s framed signal input to the ST2400, which is actively inserted into the signal path. The ST2400 provides a variety of signal and analysis options for complete testing of the 2.4 Gb/s. Payload level testing can be done by applying the 155 or 622 Mb/s signal to the auxiliary test set.

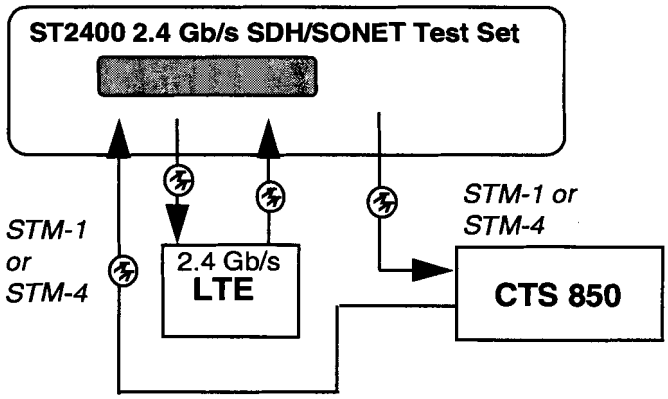


Figure 2-11. ST2400 Active Analysis

Active Through Mode Analysis

The Active Through Mode Analysis of the 2.4 Gb/s Line is similar to the Active Analysis application. The ST2400 is actively inserted into the signal path as either a regenerator or as a stress tester. The STM-16 signal is looped through the ST2400. The signal can be passed through and regenerated unchanged or alarms and errors can be added for conformance and stress testing.

The ST2400 can be used with a companion test set (CTS850) to make all of the transmission measurements required to completely test the network system. Or the ST2400 can be used without the additional tributary test set to quickly test, monitor, and verify the 2.4 Gb/s signal operation.

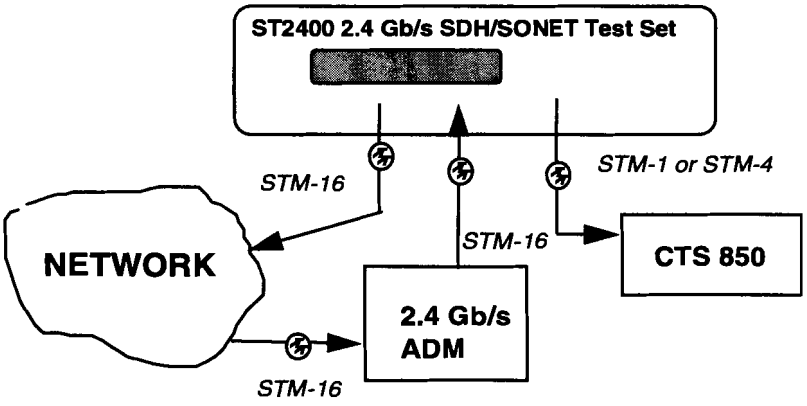


Figure 2-12. ST2400 Passive Monitoring

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Reference

This chapter describes the use of the ST2400 LCD menu structures and displays. In addition to the general displays and menus, there are separate sections that detail setup, receiver, and transmitter specifics.

Functional Verification

A functional verification of the **ST2400 2.4 Gb/s SDH/SONET Test Set** can be performed while reviewing this chapter. To do so, use an optical cable and a 15 dB attenuator connected between the transmitter laser output and the receiver laser input. To avoid damaging the receiver input always use a 15 dB attenuator in the loopback connection.

Setup Menu System

Pressing the setup key at any time will cause the ST2400 to enter the Setup Menu System, accessing the menus and submenus.

Both the setup and the enter keys are used to navigate through this menu system. The left and right arrow keys, and the increment and decrement keys are used to change values. The enter key is also used to access submenus.

The left column of Figure 3-1 shows the seven main menus that make up the Setup main menu system. It is a continuous loop that begins with the Quick Setup LCD display and ends with the Auxiliary Setup display menu. As noted in the figure, the word XXXxxx can be either SDH or SONET. That choice is made in the System Configuration submenu shown at the bottom of Figure 3-2.

When power is applied the first three LCD displays will show:

1. The *Tektronix/MWL Products* logo and *Copyright* notice.
2. Performing Self-test and Serial Number.
3. *ST2400* logotype and *Software Version* number and all front panel LEDs will illuminate, verifying their operation.

The third power-up LCD display and all of the illuminated LED indicators will be continuously displayed when you press and hold the VIEW HISTORY key before the power switch is set to on, and continue to hold it in during the power up cycle. The QUICKSET LCD will not be displayed until you release the VIEW HISTORY key.

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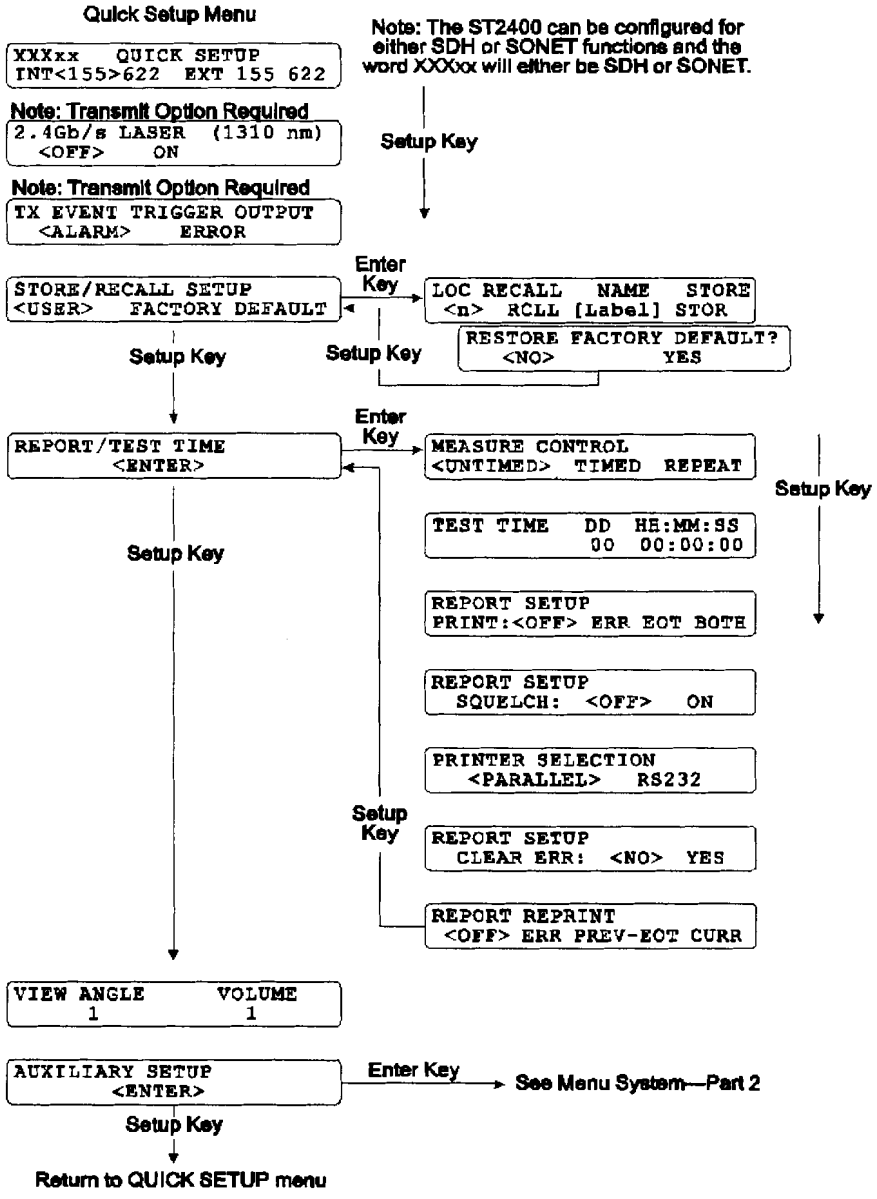


Figure 3-1. Menu System—Part 1

- The next LCD display is the QUICK SETUP menu. The menu choices are used to select the receiver drop frequency, either 155 Mb/s (OC-3) or 622 Mb/s (OC-12), from either an internally (INT) generated 2.4 Gb/s (OC-48) rate or an externally (EXT) supplied 2.4 Gb/s (OC-48) rate. When the choice is made, by pressing the enter key: alarms and errors, if on, will be turned off. Overhead byte values will be reset and set to pass mode. The next menu will be automatically displayed.

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⚠ WARNING!

Before activating the 2.4 Gb/s LASER its output must be connected to a circuit.

⚠ CAUTION!

Always use 15 dB of attenuation when connecting the ST2400 transmitter output to its receiver input. Failure to do so will damage the optical detector.

- Press the setup key to access the 2.4 Gb/s LASER menu. It is the first of two that are only displayed when the transmitter is installed. The Laser is off when the ST2400 is first powered on and can only be activated when the rear panel laser lockout key-lock is in the on position. To activate the laser use either arrow key to move the cursor to the *ON* position, then press the enter key. The laser has a five second delay when activated.
- Another push of the setup key will access the TX EVENT TRIGGER OUTPUT menu, the second transmitter only display. It is used to select whether an alarm or an error condition will be used to generate the event trigger pulse from the rear panel BNC connector. The event trigger is 2.4 Vpeak minimum, with a pulse width of 25 ns ±10%, and leads the event by less than 1µs. It can be used to synchronize other equipment, such as an oscilloscope trigger source.
- The STORE/RECALL SETUP menu is next. It is used to access either the USER stored setup or the FACTORY DEFAULT setup. Pressing the enter key will access the submenu from which one of the ten LOC (locations) can be RCLL (recalled) or STOR (stored). Up to ten individual user setups can be saved in memory locations 0 through 9. A unique 10 character label can be stored with each saved setup. The arrow keys are used to position the cursor anywhere in the label area, and the INC or DEC key is used to scroll through the ASCII characters—including numbers and symbols. Moving the cursor to FACTORY DEFAULT and pressing the enter key will access that NO or YES menu—that defaults to NO. Moving the cursor to YES and pressing the enter key will restore the factory default configuration. Pressing the setup key will return to the STORE/RECALL SETUP display.
- REPORT / TEST TIME is the next setup menu. It is used to access a complete set of measurement control, test, and report submenus that will be detailed in the next section of this chapter. Pressing the setup key will move to the next main menu.
- The VIEW ANGLE can be set to one of eight integers (0 through 7). Zero should be the best view angle when the ST2400 Test Set is positioned below the operator and 7 is best when the operator is looking up at the front panel. The change is interactive; it is executed whenever the increment or decrement key is pressed. In the same menu, the VOLUME can be set using integers 0 through 9. Zero is off and 9 is the loudest. Errors and alarms activate the beeper, unless the volume is set to zero. The operator setting will be retained when the Test Set is powered off.
- AUXILIARY SETUP is the last of the seven main setup menus. Pressing the setup key will loop back to the QUICK SETUP (starting) menu. Pressing the enter key will access the auxiliary setup menu system.

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Report/Test Time Menu System

The REPORT/TEST TIME main menu is used to access seven submenus that are used to configure the measurement control, test time, and report setup. Pressing the enter key will access the MEASURE CONTROL menu.

- The MEASURE CONTROL menu sets the test cycle to be used when the run key is pressed. UNTIMED will run until the stop key is pressed. TIMED will run the test for the duration of time set in the TEST TIME menu. REPEAT will run the test for the duration of time set in the TEST TIME menu, then start the test again. The stop key can stop any test that is running.
- Next is the TEST TIME menu used to set the test run duration, in terms of days (D), hours (HH), minutes (MM) and seconds (SS). The maximum time supported is 9 days, 23 hours, 59 minutes, and 59 seconds. Press the enter key to store any changes and the setup key to move to the next menu.
- Next is the REPORT SETUP menu used to control the printed report. It can be set to OFF—no printout, ERR—print a report when an error is detected, EOT—print a report summary at the end of test, or BOTH—print on error and at the end of test. The printer can be connected to either the parallel or serial (RS-232C) port. Parallel is the factory default setting.
- The REPORT SETUP SQUELCH menu is used to limit the total number of errors logged, saving memory space. When squelch is set to ON error recording will stop after 10 consecutive seconds with errors. Then error recording will be resumed after 10 consecutive seconds without any errors.
- The PRINTER SELECTION menu offers either PARALLEL or RS232 (serial) printer selection. The printer should be connected to the appropriate port on the ST2400 rear panel.
- In the REPORT SETUP menu CLEAR ERR (error) is used to clear the error log by moving the cursor to YES and pressing the enter key. It immediately clears the error log and returns to NO after execution. The error log should be cleared before running a long test, preventing buffer overflow. An error log warning message will be displayed when the run key is pressed, if the log is 95% full.
- The REPORT REPRINT menu is used to print the previous error log (ERR), the previous end of test summary (PREV–EOT), or the current error log (CURR) if it exist.

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Auxiliary Setup Menu System

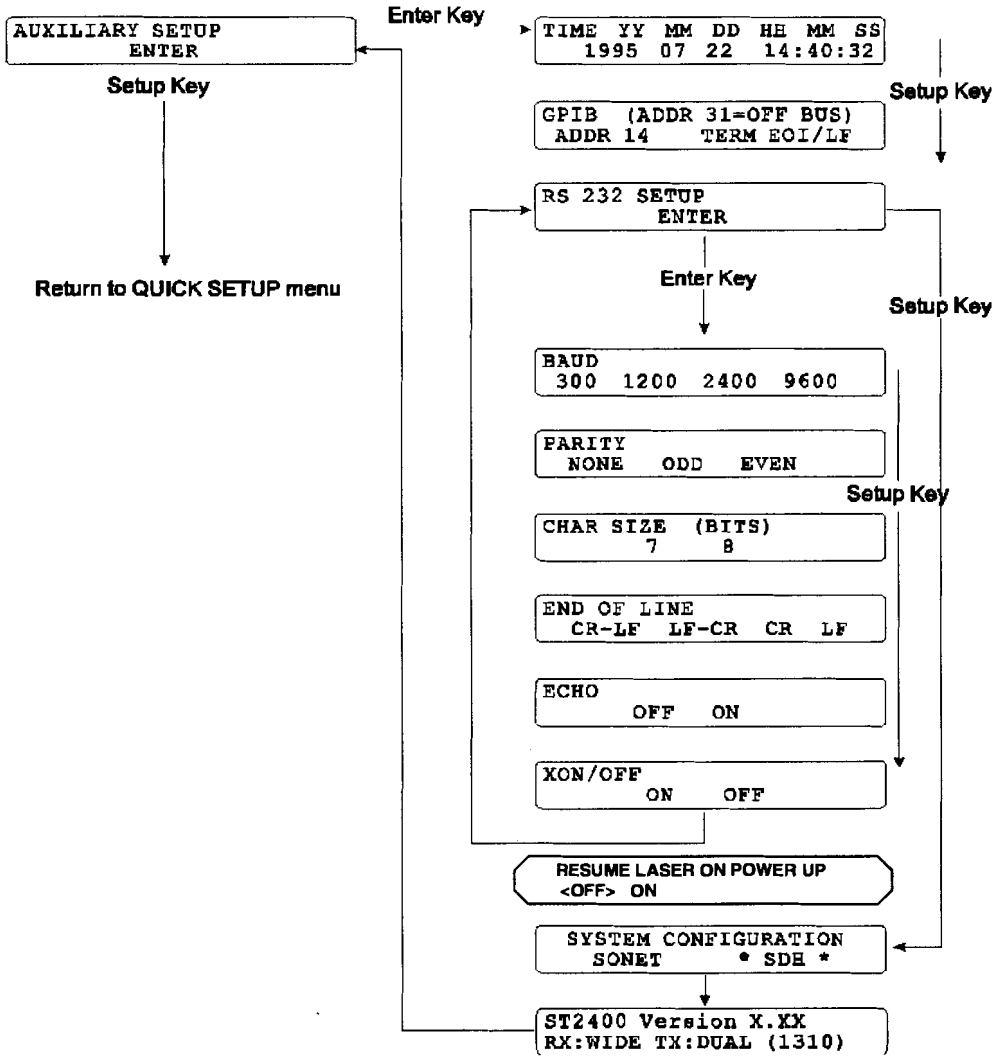


Figure 3-2. Menu System—Part 2

The left column of the figure above shows the auxiliary setup menu which is part of the seven Setup main menus. The right side shows the auxiliary submenus. Press the enter key to access them.

- TIME is the first submenu accessed from the auxiliary setup menu. It is used to store the year current (YY), month (MM), day (DD), hours (HH) minutes (MM), and seconds (SS), in a battery backed memory. Whenever changes are made, the enter key LED will start flashing. Once set, the operator setting will be retained when the Test Set is powered off.
- Use the setup key to access the GPIB port characteristics menu. The port address is an integer from 0 to 31. It can be changed with the INC or DEC keys. The enter key LED will flash, push it before proceeding. Either an EOI (End-Or-Identify) or EOI/LF (End-Or-Identify with a Line Feed) can be used to terminate the GPIB message sent by the ST2400.

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- Next is the RS 232 SETUP menu. Pressing the enter key will access to the first of six port configuration submenus. They store the characteristics for BAUD rate, PARITY, CHAR (character) SIZE, END OF LINE, ECHO, and XON/XOFF (flow control).
- **Power Fail Recovery** - Power recovery and test resume after power-up. This capability is user-selectable (recover with laser off, or recover with laser on and resume test in process).

  This menu is available under the AUXILIARY SETUP menu.

  When ON is selected, the laser will automatically be restored to its last operational state prior to the power loss. If the laser was ON, it will come back on. If the RESUME LASER selection is ON, use the proper safety procedures listed throughout this manual. If the laser was OFF, it will remain off.

  On power-up, the measurement automatically restarts (continues) if the measurement was active when the power went down. The data collection is delayed by ten (10) seconds to permit the laser to turn on and the device under test (DUT) to settle. Before this change, after a loss of power, a measurement would need to be restored due to the 2.4 Gb/s laser being turned off.

  If System Configuration of the test set (SONET or SDH) is changed, the ST2400 will automatically restart.

  RESUME LASER ON POWER UP
  <OFF> ON

  This menu applies to both TX and RX lasers.

- The SYSTEM CONFIGURATION menu can be obtained by pressing the setup key from the RS 232 SETUP menu. The ST2400 has both SONET and SDH modes. The active mode is set when the unit is powered on. It has an asterisk (*) on both sides. Using the arrow key to move the cursor to the SDH and the press the enter key to select the SDH mode. A momentary display, that reads: *Measurement mode changed, cycle power to enable* the user to power off the ST2400 and reapply power. After the power-up displays the first menu will now read SDH QUICK SETUP.
- Pressing the setup key again will loop to the ST2400 Version X.XX characteristic display. It provides a software version number and the laser wavelength for both the receiver and transmitter. A broad-band receiver, *RX: WIDE*, is shown, indicating that both 1310 and 1550 nanometer lasers are supported. The transmitter wavelength, *TX: DUAL*, indicates that the transmitter can be switched to either 1310 or 1550 nanometers. The current transmitter wavelength is also shown—*(1310)* in this example. The transmitter MODE key is used to change the TX wavelength, in a dual wavelength unit.
- Pressing the setup key again will return to the AUXILIARY menu in the quick setup main menu loop. Another press of the setup key will, once again, return to the QUICK SETUP main menu display.

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General Menus and Displays

Menu and Measurement Refinements

- **Extended range for B2 error rate measurement** - The B2 error counter has been updated to read every 20 ms, instead of every 100 ms, to extend the maximum B2 error rate which can be measured.
- **Print-on Event** function gives a printed error count for B1, B2 and FEBE (MS-REI) errors.

Option Not Installed

The **ST2400 2.4 Gb/s SDH/SONET Test Set** can be ordered in one of three configurations, which are: TRANSCEIVER, TRANSMIT-ONLY, OR RECEIVE-ONLY.

The TRANSMIT-ONLY version can be easily identified because it lacks the receiver connectors for *155/622 OUT* and *2.4 Gb/s IN* and it will not detect a receiver card during the power-on cycle. (Some early models may have all front panel connectors.) Pressing any of the control keys in the receiver section will cause the following message to be displayed:



Figure 3-3. Receiver Card Not Installed

The RECEIVE-ONLY version can be easily identified because it lacks the transmitter connectors for *155/622 IN* and *2.4 Gb/s OUT* and it will not detect a transmitter card during the power-on cycle. (Some early models may have all front panel connectors.) Pressing any of the control keys in the transmitter section will cause the following message to be displayed:



Figure 3-4. Transmitter Card Not Installed

Error Log Display

No additional entries will be logged when the error log is full. If the error log is more than 95% full when the RUN key is pressed ,the message will be displayed. Selecting NO will allow the test to run, but when the error log is full new data will be lost. Selecting YES will clear the error log.

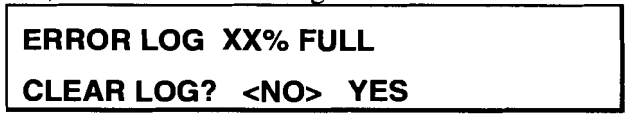


Figure 3-5. Error Log Display

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Transmitter Menus and Displays

Certain features on the ST2400 Transmitter apply specifically to firmware version 2.4 and hardware upgrade kit ST24U15.

TX Source Mode

Pressing the MODE key will access the TX MODE SELECTION menu. It is used to choose one of the three data modes that will produce the 2.4 Gb/s output signal. The three choices are: an external input (EXT) from the transmitter front panel 155 or 622 Mb/s inputs, an internally (INT) generated 2.4 Gb/s signal, or a through (THRU) mode from the receiver's 2.4 Gb/s input connector. The EXT and INT modes function on both the ST2400 transceiver and ST2400 transmitter units. The THRU mode only functions on an ST2400 transceiver unit.

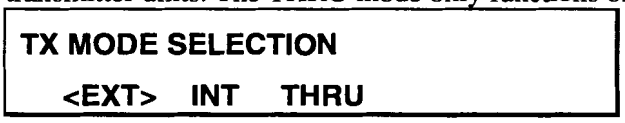


Figure 3-6. Transmitter Input Menu

The EXT input can be 155 Mb/s optical (OC-3), 622 Mb/s optical (OC-12), or 155 Mb/s CMI electrical signal. On the Transmitter 155 / 622 Input Status section there are three yellow LED indicators, two optical and one electrical.
The appropriate LED will indicate the input signal.

The INT mode generates an unequipped SONET 2.4 Mb/s (OC-48) signal with valid transport overhead that can be modified.

The THRU (Through) mode can be used to pass without modification, or modify, a 2.4 Gb/s SONET signal that entered the receiver from an external source. All three yellow status LEDs will be off when the ST2400 is in the THRU mode.

Pressing the MODE key a second time will access the TX WAVELENGTH menu, if the dual wavelength transmitter option is installed. It is used to switch between 1310 nm and 1550 nm.



External Clock Synchronization

This menu choice is available under the MODE button the front panel (TX side).

2 Mb/2 Mhz input can be utilized for external timing synchronization. This option will only appear when the "INTERNAL" transmitter mode is enabled. (A "Loss of Signal" message will be displayed on the front panel LCD, if either of these options are selected and the signal is not present.) If the 2.048 signal is lost from the front-panel , an error message will appear on the LCD screen - "TX: LOSS OF 2.048 CLK", which will flash on and off in 3-second intervals.

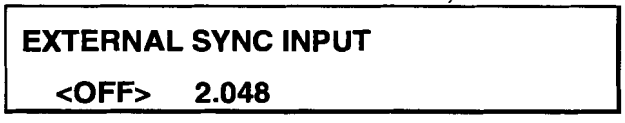


Figure 3-7.External Timing Synchronization (MODE button) (SONET)

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PRBS Mappings

These menu choices are available under the MODE button the front panel (TX side).

User can select one of three TX patterns (All-Zeros, PN23, PN23 Inverted) as internally-generated payload. The only structured payload mappings available in SDH mode is (16 x VC-4). Structured payload mapping are selectable for STS1 and STS3c in SONET mode. The entire OC-48 payload can be created from 16 x 3 STS1 or 16 x STS3c. In the SDH mode, the entire STM-16 payload can be created from 16 x VC4 filled with selected pattern.

User can also select one of three TX patterns to fill the background of internally-generated 2.4 Gbit/s signal to which externally-supplied 155 or 622 Mbits/ signal is added (EXT mode). The user has the same background mapping selections (STS1 or STS3c in SONET, VC4 in SDH).

Payload and test patterns are compatible with ITU-T O.181.

This option will appear in both "INTERNAL" or "EXTERNAL" transmitter modes. The first menu below (STS1, STS3c) will only appear in SONET measurement mode, since VC4 Test Pattern is the only valid option in SDH measurement mode.

Internal Mode

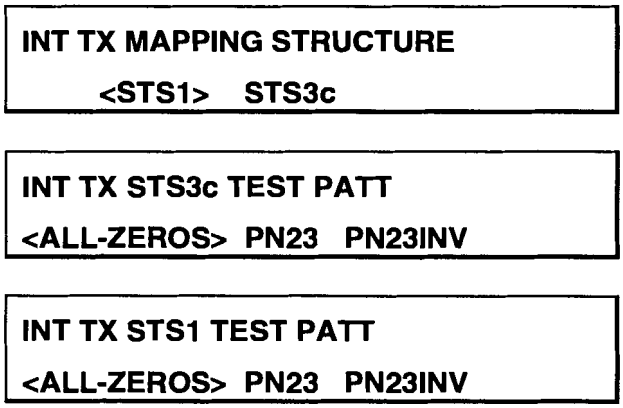


Figure 3-8. PRBS Mappings (Internal) (MODE button) (SONET)

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External Mode

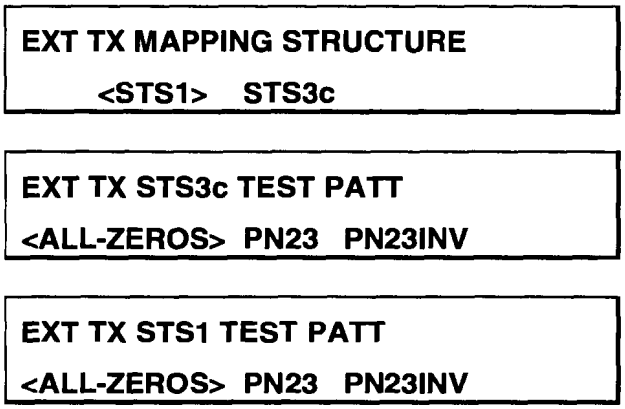


Figure 3-9. PRBS Mappings (External) (MODE button) (SONET)

Thru Mode



Figure 3-10. PRBS Mappings (Thru) (MODE button) (SONET)

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Input Select, Transmitter



Figure 3-11. Input Select Menu

The transmitter SELECT key is used to pick one of three tributary choices when the MODE is set to EXT (external). The input can be 155 Mb/s (OC-3) optical, 622 Mb/s (OC-12) optical, or 155 Mb/s CMI electrical signal source from the appropriate connector.

Tributary Select, Transmitter

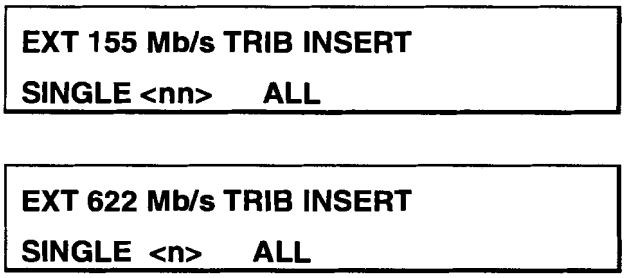


Figure 3-12. Transmitter Tributary Select Menus

The TRIB key on the transmitter side is used to select how the external source (tributary) will be multiplexed into the 2.4 Gb/s signal. Only one of the two menus will be displayed. They offer a choice between multiplexing the tributary into one specific channel or into all available 2.4 Gb/s channels. This menu depends on the choice that was made in the *Input Select* menu—155, 622, or CMI.

- The first menu is the 155 Mb/s tributary insert menu that is used to select between multiplexing the external source tributary into 1 of 16 channels or all 16 channels of the 2.4 Gb/s channel. It refers to both the optical and electrical (CMI) 155 Mb/s transmitter input signals.
- The second menu is the 622 Mb/s tributary insert menu that is used to select between multiplexing the external source tributary into 1 of 16 channels or all 16 channels of the 2.4 Gb/s channel. It refers to the optical tributary source.

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Illegal Mode



Figure 3-13. Transmitter Alarms

If the TRIB or INPUT SELECT keys are pressed when the transmitter is in the INT (internal) or THRU (through) mode, the illegal mode display will be exhibited for three seconds and then switched to the TX MODE SELECTION menu.

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Alarm Generation Menus—SONET

The left column shows the four SONET alarm displays that will be scrolled in a loop each time the transmitter alarm key is pressed. The right side shows the same alarm displays when the continuous mode is being accessed. The arrow keys, increment and decrement keys, and the enter key are used to modify the alarm conditions and access the continuous displays.

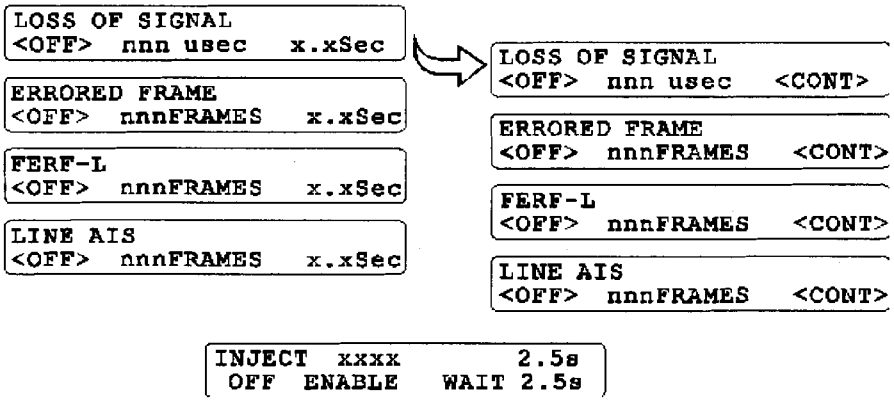


Figure 3-14. Transmitter Alarms SONET

The transmitter ALARM key is used to select one of the five alarm menus; four on the left, and one centered at the bottom LOS (Loss Of Signal), ERRORED FRAME, FERF-L, LINE AIS, and INJECT. The alarm menus are used to set specific parameters simulating various synchronization defects as detailed below. The four alarm conditions are defined in Bellcore GR-253-CORE.

Each of the first four transmitter alarm menus have the following parameters:

- OFF: The alarm is disabled.
- nnn µsec (or nnn FRAMES): Sets the duration of the alarm in microseconds for the LOS alarm or frames for the other alarms. Position the cursor using the left and right arrow keys. Use the INC and DEC keys to change the value from 1 to 127 microseconds or frames. Press the enter key to generate the alarm.
- x.xSec: Sets the on time for the burst operation from 0.1 to 9.9 seconds. This alarm condition generates extensive signal failure. Each time the enter key is pressed an asterisk (*) and the word ACTIVE will be displayed in the upper right side of the display. Use the arrow keys to position the cursor, and the INC and DEC keys to change values. This field changes to CONT, when the value is incremented beyond 9.9 seconds. Or when the cursor positioned under the letter S in the x.xSec and the increment key is pressed. The DEC key is used to return to this (x.xSec) value.

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- CONT: Turns the alarm condition on continuously, generating a hard failure. To access this hidden field see x.xSec above. Pressing the enter key will turn on the alarm continuously, displaying an asterisk (*) and the word ACTIVE. Use the right arrow key to move the cursor to OFF and the enter key to turn the alarm off. Then use the left arrow key to move the cursor back to CONT and the enter key to activate the alarm. Using the alarm key to leave the menu will not turn the alarm off.

The INJECT xxxx alarm menu, permits recurring alarm conditions to be set. Position the cursor under the alarm—xxxx in this case—and use the increment key to select the alarm type. Then set the alarm INJECT (on time) period from 0.1 to 9.9 seconds, and the WAIT (off time) for a period from 1.0 to 30.0 seconds. An asterisk (*) will switch between the wait and inject states, replacing the letter *s*, indicating which is the active state. Only one alarm condition can be activated at any one time. Enabling the recurring alarm will disable any other active alarm. Moving the cursor to OFF and pressing the enter key will stop the alarm cycle. When off, the letter s will appear at the end of both top and bottom LCD display lines.

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Overhead Menus (SONET), Transmitter

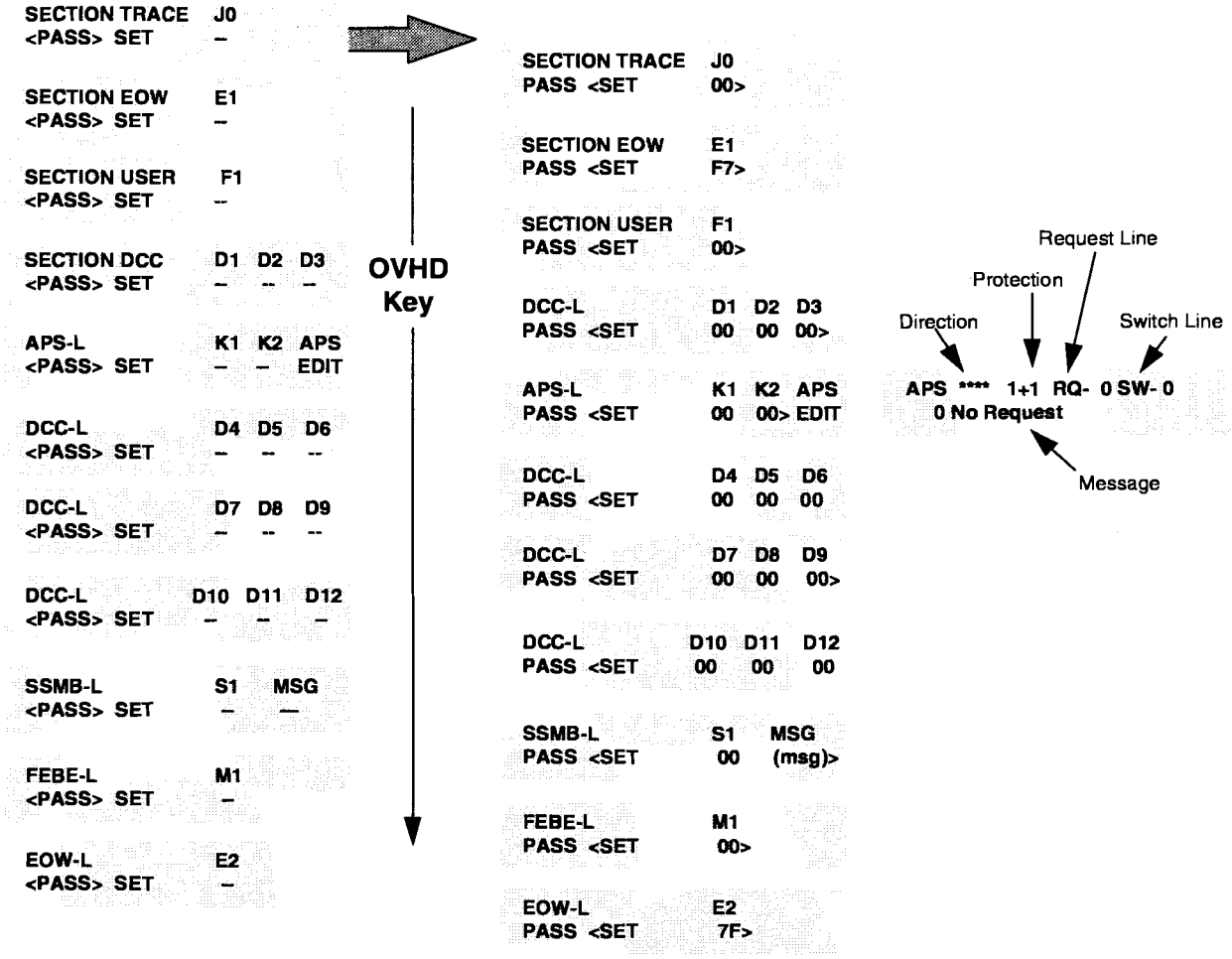


Figure 3-15. Transmitter Overhead Menus (SONET)

The transmitter overhead byte menus can be used to pass or change the 2.4 Gb/s signal overhead bytes in the first STS-1 of the OC-48 frame. The transmitter OVHD (overhead) key is used to scroll through the Section (SECT) and Line (LINE) overhead byte. The top line of each display identifies the designated SONET byte. The bottom line is used to either PASS or SET (change) the value. When the cursor is on PASS the byte is hidden. When the cursor is moved to SET the byte value is displayed and the enter key LED starts to flash. Use the arrow keys to move the cursor, and the INC and DEC keys to change values. Pressing the enter key or the overhead key will store the value.

Bytes D4 through D12 are passed or set as a group. Each can be individually changed, using the INC and DEC keys, but pressing the enter key to SET any one of them will set all of them. Passing any one will pass them all.

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Use the EDIT command in the LINE APS menu to access and change the Automatic Protection Switching bytes. Position the cursor over the word EDIT (LINE APS menu) and press the enter key. The APS menu will be displayed. Use the arrow, INC and DEC, and ENTER keys to select, change, and store values. Press the OVHD key to return to the LINE APS menu.

Ability to edit M1 Byte



Figure 3-16. Transmitter Overhead (OVHD button) (SONET)

The transmitter overhead byte menus can be used to pass or change the 2.4 Gb/s signal overhead bytes, in the first column of the STM-1. The transmitter OVHD (overhead) key, on the lower left side of the ST2400 front panel, is used to scroll through the Line Overhead and Section Overhead bytes. The top line of each display identifies the designated SONET overhead byte. The bottom line is used to either PASS or SET (change) the value. When the cursor is on PASS, the byte is hidden. When the cursor is moved to SET the byte value is displayed and the enter key LED starts to flash. Use the arrow keys to move the cursor, and the INC and DEC keys to change values. Pressing the enter key or the overhead key will store the value. The value of the editable M1 byte can range from 00 to FF.

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Error Generation Menus (SONET)

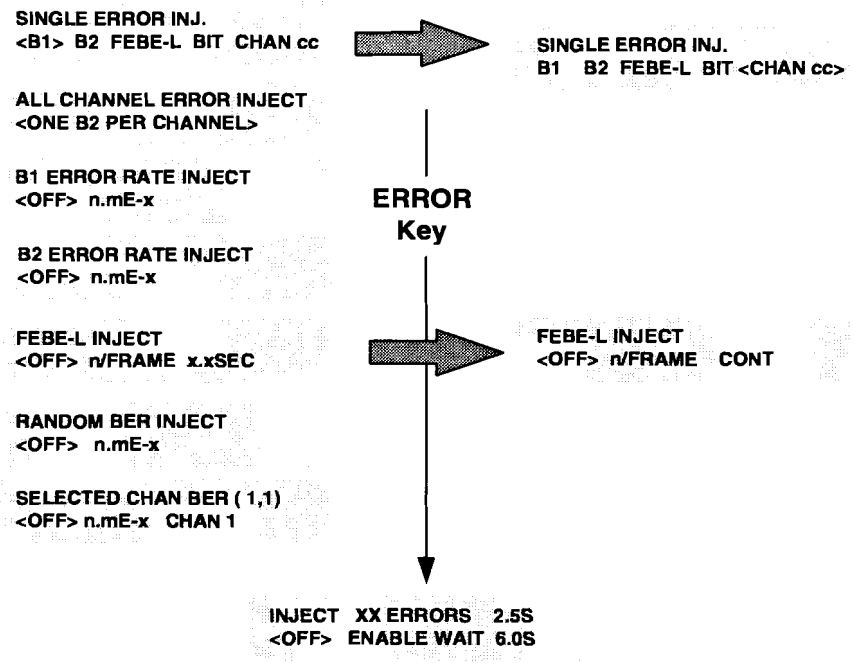


Figure 3-17. Transmitter Error Generation (SONET)

Pressing the transmitter ERROR key will scroll through the main menus. The arrow keys are used to move the cursor when selecting menu items. The INC and DEC keys are used to change values. The ENTER key is used to execute the function. Enabling any error will disable all other active errors.

The first menu, SINGLE ERROR INJ, is used to inject one error each time the enter key is pressed. Use the arrow keys to position the cursor over the B1, B2, FEBE-L, BIT, or CHAN, and press the ENTER key to generate that error. Move the cursor to CHAN cc and use the INC and DEC keys to change the channel number. Whenever the cursor is moved to CHAN the equivalent STS-1 (dd) will be displayed. At channel 48 the dd,e will read 16,3.

The error key is pressed again to obtain the B1 or B2 ERROR RATE INJECT menu. Use the arrow keys to move the cursor to n.mEx and the INC and DEC keys to set the error rate. Pressing the enter key will inject the B1 or B2 error at that rate, continuously. The B1 rate is inserted as a negative exponent from 2.5E-5 to 0.1E-9. The B2 rate is inserted as a negative exponent from 1.0E-4 to 0.1E-9. An error rate of 1.0E-6 would equate to the decimal number derived from sending one errored bit in a million bits. In other words, one divided by one million would equal 0.000001 or 1.0E-6 decimal.

The FEBE-L INJECT menu has three functions:

- A number of FEBE-L errors can be injected into one frame. The ERROR key is used to select the menu, and the arrow keys are used to position the cursor over the n/FRAME (n per frame) field. The number of FEBE-L errors per frame can be set from 1 to 255 using the INC and DEC keys. Pressing the enter key while this field is selected will insert that number into a single frame.

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- Move the cursor to x.xSEC and use the INC and DEC keys to set the period from 0.1 to 9.9 seconds. Pressing the ENTER key when the cursor is in the x.xSEC position will inject the number of FEBE-L errors (n/FRAME) for the period (x.xSEC), effecting multiple frames. For example, one FEBE-L per frame could be injected for 9.9 seconds. An asterisk and the word *ACTIVE* will be displayed for the duration of the FEBE-L injection.
- Moving the cursor under the letter *s* in x.xSec or pressing the INC key when the period is set to 9.9 seconds will access the CONT (continuous) command. Positioning the cursor over CONT and pressing the enter key will insert the number of FEBE-L (n/FRAME), continuously. An asterisk and the word *ACTIVE* will be displayed indicating that the error is being injected. Use the right arrow key to move the cursor to OFF and press ENTER. The asterisk and the word *ACTIVE* will no longer be displayed, indicating the error injection is off.

The RANDOM BER (Bit-Error-Rate) INJECT main menu is used to set the rate to a number from 1.0E-3 to 0.1E-9. Pressing the enter key will inject errors at that rate on different OC-48 channels, selected at random.

The Selcted Channel BER (Bit-Error-Rate) main menu is used to set the rate to a negative exponent from 1.0E-3 to 0.1E-9 for the CHAN (channel) selected. Positioning the cursor over the selected channel (CHAN cc) in the lower right field and use the INC and DEC keys to select the STS-1 (OC-1) channel number. The display also shows the selected STS-1 (e) in its upper right field (dd, e).

The INJECT XX ERROR menu, permits recurring error conditions to be set. Position the cursor under the XX and use the INC key to select the error type. The INJECT period (on time) is located in the top right field, 2.5S in this case. It can be set from 0.1 to 9.9 seconds. The WAIT period (off time) is in the lower right field, 6.0S in this case. It can be set from 1.0 to 30.0 seconds. The rates are set in each individual menu, B1, B2, FEBE-L, RANDOM BER, and CHANxx BER. An asterisk (*) will switch between the wait and inject states, indicating which is active. Only one error condition can be activated at any one time.

NOTE: Bit Error Rates are inserted as a negative exponent. An error rate of 1.0E-6 would equate to the decimal number derived from sending one errored bit in a million bits. In other words, one divided by one million would equal 0.000001 or 1.0E-6 decimal.

B2 Error Inject (Single, All channels simultaneously)

This menu choice is available under the ERROR button on the front panel (TX side).

The user of this test unit can inject a single B2 error (one B2 error in fixed channel of 2.4 Gbit/s payload), or the user an inject B2 errors in all channels of 2.4 Gbit/s payload.

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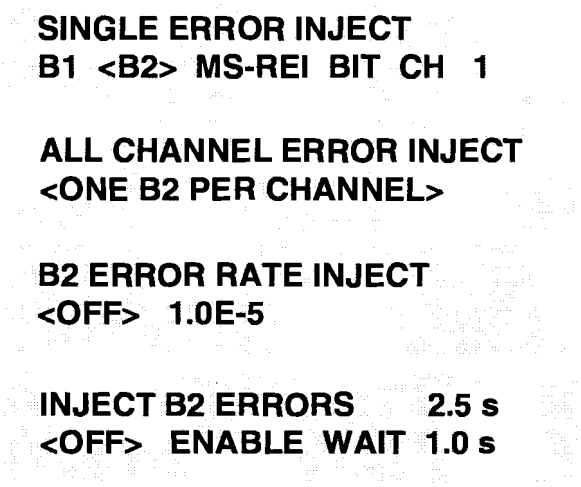


Figure 3-18. Transmitter Error Generation (ERROR button) (SONET)

Pressing the Transmitter ERROR key on the lower left side of the ST2400 front panel will scroll through the available menus. The arrow keys are used to move the cursor when selecting menu items. The INC and DEC keys are used to change values. The ENTER key is used to execute the function. Enabling any error will disable all other active errors.

The first menu, SINGLE ERROR INJ, is used to inject one error each time the enter key is pressed. Use the INC key to position the cursor over the B1, B2, FEBE-L, BIT, or CH (Channel), and press the ENTER key to generate that error. When the cursor is positioned over B1, press the INC key again to change to the B2 byte.

Press the ERROR key to move to the next menu, B2 ERROR RATE INJECT. Use the arrow keys to move the cursor to **1.0E-5** and the INC and DEC keys to set the error rate. Pressing the enter key will inject the B2 error at that rate, continuously.

The fourth menu permits injecting a single B2 error into all channels.

Inject Random BER on one Selectable Channel

This menu choice is available under the ERROR button on the front panel (TX side).

The user of this test unit can inject a random bit error rate on one selectable channel.

The (1,1) information will only appear with STS1 mapping.



Figure 3-19.Random BER on one Selectable Channel (ERROR button) (SONET)

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Receiver Menus and Displays

Error Measurements (SONET), Receiver

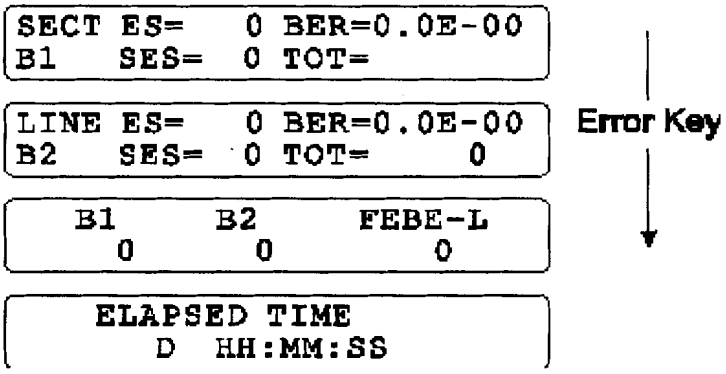


Figure 3-20. Receiver Error (SONET)

The ERROR key on the receiver side of the front panel is used to scroll through the four LCD displays. Errors that were detected on the SONET 2.4 Gb/s signal are included in the B1 SECT (section) and B2 LINE error summary menus. A third press of the error key will display the totals for B1, B2, and FEBE-L (Far End Block Error-Line). A fourth press will display elapsed test time. Each press of the error key will cycle to the next error display in a continuous loop, until some other key is pressed. The first two menus include the ES (Errored Seconds), SES (Severely Errored Seconds), the BER (Bit Error Rate), and the TOT (Total Count) for the B1 and B2 bytes.

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Overhead Displays (SONET), Receiver

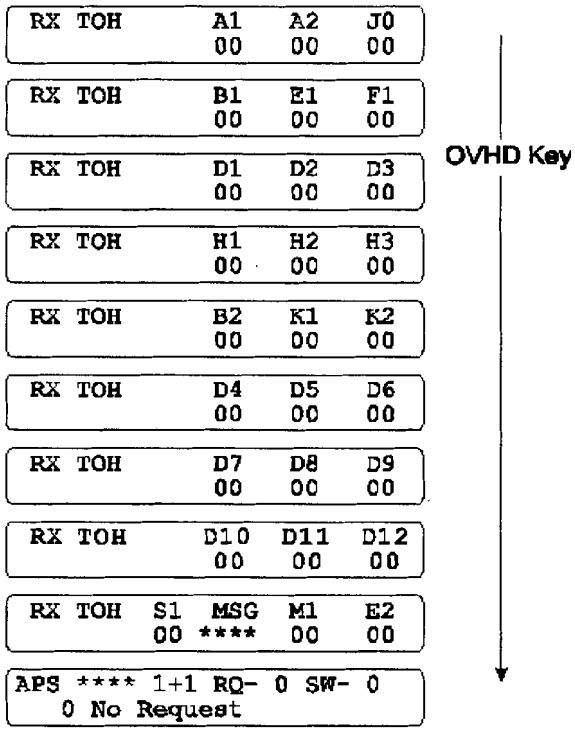


Figure 3-21. Receiver Overhead LCD Displays

The ten displays above are RX TOH SONET overhead bytes in the first STS-1 of the OC-48 frame. They can be displayed by pressing the OVHD key on the receiver panel. Each time the key is pressed the next group of overhead bytes will be displayed in a continuous loop, until some other key is pressed. There are nine displays of three bytes each. The first nine are section bytes and the next eighteen are line. The ninth display provides the ASCII synchronization messages from the S1 byte and the tenth is the APS message.

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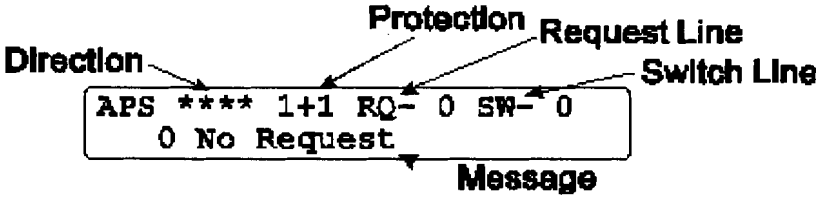
ASCII Synchronization Messages—S1 byte

For convenience both the SONET and SDH modes are compared below. The S1 byte is in hexadecimal. The unused SONET values are left blank. The unknown SDH value is marked with three question marks and unused codes are marked RES (reserved).

S1 Byte	SONET	SDH	S1 Byte	SONET	SDH
00	STU	???	08		812L
01	PSR	RES	09		RES
02		811	0A	ST3	RES
03		RES	0B		SETS
04		812T	0C	SIC	RES
05		RES	0D		RES
06		RES	0E	RES	RES
07	ST2	RES	0F	DUS	DNU

Automatic Protection Switching (APS)

From the top line: The direction can be UNI (unidirectional), BI (bi-directional), FERF-L (Far End Receive Failure-Line), AIS (Alarm Indication Signal), or four asterisks (****) indicating none of the four line types. The Protection can either be 1+1 (one-to-one) or 1:N (several unallocated lines specified by the number N). The Request Line (the line requesting to be switched) and the Switch Line (the line that the Request Line wants to switch to) can be any decimal number from 0 to 15.



Automatic Protection Switching (APS)

The bottom line of the APS will display one of sixteen possible messages:

0	No Request	8	Manual Switch
1	Do Not Revert	9	Invalid
2	Reserve Request	10	SD-Lo Priority
3	Invalid	11	SD-Hi Priority
4	Exercise	12	SF-Lo Priority
5	Invalid	13	SF-Hi Priority
6	Wait To Restore	14	Forced Switch
7	Invalid	15	Lockout Protect

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Receiver Drop Select



Figure 3-22. Receiver Drop Select Menu

The menu display is accessed by pressing the receiver DROP SELECT key. Use the arrow and enter keys to select one of the three choices. OFF will drop a 155 Mb/s electrical signal to the CMI connector and disable the optical drops. The 155 Mb/s (OC-3) optical drop or the 622 Mb/s (OC-12) optical drop can be selected by choosing either the 155 or 622, respectively. The 155 or 622 LED on the receiver section of the front panel will indicate which drop is selected—both are off when the 155 CMI is selected. This menu is used with the *Receiver Tributary Select* menus.

⚠ WARNING!

Before activating the 2.4 Gb/s LASER its output must be connected to a circuit. Always replace the screw caps when the optical outputs are not in use.

Receiver Tributary Select (SONET)





Figure 3-23. Receiver Tributary Select Menus

The TRIB key is used to select which tributary will be dropped out of the 2.4 Gb/s (OC-48) signal. One of sixteen 155 Mb/s STS-3 (OC-3) tributaries or one of four 622 Mb/s STS-12 (OC-12) tributaries can be selected using the front panel increment and decrement keys. This display depends on which drop was selected in the *RX DROP SELECT* or *SONET QUICK SETUP* menu—off, 155, or 622.

- The first menu is the SONET 155 Mb/s tributary select menu used to select 1 of 16 tributaries.
- The second menu is the SONET 622 Mb/s tributary select menu used to select 1 of 4 tributaries.

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Virtual Front Panel

This section describes the use of ST2400 terminal displayed menu structures, accessed by using a VT-100 or VT-100 terminal emulator. These full screen displays provide more information than individual LCD displays and can be used with a remote or local terminal. There are separate sections that detail setup, receiver, and transmitter specifics.

Terminal Type and Setup

The ST2400 can display its Virtual Front Panel (VFP) on a VT-100 terminal that has a 24 line 80 column display, or on a personal computer (PC) running VT-100 emulation software. Standalone communication applications such as Procomm®, Crosstalk®, or the Terminal software bundled with Windows® will run the ST2400 Virtual Front Panel. Some applications may not have a VT-100 selection. Crosstalk 2.0 for Windows offers a VT-102 terminal selection that is VT-100 compatible. The communication software documentation should identify their VT-100 compatible emulators. All references to the word terminal in this manual mean any VT-100 compatible terminal or PC running VT-100 emulation software.

Use an RS-232C modem cable to connect the serial port of the terminal and the ST2400. The cable must have a 9 pin D-type plug, for the ST2400, and the appropriate mating connector for the terminal or selected PC port.

RS-232C Port Settings

Use the Quick Set-up menus detailed in *Chapter 3-Reference* to set the ST2400 RS-232C port as follows:

Baud Rate	9600 b/s	End of Line	CR-LF
Parity	None	XON/XOFF	ON
Data Bits	8 Bit	Local Echo	ON

Access the QUICK SETUP menu by pressing the ST2400 front panel SETUP key. Continue pressing the SETUP key until the AUXILIARY SETUP menu is displayed, then push the ENTER key. Continue pressing the SETUP key until the RS 232 BAUD menu is displayed, beginning the RS-232C port configuration menus. Use the arrow keys and the enter key to configure the port as shown above. The new settings will be retained when the ST2400 is powered off. If the selections described above are already set correctly, use the setup key to move to the next menu. Press any other key to exit the quick setup menu system. Use the same settings for your terminal.

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Terminal Set Up

After reviewing the documentation that came with your terminal or terminal emulator, configure the serial port using the same settings listed above, with the following additions:

Local Echo	OFF
Stop Bits	1

Function keys that may have been changed by the terminal emulator, other software, or communication application may need to be reset to their default values. Other options, such as those that hide or turn off the cursor may also need to be reset. Additional settings recommended for the Windows 3.1 Terminal Software or other communication packages may be available from Tektronix/Microwave Logic Customer Support.

Remote Modem Connections

Remote connections using modems should use the same configuration and will operate identically with the addition of the modem set-up and dialing commands. 9600 baud between the ST2400 and its local modem and the VT-100 and its local modem is the recommended speed, though lower rates are supported.

Communications Initiation

Pressing the enter key on the terminal or PC should cause the ST2400 prompt to appear on the terminal screen.

ST2400>

If it does not, or if a message appears, indicating that the input was lost, verify the port parameter settings for the ST2400 and the terminal. Verify that the ST2400 RS-232 ECHO is enabled using the setup LCD menu. Verify that the RS-232C interface cable is properly connected.

When the ST2400 prompt appears on the screen, type either:

VT100 *(when using a VT-100 compatible terminal)*

PC100 *(when using an IBM compatible PC)*

The difference between the VT100 and the PC100 commands are the character sets used to draw lines and boxes. Standard ASCII characters are used when the PC is running a VT100 emulator. Special PC graphic characters are used in the PC100 mode. After entering either command the ST2400 will draw the Virtual Front Panel on your terminal or PC screen, as illustrated in the next figure, and throughout the next section. If your display looks different, type CTRL Q to quit and try the other command.

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Screen Displays

All of the screens illustrated in this chapter are shown as either full 24 lines by 80 column screens, or partial screen that focus on the individual example. All are intended to illustrate current samples and provide simplified explanations. Some minor differences in location, size, and shape may occur.

Setup and Current Configuration Screen

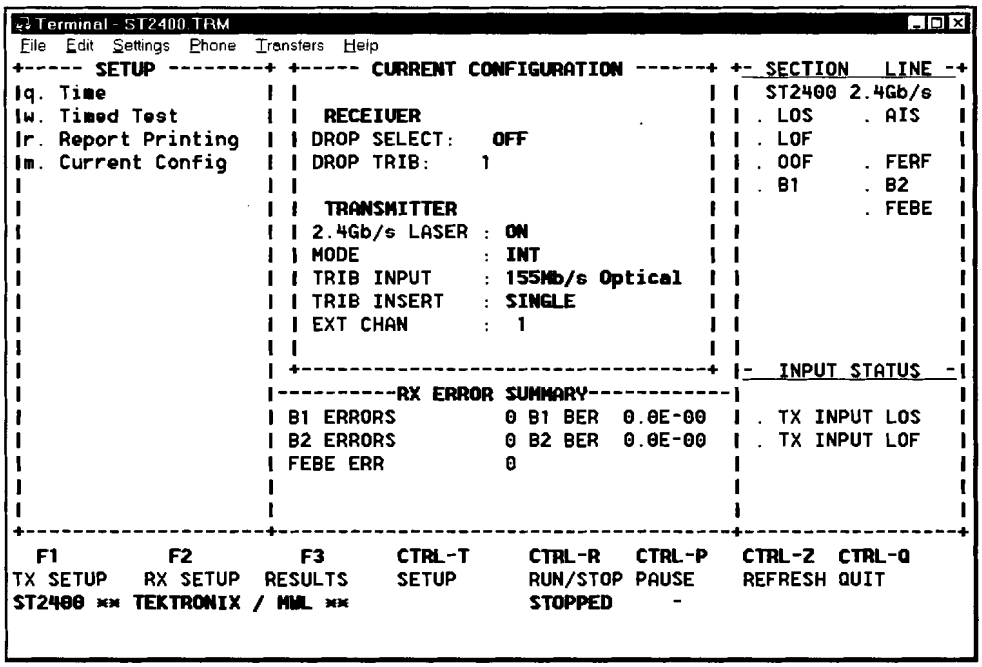


Figure 3-24. Virtual Front Panel (VFP) Setup Display

The setup display is divided into six areas. On the upper left there is a list of submenus (in this example they are: (q) Time, (w) Timed Test, (r) Report Printing, and (m) Current Configuration). Pressing the appropriate key (*q, w, r,* or *m*) on the keyboard will access these submenus. Menu keys are only active when they are displayed. Some submenus, described later, will not show this field.

The Current Configuration submenu, at the top center of the display, is a read only display. It shows the receiver and transmitter selections made in other menus. The *m* key returns it to the top center display after using any other menu.

The ST2400 front panel status LED indicators are replicated on the right side of the display. The Section and Line indicators are preceded by an asterisk, period, or the letter *H* indicating their respective status—on, off, or history. The Input Status LED indicators TX INPUT LOS and TX INPUT LOF are either on or off as indicated by the preceding asterisk or period, respectively.

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Receiver Error Summary data is shown in the center of the display, below the Current Configuration. Listed are the error totals for B1, B2, FEBE, and the Bit Error Rates (BER) for B1 and B2 errors.

NOTE: Bit Error Rates are displayed as a negative exponent. An error rate of 1.0E-6 would equate to the decimal number derived from receiving one errored bit in a million bits. In other words, one divided by one million would equal 0.000001 or 1.0E-6 decimal.

Function and Control Keys, Virtual Front Panel

Along the bottom of the display are the function and control keys. Three function keys and one control key are used to access four Virtual Front Panel screens.

TX SETUP (F1)	RX SETUP (F2)	RESULTS (F3)	SETUP (CTRL-T)

These four menus will be detailed under their appropriate headings in this chapter.

Two additional control keys are used as switches. The CTRL-R will run and stop receiver test cycles and CTRL-P will pause and resume them. Starting a test cycle will erase all previously collected data. Stopping or pausing a test cycle will not affect the stored data.

When CTRL R is used to start the test the following message may be displayed across the bottom of the screen if the error log buffer is full:

ERROR LOG IS > THAN 95% FULL
TO CLEAR IT HIT KEY "Y"
OTHERWISE HIT KEY "N"

Select *Y* for yes or *N* for no, when prompted. When the error log is full, no additional data can be stored. Pressing CTRL R while a test is running will stop the test and disable the error log. CTRL P is used to pause the test and maintain the current error log. Pressing CTRL P again will restart the test in progress. The words *STOPPED*, *RUNNING*, or *PAUSED* will appear under the appropriate control key, indicating the test status.

Test cycles stopped with CTRL-R may be restarted with the pause-run-resume sequence, saving previously stored data. Press CTRL-P, CTRL-R, and CTRL-P, in that order. Stored data can be seen in the RX Error Summary or by pressing the F3 function key. CTRL-T returns to the setup menu.

The last two control keys interrupt the Virtual Front Panel. The CTRL-Z is used to refresh the VT-100 display and CTRL-Q exits the Virtual Front Panel program. Refreshing the display or exiting the Virtual Front Panel will not alter any of the ST2400 settings. If the receiver test cycle was running when the Virtual Front Panel session ended, it will still be running the same test cycle when the VT-100 Virtual Front Panel is reentered.

NOTE: Some communication software packages and VT-100 emulators allow the user to define special keys—such as function, control, arrow, and others. These unique settings may cause Virtual Front Panel problems—disable them before starting the Virtual Front Panel.

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Configuration Submenus

The Current Configuration menu, displays the receiver and transmitter selections made in the appropriate setup menus and described later in this chapter. Other setup submenu selections are made from the upper left side of the display by typing the appropriate letter: *g*, *w*, or *r*. The letter *m* will return to the Current Configuration display.

Time Setup Menu

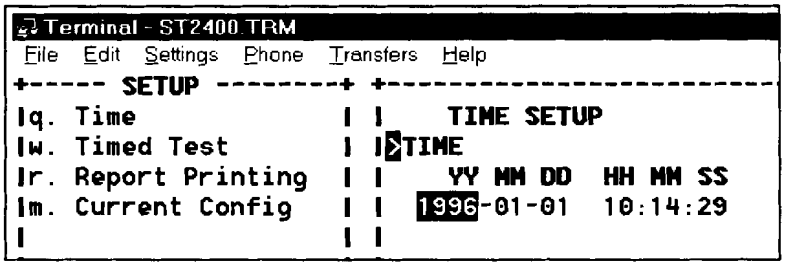


Figure 3-25. Virtual Front Panel Time Setup Display

The date and time sub menu *q* is selected by pressing the letter *q* on the keyboard. This display is used to enter the year (YY), month (MM), day (DD), hours (HH) minutes (MM), and seconds (SS). The year is four digits, all the rest are two. All changes are immediately entered into a battery backed memory, and will be retained even when the ST2400 is powered off.

Timed Test Menu

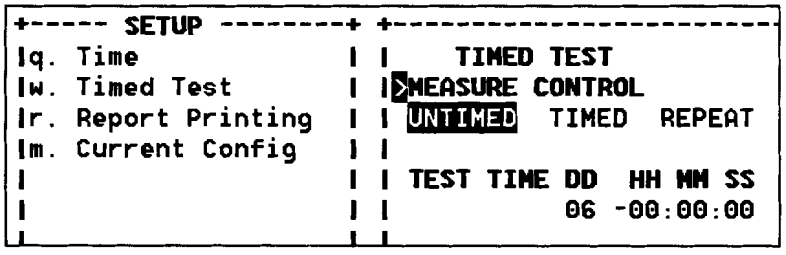


Figure 3-26. Virtual Front Panel Timed Test Setup Display

The TIMED TEST submenu *w* is selected by pressing the letter *w* on the keyboard. Use the up and down arrows to move between the MEASURE CONTROL and TEST TIME fields. Use the left and right arrows to move within the fields. Moving to the end of the TEST TIME field, with the left or right arrow, will switch to the MEASURE CONTROL field. Moving to the end of the MEASURE CONTROL field, with the left or right arrow, will not switch to the TEST TIME field. Use the number keys to change the time that the test will run for, in terms of days (DD), hours (HH), minutes (MM) and seconds (SS). The maximum test time supported is 9 days, 23 hours, 59 minutes, and 59 seconds. All changes are immediately entered into a battery backed memory, and will be retained even when the ST2400 is powered off.

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Print Report Setup

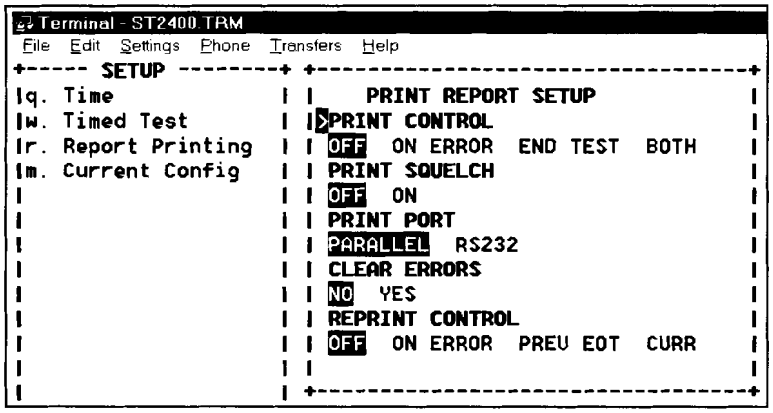


Figure 3-27. Virtual Front Panel Print Report Setup Display

Letter *r* is the PRINT REPORT submenu. Use the up and down arrow keys to move between fields. Use the left and right arrow keys to move within the field. The fields are used as detailed below.

- PRINT CONTROL: Use the left and right arrow keys to select one of four settings: *OFF* will not print any reports. *ON ERROR* will print a report when an error is detected. *END TEST* prints a report summary at the end of the test cycle. Or, *BOTH* will print a report when an error occurs and a summary at the end off the test cycle. Leaving the menu will enter the new value.
- PRINT SQUELCH: Is used to reduce the total number of errors logged. When squelch is ON errors will be logged for 10 consecutive seconds, then stop. Error logging will resume when ten consecutive seconds have passed without error. Squelch ON saves memory and reduces lengthy error reports. Leaving the menu will enter the new value.
- PRINT PORT is used to set the printer port to either parallel or RS232 (serial). The printer may be connected to the parallel port on the ST2400 rear panel. Or the VT-100 emulator can be used to set up the ST2400 then use *CTRL-Q* to exit the VT-100 program, and use the remote run command *test_state run* to initialize the test. This allows the test data to be fed back and made available for captured by a terminal emulator program. Many communications software programs support this procedure. The ST2400 will still accept remote commands, such as *test_state stop* or *test_state?*, and VT-100 commands, such as *VT100* to restart the Virtual Front Panel.
- CLEAR ERRORS: Is used to clear the error log by moving the cursor to YES and pressing the enter key. It immediately clears the error log and returns to NO after execution. The error log should be cleared before a test run because when the error log is full new errors will be discarded. Clearing the error log while the test is running will stop the test.
- REPRINT CONTROL: Is used to print the previous error log *ON ERROR*, the previous end of test summary *PREV–EOT*, or the current error log *CURR* if it exist.

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Receiver Screens

Receiver Setup and Current Configuration

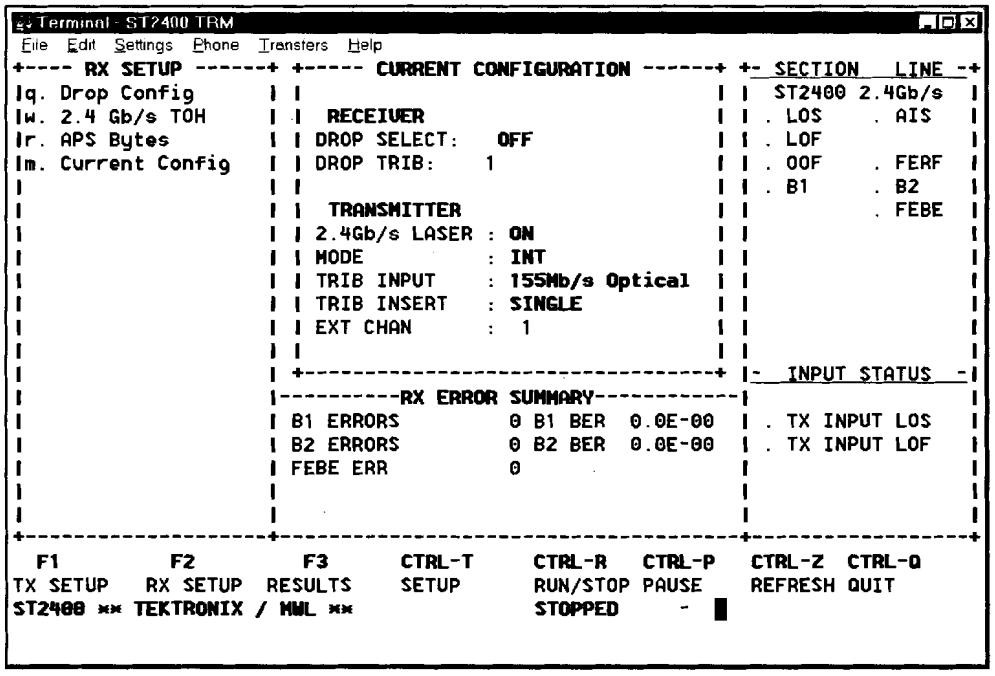


Figure 3-28. Virtual Front Panel (VFP) Receiver Setup

The F2 key will access the receiver setup display. It is divided into the same six areas previously described under the SETUP Screen. Only the submenus listed on the upper left are different. They now include three receiver setup menus: Drop Configuration (q), 2.4 Gb/s TOH (w), and Automatic Protection Switching Bytes (r). Receiver (RX) changes will be displayed in the Current Configuration (m) read-only display.

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Receiver Drop Configuration

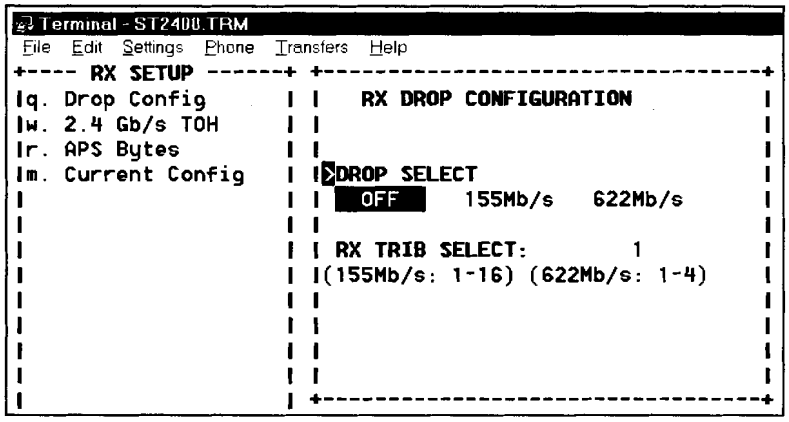


Figure 3-29. Receiver Drop Configuration

⚠ WARNING!

Before activating the 2.4 Gb/s LASER its output must be connected to a circuit. Always replace the screw caps when the optical outputs are not in use.

The RX DROP CONFIGURATION (g) menu includes three tributary DROP SELECT choices. The word *OFF* turns off the optical drop, if it was on, and activates the 155 Mb/s electrical CMI drop, available from the front panel 75 ohm BNC connector. The other two choices are 155 Mb/s optical or 622 Mb/s optical. Both are available from the receiver's front panel optical connector. The RX TRIB SELECT group can be one of sixteen 155 Mb/s tributaries or one of four 622 Mb/s tributaries. Use the arrow keys to move between fields. Changes are entered by moving to another field or display, such as pressing the m key to view the current configuration.

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Receiver 2.4 Gb/s TOH Overhead

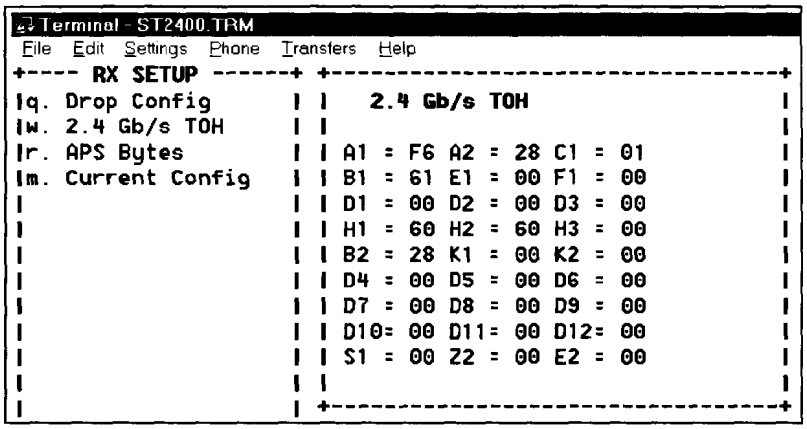


Figure 3-30. Virtual Front Panel Receiver Overhead display

The 2.4 Gb/s TOH submenu (w) is a read-only display of the section and line overhead bytes received on the first STS-1 of the 2.4 Gb/s signal. The display uses a three by nine matrix. The top three rows are the section overhead bytes and the bottom six rows are the line. Because the display is a Virtual Front Panel, all changes will be indicated, immediately.

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Receiver APS Bytes

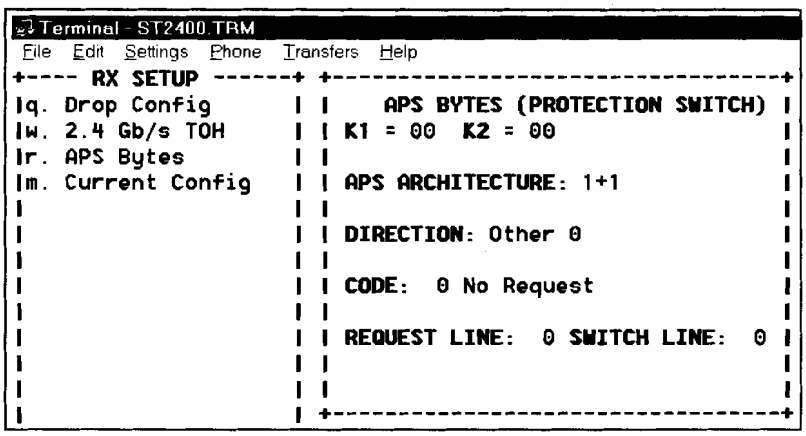


Figure 3-31. Virtual Front Panel Automatic Protection Switching (APS) Bytes

Submenu *r* is a read only display of the APS (Automatic Protection Switch) bytes. At the top of the display are the K1 and K2 bytes in hexadecimal. The APS line architecture can be either 1+1 (one-to-one) or 1:N (one-to-several unallocated lines specified by the number N). The line direction can be UNI (unidirectional), BI (bi-directional), FERF, AIS, or other indicating none of the four line types. Code *8 Manual Switching* is shown, other possible codes are listed below. The Request Line (the line requesting to be switched) and the Switch Line (the line that the Request Line wants to switch to) can be any decimal number from 0 to 15.

0	No Request		8	Manual Switch
1	Do Not Revert		9	Invalid
2	Reserve Request		10	SD-Lo Priority
3	Invalid		11	SD-Hi Priority
4	Exercise		12	SF-Lo Priority
5	Invalid		13	SF-Hi Priority
6	Wait To Restore		14	Forced Switch
7	Invalid		15	Lockout Protect

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Receiver Error Summary Display

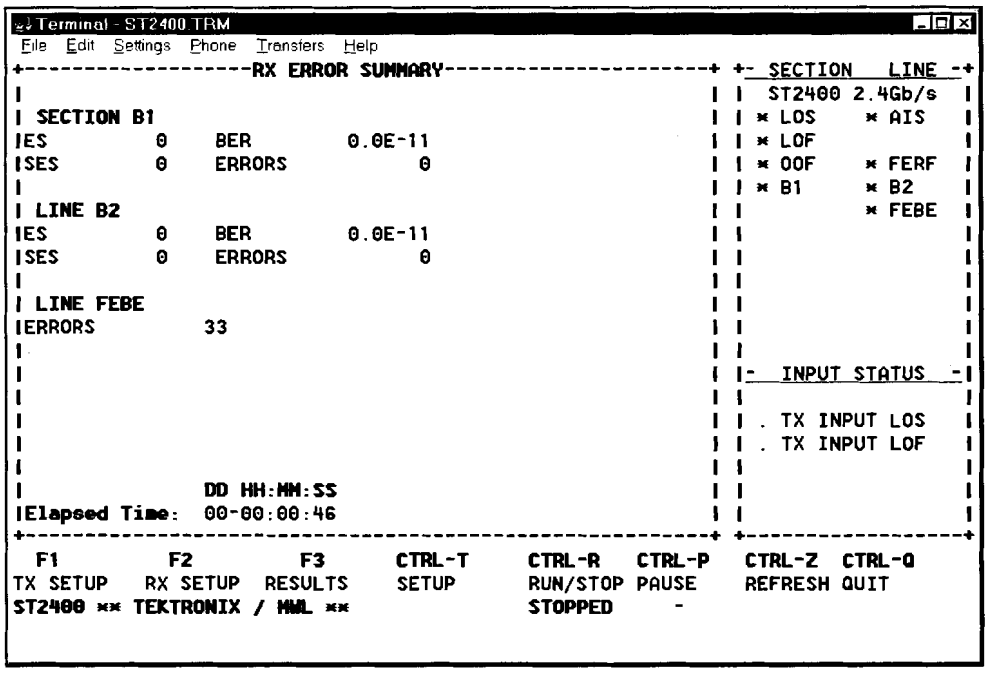


Figure 3-32. Receiver Error Summary Terminal Display

Pressing the F3 (RESULTS) function key will display the read-only receiver error summary menu. The large RX ERROR SUMMARY display area does not list any other accessible submenus on its upper left side. The only keys that can be used to exit this display are *F1*, *F2*, or *CTRL-T*.

The RESULTS screen includes the section (B1) and line (B2) errors. The totals for B1 and B2 errored seconds (ES), severally errored seconds (SES), Bit Error Rate (BER), and the total number of Line FEBE ERRORS can be read.

NOTE: The Bit Error Rate (BER) is displayed as a negative exponent. An error rate of 1.0E-6 would equate to the decimal number derived from receiving one errored bit in one million. In other words, one divided by one million would equal 0.000001 or 1.0E-6 decimal.

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Transmitter Screens

Transmitter Current Configuration

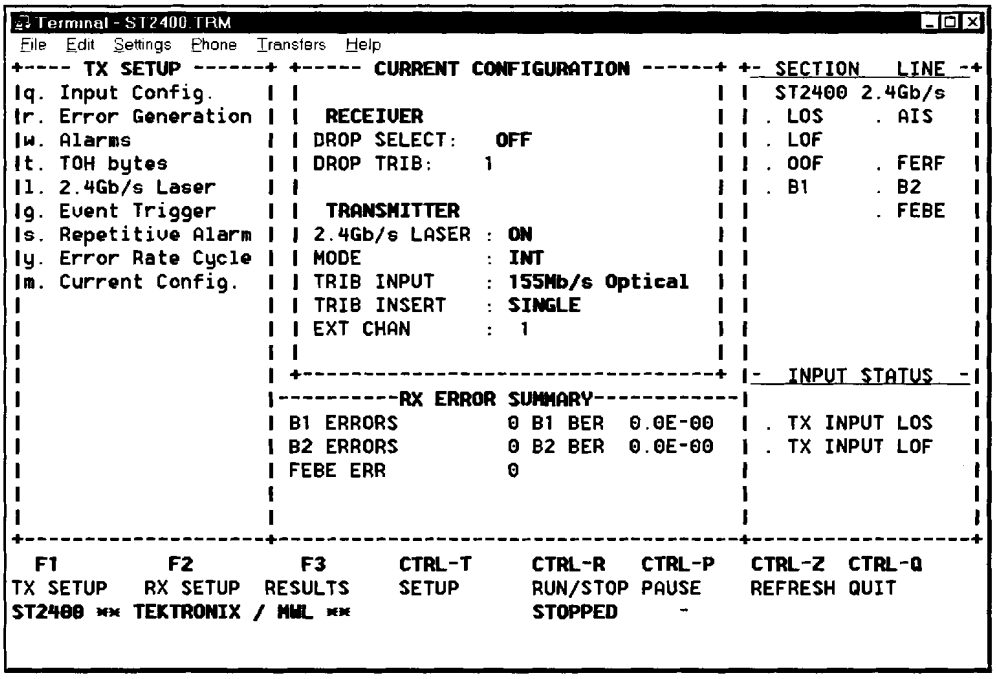


Figure 3-33. Example of Virtual Front Panel (VFP) Transmitter Configuration

Use the F1 function key to access the Transmitter setup display. Its menu and submenus are used to configure the SONET test signal. The main menu is divided into the same six areas previously described in the SETUP Screen section of this chapter. The list of submenus on the upper left side of the figure, now include the Input Configuration (g), Error Generation (r), Alarms (w), TOH (overhead) Bytes (t), 2.4 Gb/s Laser Control (l), Event Trigger Control (g), Repetitive Alarm (s), Error Rate Cycle (y), and the Current Configuration (m).

For the firmware version listed on the title page, the following changes have been made:

Add: p. Payload Config

Add: x. Ext Sync Input

Add: Two more sub-menus are available - TX Mapping and External Sync Input (see the Reference chapter of this user manual for what th menus look like and what they are used for).

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Transmitter Input Configuration

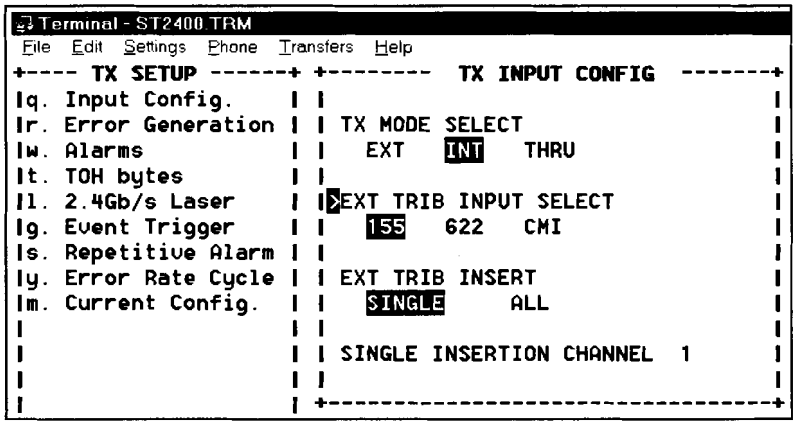


Figure 3-34. Virtual Front Panel Transmitter Input Configuration

Submenu *g*, the Transmitter Input Configuration, is used to select the 2.4 Gb/s input. Use the up and down arrow keys to move between fields and the left and right arrow keys to move within the field. Leaving the field will set the choice.

The TX MODE SELECT field has three choices: an external input (EXT) from the transceiver front panel, an internally generated 2.4 Gb/s signal (INT), or a through (THRU) input from the receiver section.

The EXT TRIB INPUT SELECT field is used in the EXT (external) mode, to select one of three tributaries sources. The transmitter front panel input can be from the optical connector at either 155 Mb/s optical (OC-3) or 622 Mb/s optical (OC-12). Or, it can be from a 155 Mb/s CMI electrical external source connected to the transmitter's front panel BNC connector.

The EXT TRIB INSERT field is used to select where the source tributary will be multiplexed into the 2.4 Gb/s (OC-48) signal. When SINGLE is selected the tributary will be multiplexed into one specific channel. If ALL is selected then the tributary will be copied and multiplexed into all of the channels.

The SINGLE INSERTION CHANNEL field is used to select one of sixteen OC-3 channels or one of four OC-12 channels that the source tributary will be inserted into.

For the firmware version listed on the title page, the following changes have been made:

Add: p. Payload Config

Add: x. Ext Sync Input

Change the CMI selection in the EXT TRIB INPUT SELCT choice to 155e

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Transmitter Error Generation

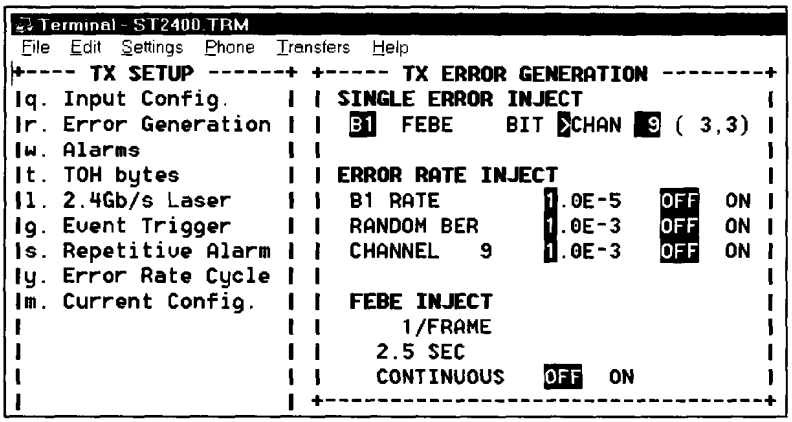


Figure 3-35. Virtual Front Panel Transmitter Error Generation Submenu

The Transmitter Error Generation submenu *r* is used to generate B1, FEBE-L (Far End Block Errors), BIT, and Channel errors. Use the up and down arrow keys to move between fields and the left and right arrow keys to move within the field. Use the enter key to generate the error. Leaving a field may also generate an error, if the field had been changed to a new value.

The SINGLE ERROR INJECT field is used to insert a B1, FEBE-L, BIT, or CHAN error. Using the left and right arrow keys to select the error and the enter key to inject that error. Pressing the down arrow will move the cursor over the channel number, nine in this case, shown as reverse print. Changing the channel number in the CHAN will change it in the CHANNEL field below. It will also changes the last two numbers, on the second line (in parentheses), indicating the selected (OC-3, OC-1) channel numbers.

Under the heading ERROR RATE INJECT are six fields. Three, on the left, are used to set the error rates. They control the error ratio (bit errors divided by total bits). The B1 Error Rate can be set, as a negative exponent, from 2.5E–5 to 0.1E–9. The RANDOM BER (bit-error-rate) and the CHANNEL error rate can be set from 1.0E-3 to 0.1E-9. The random bit error will occur on any channel and the channel error will occur on a specific channel. Changing the CHANNEL number, in this case, will change the CHAN number.

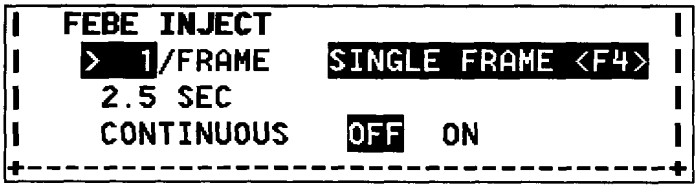


Figure 3-36. Virtual Front Panel FEBE INJECT Error Generation Field

The last three lines of our display are used to inject Far End Block Errors. From 1 to 255 FEBE errors can be inserted into each frame. The hidden SINGLE FRAME message will be displayed whenever that field is selected. Pressing the F4 function key will execute the indicated error. 1/FRAME SINGLE FRAME in this example will insert the specified number of FEBE errors into one frame.

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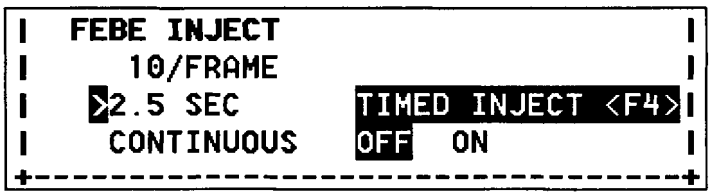


Figure 3-37. Virtual Front Panel FEBE INJECT Error Generation Field

The F4 function key message will also appear with TIMED INJECT command in the next field, 2.5 SEC (seconds) in this case. Pressing F4 will inject the FEBE error for a period of time, from 0.1 to 9.9 seconds. Or, in the last field, the FEBE can be turned ON continuously.

Transmitter Alarm Generation

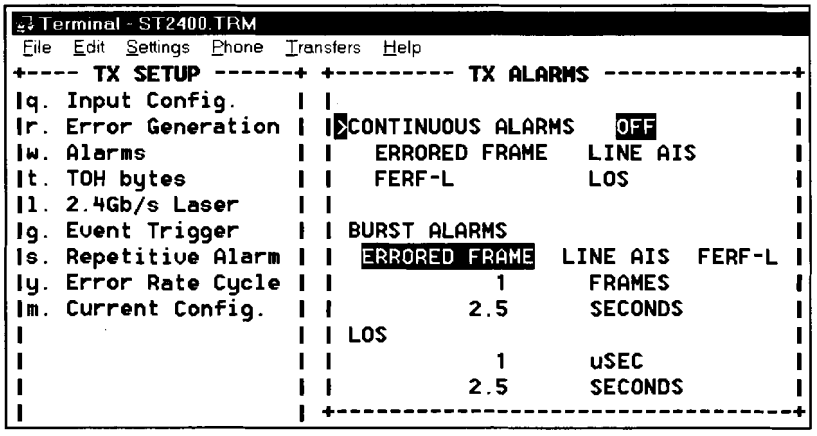


Figure 3-38. Virtual Front Panel Transmitter Alarm Generation

Pressing the *w* key selects the TX ALARM submenu used to generate continuous alarm conditions. The CONTINUOUS ALARMS field has five choices: OFF, ERRORED FRAME, LINE AIS, FERF-L, and LOS (Loss Of Signal). Use the left and right arrow keys to move the cursor over the choice and the enter key to execute the choice. Leaving the field will activate the last choice selected by cursor position. Therefore, it is suggested that the left and right arrow keys are used to position the cursor over the word OFF before using the up and down arrow keys to change fields.

For the firmware version listed on the title page, the following changes have been made:

Add: p. Payload Config

Add: x. Ext Sync Input

Add: ALL CHAN ERROR INJECT <SINGLE B2> to choices under SINGLE ERROR INJECT.

Add : B2 Rate to choices under ERROR RATE INJECT.

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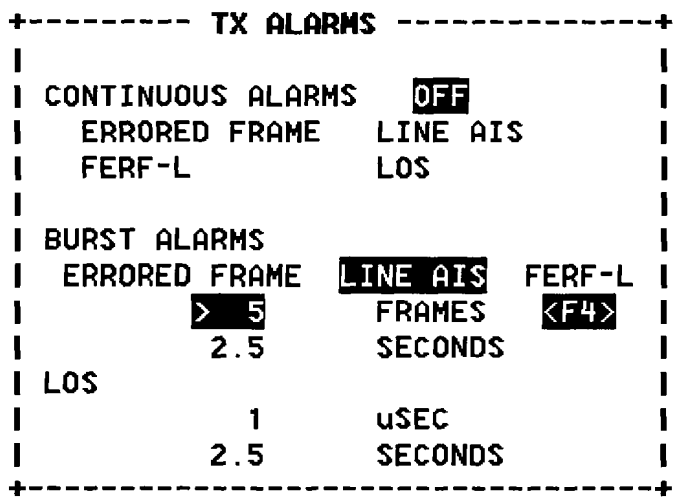


Figure 3-39. Virtual Front Panel Transmitter Alarm Generation

The next field, BURST ALARMS offers three choices: ERRORED FRAME, LINE AIS, and FERF-L (Far End Receive Failures-Line). They can be injected into the OC-48 signal for a number of frames (from 1 to 127), 5 in this example, or a number of seconds (from 0.1 to 9.9), by pressing the F4 function key. Whenever the F4 function key is active, it will appear on the Virtual Front Panel screen.

The LOS (Loss Of Signal) can be set to occur for a period of from 1 to 127 microseconds or from 0.1 to 9.9 seconds, when the F4 function key is pressed.

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Transmitter Overhead Bytes

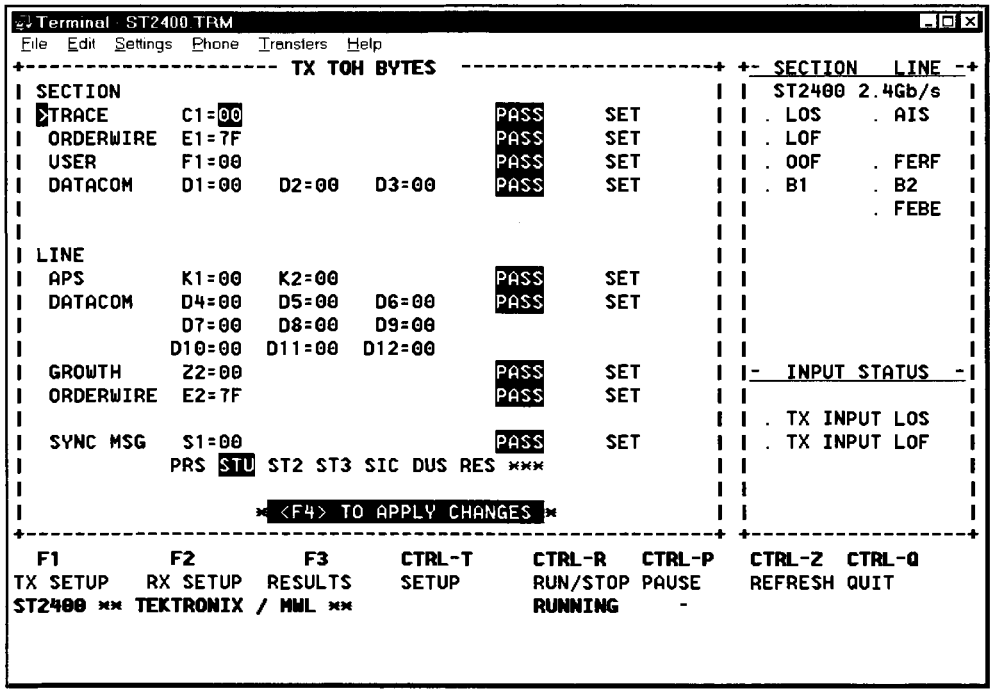


Figure 3-40. Virtual Front Panel Transmitter Overhead Bytes

The TX TOH BYTE (Transmitter Overhead Bytes) submenu *t* is used to display and change the current value of the section and line overhead bytes in the first STS-1 of the OC-48 signal. Use the up and down arrows to move between fields, use the left and right arrow keys to move within the field. The value of each byte can either be passed (PASS) without change or be changed (SET) to a new value. Function key F4 is used to apply all changes. When pressed, the *EXECUTED* message will be displayed at bottom of the screen.

TX TOH BYTE is an oversized submenu display, pressing the F1 function key will return to the default TX SETUP menu. Only the function and control keys displayed, along the bottom of the menu, are active.

Changes made to the overhead bytes are stored in memory. They can be remotely restored to their factory default values with the *tx_oh_def* command. Exit the Virtual Front Panel mode to use this, or any other, remote command.

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2.4 Gb/s Laser Control

⚠ WARNING!

Before activating the 2.4 Gb/s LASER its output must be connected to a circuit.

⚠ CAUTION!

Always use 15 dB of attenuation when connecting the ST2400 transmitter output to its receiver input. Failure to do so will damage the optical detector.

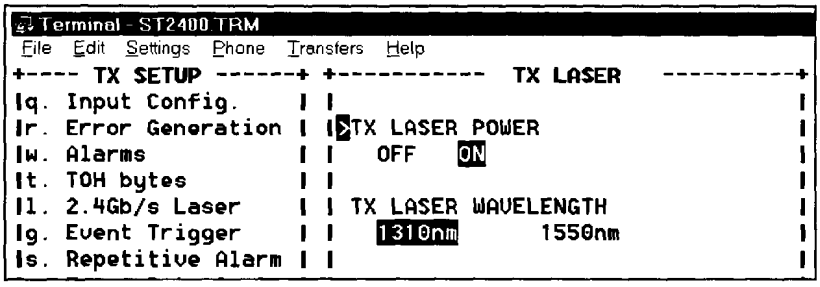


Figure 3-41. Virtual Front Panel 2.4 Gb/s Laser Control

Submenu *l* is used to control the transmitter 2.4 Gb/s laser output. It can be set to on or off. The laser can only be activated when the rear panel keylock is set to on. The Laser has a five second delay. The transmitter laser wavelength can also be switched between 1310nm and 1550nm, when using a dual mode unit. Use the arrow keys to position the reverse video cursor and the enter key to set the new value. *CTRL-T* or the *m* key can be used to display the current configuration.

For the firmware version listed on the title page, the following changes have been made:

Add: TX LASER RESUME ON POWER UP <OFF> ON at the bottom of the area labeled TX LASER.

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Event Trigger Control

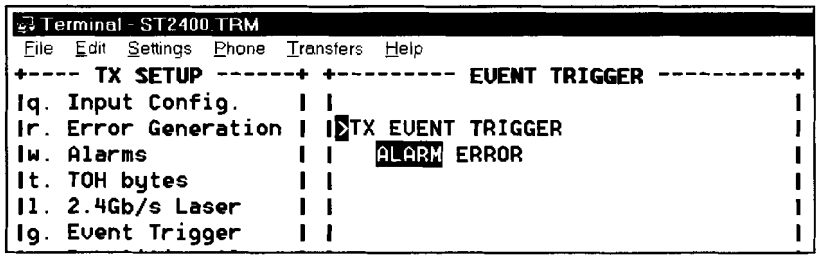


Figure 3-42. Virtual Front Panel Event Trigger Control

Menu *g*, the Event Trigger can be generated by any one of the following programmed alarm or error conditions: AIS, RDI/FERF, LOS, and FRAME ERRORS, including LOF. The Virtual Front Panel shown above, is used to choose whether a preset alarm or a preset error condition will be used to generate the trigger pulse from the rear panel connector. The event trigger has a rear panel TTL output signal of 2.4 Vpeak minimum, with a pulse width of 25 ns ±10%, and it leads the event by less than 1µs.

Repetitive Alarm Selection

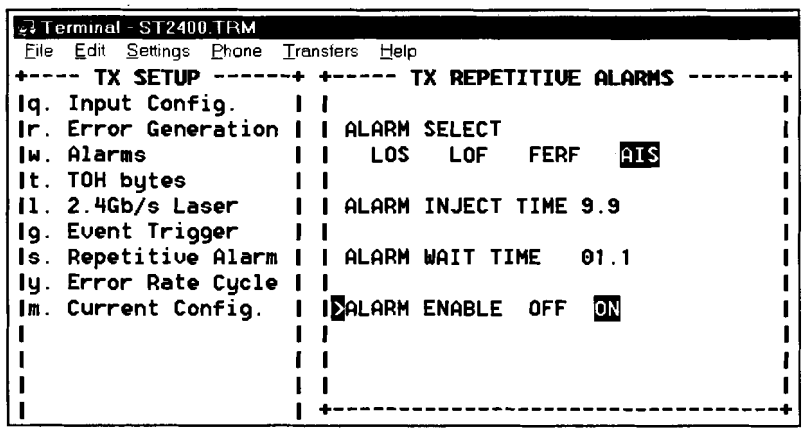


Figure 3-43. Virtual Front Panel Repetitive Alarm Selection Display

The TX REPETITIVE ALARMS submenu *s* permits recurring alarm conditions to be set. Use the up and down arrow keys to move between fields, the left and right arrows to move within a field. The ALARM SELECT field is used to select one of four alarms: LOS, LOF, FERF, or AIS. Moving the cursor over the alarm and leaving the field will set it. The ALARM INJECT TIME (on time) can be set from 0.1 to 9.9 seconds. The ALARM WAIT TIME (off time) can be set from 1.0 to 30.0 seconds.

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Once the variables are selected, move to the ALARM ENABLE field and position the cursor over the ON switch. Use the enter key to activate the alarm. Move the cursor over the OFF switch and press the enter key.

As in other variables, leaving the field will also set the variable. If the cursor is over the ON switch when the menu is changed, pressing the F2 key for example, the repetitive alarm will be activated. Both the F1 and the *s* key would need to be pressed to return to this menu and switch it off.

Only one alarm condition can be activated at any one time. Enabling any repetitive alarm will disable any other active alarm.

Repetitive Errors

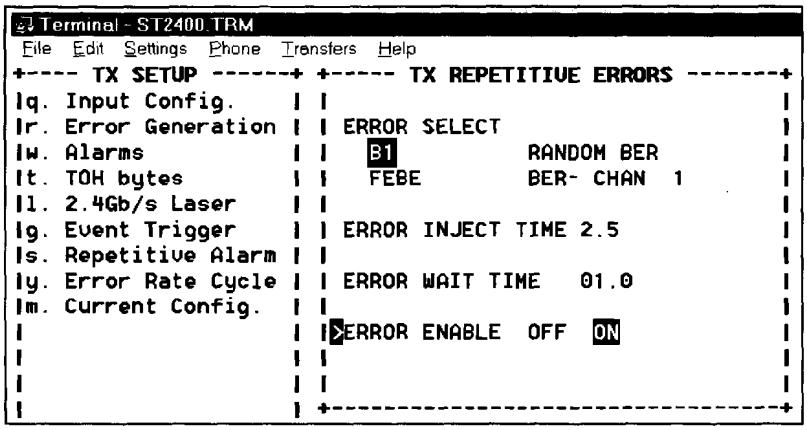


Figure 3-44. Virtual Front Panel Repetitive Error Selection Display

The TX REPETITIVE ERRORS submenu *y* permits recurring error conditions to be set. Use the up and down arrow keys to move between fields, the left and right arrows to move within a field. The ERROR SELECT field is used to choose between four error types: B1, B2, FEBE, RANDOM BER, or BER- CHAN n. The channel is set in submenu *r*, Error Generation.

The ERROR INJECT TIME (on time) can be set from 0.1 to 9.9 seconds. The ERROR WAIT TIME (off time) can be set from 1.0 to 30.0 seconds. The error rate is set in submenu *r*, Error Generation. Only one error condition can be activated at any one time.

Once the variables are selected, move to the ERROR ENABLE field and position the cursor over the ON switch. Use the enter key to activate the alarm. Move the cursor over the OFF switch and press the enter key.

As with other variables, leaving the field will also set the variable. If the cursor is over the ON switch when the menu is changed, pressing the F2 key for example, the repetitive alarm will be activated. Both the F1 and the *s* key would need to be pressed to return to this menu and switch it off.

NOTE: Bit Error Rates are inserted as a negative exponent. An error rate of 1.0E-6 would equate to the decimal number derived from sending one errored bit in a million bits. In other words, one divided by one million would equal 0.000001 or 1.0E-6 decimal.

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Appendices

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Specifications, SONET

General Specifications

Temperature Ranges

Operating Temperature: 0 to 40 degrees Centigrade

Storage Temperature: 0 to 60 degrees Centigrade

Dimensions and Weight

Approximately 4.5" (11.6 cm) H x 14.5" (37.2 cm) W x 17.5" (44.9 cm) D

The weight is 25 pounds (11.4 kilograms) maximum.

Power

Voltage Requirements: auto-ranging 110 (90 to 135) VAC or
220 (180 to 270) VAC, 47-63 Hz

Power Consumption: 250 watts maximum

Safety Certification Compliance

Category	Standard
Temperature (operating)	+5 to +35°C
Altitude (maximum operating)	2000 meters
Equipment Type	Test and Measuring
Safety Class	Class I (as defined in IEC 1010-1, Annex H) - grounded product
Overvoltage Category	Overvoltage Category II (as defined in IEC 1010-1, Annex J)
Pollution Degree	Pollution Degree 2 (as defined in IEC 1010-1). Note - Rated for indoor use only.

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Safety Standards

Category	Standard
U.S. Nationally Recognized Testing Laboratory Testing (NRTL)	UL 1244 - Electrical and Electronic Measuring and Testing Equipment
Canadian Certification	CAN/CSA-22.2 No. 231 CSA Safety Requirements for Electronically and Electronic Measuring and Testing Equipment

Transmitter (Generator) Specifications

155 Mb/s Source Modes

These modes are valid for the optical or CMI inputs.

155 All (Replicate) Mode

Data: 2.488 Gb/s output is made from 16 copies of the incoming 155 Mb/s data.

155 Single Channel Mode

Data: 2.488 Gb/s output is made from 1 copy of the incoming 155 Mb/s data in a user selected channel. The remaining 15 channels are filled with an unequipped pattern.

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622 Mb/s Source Modes

These modes are valid for the optical input.

622 All (Replicate) Mode

Data: 2.488 Gb/s output is made from 4 copies of the 622 Mb/s incoming data.

622 Single Channel Mode

Data: 2.488 Gb/s output is made from 1 copy of the incoming 622 Mb/s data in a user selected channel. The remaining 3 channels are filled with an "unequipped" pattern.

Internal Mode

This mode requires no external test equipment to generate a valid 2.488 Gb/s output.

- Data: 2.488 Gb/s output is made with an "unequipped" pattern.
- Default Overhead: A1 and A2 are set to (hexadecimal) F6H and 28H, respectively; the J0 bytes are numbered from 1 to 48; H1 and H2 bytes are set to 60H in a SONET network; B1 contains B1 BIP and B2 contains B2 BIP; all other overhead bytes and the payload are equal 00H.

THRU (Through) Mode

This mode is only usable when the receiver is framed to a valid 2.488 Gb/s SDH/SONET signal.

- Data: 2.488 Gb/s output is copied from the incoming 2.488 Gb/s signal
- Default Overhead: Copied from the incoming 2.488 Gb/s signal

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Overhead Manipulation Specifications

The SOH and LOH are constructed as follows:

Overhead bytes are copied from the multiplexed tributary. In the *All* mode copies are used to fill the entire OC-48 overhead, in the *Single* mode one copy is sent to the selected channel and the remaining channels are filled with the Unequipped channel overhead. In the Internal mode all channels are filled with the Unequipped channel overhead. In through mode the overhead is copied from the in coming OC-48. The J0 bytes are numbered 1 to 48, the first STS-1 of the OC-48 signal overhead bytes can be edited by the user (see below), error injection can be added, and finally B1 and B2 parity bytes are calculated.

Overhead byte editing.

The following bytes of the first STS-1 of the OC-48 frame can be edited and selected individually or as a group.

J0, E1, F1, D1-D3 (group selected), K1, K2, D4-D12 (group selected), S1, Z2, E2

These bytes of the first STS-1 of the OC-48 frame CANNOT be edited: A1, A2, B1, H1-H3, B2.

Overhead Bytes Generated by the ST2400:

BYTE Description:

J0 STS 1 Channels are numbered 1 to 48.

B2 STS channels 1 and 3 only , with calculated Line BIP-8 parity.

B1 STS channel 1 only with calculated Section BIP-8 parity.

Unequipped channel Overhead content:

Default Overhead: A1 and A2 are set to hexadecimal F6H and 28H, respectively; the J0 bytes are numbered from 1 to 48; the H1 and H2 bytes are set to 60H in a SONET network; B1 equals B1 BIP and B2 equals B2 BIP; all other overhead bytes and the payload are equal 00H.

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Error Injection

Error Rates: All error rates, except B1 and B2, can be selected in the form X. Y e-Z. The rates range from 1.0e–3 to 0.1e–9.

B1 or B2 Section single error or error rate is generated by inverting a random bit in the byte. The B1 rate ranges from 2.5e–5 to 0.1e–9. The B2 rate ranges from 1.0E-4 to 0.1E-9.

Selected Channel: Single error or error rate, caused by inverting a random bit in a specific STS-1/STM-1 of the 2.488 Gb/s signal.

All channels: Single error or error rate, caused by inverting a random bit in the 2.488 Gb/s signal.

L-FEBE: The STS channel 3 Z2 byte is overwritten to convey the error count.

Alarm Generation

LOS: 2.488 Gb/s output is forced to all zeros for a user selected time, from 1 to 127 microseconds with a resolution of 1 microseconds, or 0.1 to 9.9 seconds.

LOF, OOF: All of the A1 and A2 bytes of the 2.488 Gb/s output are inverted for a user selected time. The time is selected in frames, up to 127 or continuous, or 0.1-9.9 seconds.

L-AIS: The LOH and the entire SPE are set to all ones for a user selected time. The time is selected in frames, up to 127, or 0.1 to 9.9 seconds, or continuous.

L-FERF: The '110' code is set in the three least significant bits of the K2 byte for a user selected time. The time is selected in frames, up to 127, or 0.1 to 9.9 seconds, or continuous.

Source Monitoring

The SONET inputs to the generator section are monitored to ensure valid signals for multiplexing and timing generation.

LOS: Detects the Loss of Signal alarm by monitoring the inputs for activity.

LOF: Detects the Loss of Frame alarm by monitoring an OOF condition for 3 ms.

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Receiver (Analyzer) Specifications

Measurements

B1 Errors: The 2.488 Gb/s input is monitored for Section level errors by comparing the B1 byte to the calculated BIP-8 parity. The errors are detected and counted. They can be displayed as a total error count or an error rate in the form X. Y e –Z

B2 Errors: The 2.488 Gb/s input is monitored for Line level errors by comparing the 48 B2 bytes to the calculated BIP-8 x 48 parity. The errors are detected and counted. They can be displayed as a total error count or an error rate in the form X.Y e –Z

Line FEBE: The 2.488 Gb/s input is monitored for Line level FEBE in the third M1. The FEBEs are detected and counted. They are displayed as a total error count.

Alarms Detection

LOS: 2.488 Gb/s input is monitored for the all zero condition. When the 2.4 Gb/s signal has been off for more than 2 microseconds the LOS condition is declared. The LOS alarm will assert no later than 127 microseconds after receiving the low signal (all zero) condition.

LOF, OOF: The last A1 byte and the first two A2 bytes (A1, A2, A2) of the 2.488 Gb/s input are monitored for errors. If 4 or more consecutive frames have errors OOF is declared and reframing is attempted. If OOF persists for more than 3 milliseconds LOF is declared.

AIS: The K2 byte is monitored for the occurrence of all ones in the three least significant bits.

- SONET: If it occurs in 5 consecutive frames Line AIS is declared.

FERF: The K2 byte is monitored for the occurrence of the '110' code in the three least significant bits.

- SONET: If it occurs in 5 consecutive frames Line FERF is declared.

Overhead Display

Approximately every 100 milliseconds each byte of the STS-1 Transport Overhead is extracted and displayed.

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APS Display

Approximately every 100 milliseconds the K1 and K2 bytes are extracted. The bytes are decoded, according to Bellcore GR-253-CORE, into the APS messages, modes and channels and displayed.

SONET/SDH Drop Modes

The analyzer drops a SONET/SDH signal at either 155 Mb/s or 622 Mb/s. A valid SONET/SDH signal is constructed from a fraction of the 2.488 Gb/s input data and overhead.

155 Drop Mode

Data: User selects 1 of the 16 channels in the 2.488 Gb/s input data to copy to the drop signal.

Overhead: B1, B2 recalculated by the ST2400.

H1, H2, H3, A1, A2, J0 are copied from the selected drop channels.

The remainder of the drop signal is copied from the first three STS-1 channels of the 2.488 Gb/s input.

Output: This mode is valid on the optical and electrical (CMI) outputs.

622 Drop Mode

Data: User selects 1 of the 4 channels in the 2.488 Gb/s input data to copy to the drop signal.

Overhead: B1, B2 are recalculated by the ST2400

H1, H2, H3, A1, A2, J0 are copied from the selected drop channels.

The first three STS-1 channels of the remainder of the drop signal are copied from the first three STS-1 channels of the 2.488 Gb/s input. The last nine STS-1 channels of the remainder are copied from the selected drop channel.

Output: This mode is valid only on the optical output

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Input and Output Specifications, Generator

Option #s since 11/96	Laser	Transmit or Transceiver	Specifications
12	1310	Transmit only	Type: DFB laser diode, Wavelength: 1310 ± 10 nm Average power: 3 dBm to –2 dBm minimum Spectral Width: 1 nm (0.3 nm typical) Extinction Ratio: 10 dB minimum Category: LR-1
13	1310	Transceiver	Type: DFB laser diode, Wavelength: 1310 ± 10 nm Average power: 3 dBm to –2 dBm minimum Spectral Width: 1 nm (0.3 nm typical) Extinction Ratio: 10 dB minimum Category: LR-1
14	1550	Transmit only	Type: DFB laser diode, Wavelength: 1550 ± 10 nm Average power: 3 dBm to –2 dBm minimum Spectral Width: 1 nm (0.3 nm typical), Extinction Ratio: 10 dB minimum Category: LR-2
15	1550	Transceiver	Type: DFB laser diode, Wavelength: 1550 ± 10 nm Average power: 3 dBm to –2 dBm minimum Spectral Width: 1 nm (0.3 nm typical), Extinction Ratio: 10 dB minimum Category: LR-2
16	1310/ 1550	Transmit only	Type: DFB laser diode, Wavelength: 1550 ± 10 nm Average power: 3 dBm to –2 dBm minimum Spectral Width: 1 nm (0.3 nm typical), Extinction Ratio: 10 dB minimum Category: LR-2 *and* Type: DFB laser diode, Wavelength: 1310 ± 10 nm Average power: 3 dBm to –2 dBm minimum Spectral Width: 1 nm (0.3 nm typical) Extinction Ratio: 10 dB minimum Category: LR-1
17	1310/ 1550	Transceiver	Type: DFB laser diode, Wavelength: 1550 ± 10 nm Average power: 3 dBm to –2 dBm minimum Spectral Width: 1 nm (0.3 nm typical), Extinction Ratio: 10 dB minimum Category: LR-2 *and* Type: DFB laser diode, Wavelength: 1310 ± 10 nm Average power: 3 dBm to –2 dBm minimum Spectral Width: 1 nm (0.3 nm typical) Extinction Ratio: 10 dB minimum Category: LR-1

See the following note on the next page:

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Note to previous table:

Older units may have 1310 lasers with the following specifications: Type: DFB laser diode, Wavelength: 1310 nm Typical (1280 nm -1335 nm) Average power: 3 dBm to –2 dBm minimum Spectral Width: 1 nm, Extinction Ratio: 10 dB minimum Category: IR-1
Older units may have 1550 lasers with the following specifications: Type: DFB laser diode, Wavelength: 1550 nm Typical (1480 nm -1580 nm) Average power: 3 dBm to –2 dBm minimum Spectral Width: 1 nm, Extinction Ratio: 10 dB minimum Category: IR-2

Signal Name: 2.488 Gb/s Output Data

Connector: FC/PC (standard), SC, or ST available

This output can be "locked out" for safety (as U.L. safety requirements specify) using the rear panel key switch or remote interlock.

Fiber Type: Single Mode

Description: Primary output to device under test

Signal Name: 155 Mb/s / 622 Mb/s Input Data

Connector: FC/PC (standard), SC, or ST available, Type: Optical

Wavelength: 1310 nm, Maximum Input: –8 dBm

Sensitivity: –28 dBm minimum

Category: IR-1

Fiber Type: Multi-Mode

Description: 155 or 622 Mb/s data input to multiplexer, intended for connection to supplemental test equipment.

Signal Name: 155 Mb/s Electrical Input

Connector: BNC - 75 Ω

Type: CMI per Bellcore GR-253-CORE and CCITT Rec. G.708, G.709

Description: 155 Mb/s electrical data input to multiplexer, intended for connection to supplemental test equipment.

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SYNC Output

SYNC Output (Clock Trigger) is an AC-coupled output. The voltage level is 500 mV peak-to-peak minimum. This output needs a 50-Ohm termination to work properly. This output is used to trigger a oscilloscope to measure the eye diagram of an OC-48/STM-16 signal.

Frame Sync:

Connector: BNC - 50 Ω Type: ECL with internal pull-down, series 50 ohm.

Description: Derived from generator, pulse width of 16 bits .

Event trigger:

Connector: BNC - 50 Ω Type: TTL

Description: Active during LOS, LOF, AIS, FERF, Error Inject, or TOH byte edit.

Input and Output Specifications Analyzer

Signal Name: 2.488 Gb/s Input Data

Connector: FC/PC (standard), ST, or SC available

Type: InGaAs APD optical receiver

Wavelength: 1310 / 1550 nm

Maximum Input: –10 dBm (damage may result)

Sensitivity: –29 dBm minimum @ 10^{-10} BER

Category: LR-2

Fiber Type: Single Mode

Description: Primary input from device under test

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Signal Name: 155 Mb/s / 622 Mb/s Output Data

Connector: FC/PC (standard), ST, or SC available

Type: Optical

Wavelength: Wavelength: 1310 nm (1273 to 1355 nm)

Average Power: –15 dBm minimum

Maximum Average Power: –8 dBm

Category: IR-1

Fiber Type: Single Mode

Description: 155 or 622 Mb/s data output from demultiplexer, intended for connection to supplemental test equipment.

Signal Name: 155 Mb/s Electrical Output

Connector: BNC - 75 Ω

Type: CMI per Bellcore GR-253-CORE and CCITT Rec. G.708, G.709

Description: 155 Mb/s electrical data output from demultiplexer, intended for connection to supplemental test equipment.

GPIB I/O

Connector, signal level, and protocol per IEEE 488.2

Description: Byte serial industry standard instrument interface, used for remote or automated control of the ST2400.

Serial I/O

RS232C Connector, signal level and protocol per ANSI RS-232C

Description: Bit serial industry standard interface, used for remote control and software download of the ST2400. External null modem not required.

ST112-RS232C Connector, signal level and protocol per ANSI RS-232C

Description: Bit serial interface, used for directly connecting to an ST112 for combined mode operation. External null modem is not required.

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Printer Output

Connector: DB-25, Signal: TTL

Description: Byte serial ASCII printer interface. Follows industry standard DB-25 translation of Centronics interface

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Synchronization Specifications

Generator Timing

The 2.488 Gb/s output can derive synchronization from three different sources. These sources are only valid in the indicated modes.

External Timing:

The output timing is obtained by phase lock loop (PLL) multiplying the clock recovered from the source 155/622 Mb/s SONET/SDH signal. This timing mode is valid if the generator is in EXT (external) mode. To obtain loop timing in these modes the supplemental test equipment providing Path and payload testing must be set to loop timing. This is the only generator timing mode valid with external lower rate test equipment.

Source Frequency Range: 155.52 Mb/s ±100 ppm or 622.08 Mb/s ± 100 ppm

Loop Timing (THRU Mode):

The output timing is obtained from the 2.488 Gb/s SONET/SDH signal input to the analyzer. The clock recovered from this input generates the output signal.

Source Frequency Range: 2.48832 Gb/s ±20 ppm.

Internal Timing:

The output timing is obtained from an internal clock source. This timing mode can be used if the generator is in internal mode operating stand-alone.

Output Frequency Accuracy: 2.48832 Gb/s ±20 ppm.

Output Jitter: Meets Bellcore GR-253-CORE and ITU G.783, G.81S

Analyzer Timing

Analyzer Clock Recovery

Input Frequency Range: 2.48832 Gb/s ±20 ppm.

Input Jitter Tolerance: Meets Bellcore GR-253-CORE and ITU G.783, G.81S

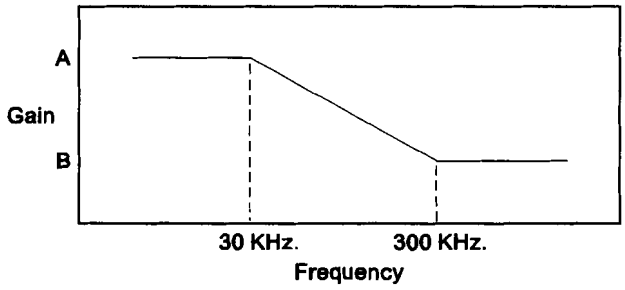
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155/622 Mb/s Output Timing

Derived by dividing the clock recovered from the Analyzer 2.488 Gb/s input.

Jitter Transfer

ST2400 Jitter Transfer is a function of the clock recovery, clock multiply, and/or clock divide function in the Transmitter or Receiver. The Transmitter recovers clock from the 155 MHz or 622 MHz inputs, then multiplies them up to 2.488 GHz. In THRU Mode, the Transmitter gets a 78 MHz clock from the Receiver and multiplies that to 2.488 GHz. The Receiver divides its input 2.488 GHz clock to 155 MHz or 622 MHz for the tributary drop rates, or to 78 MHz for the Transmitter in THRU Mode. The resulting maximum peak-peak Jitter Gain is shown in the tables and diagram below.



SONET Jitter Transfer	A	B
OC-3 input to OC-48 Tx output	25db	10db
CMI input to OC-48 Tx output	25db	10db
OC-12 input to OC-48 Tx output	15db	–5db
OC-48 Rx input to OC-48 Tx output	.3db	.3db
OC-48 Rx input to OC-3 output	–24db	–24db
OC-48 Rx input to CMI output	–24db	–24db
OC-48 Rx input to OC-12 output	–12db	–12db

SDH Jitter Transfer	A	B
STM-1 input to STM-16 Tx output	25db	10db
CMI input to STM-16 Tx output	25db	10db
STM-4 input to STM-16 Tx output	15db	–5db
STM-16 Rx input to STM-16 Tx output	.3db	.3db
STM-16 Rx input to STM-1 output	–24db	–24db
STM-16 Rx input to CMI output	–24db	–24db
STM-16 Rx input to STM-4 output	–12db	–12db

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Appendix B

Incoming Inspection Test

The purpose of this procedure is to verify that the ST2400 Transceiver received from Tektronix is operational upon arrival. This procedure briefly verifies that the general functionality of the unit responds correctly. The incoming inspection is divided into separate tests for SDH and SONET.

Required Equipment

The following equipment is required to verify that the ST2400 Transceiver is functioning properly.

- Fiber Optical Cable - must be a single mode cable and have connectors matching those on the unit under test
- In-line 15db optical attenuator
- Optical cleaning kit *(Note: See last section of instructions for contents)*

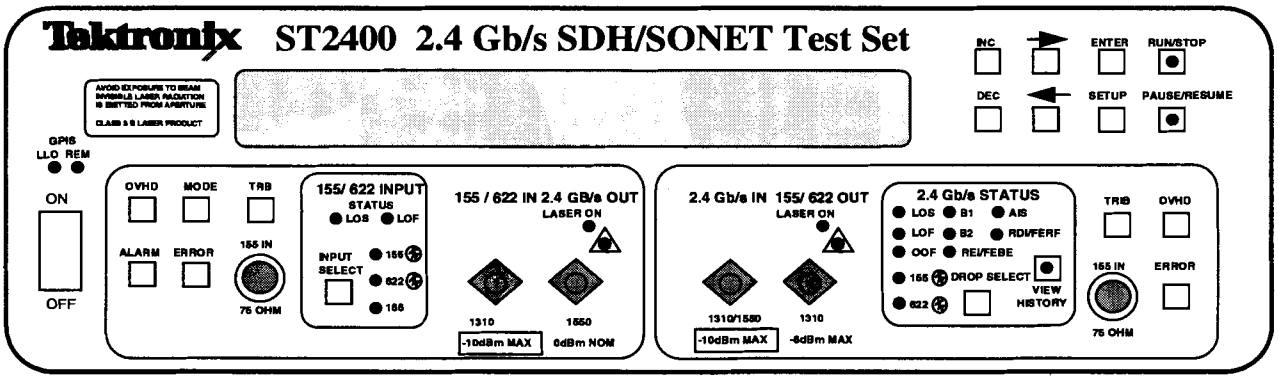


Figure B-1. ST2400 front panel - Transmitter (left-side) and Receiver (right-side)

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General Functionality Verification

This section of the User Manual tests the functionality of the unit. The procedure consists of eleven sections in which the functionality of the unit is verified. *Note: The procedure assumes you are proceeding in sequential order.* Before beginning the procedure, you must set the unit to factory default settings to ensure that you are starting the procedure from a known state. To default the unit to its factory settings, follow the procedure below.

1. On the front panel, press SETUP until the display shows the STORE/RECALL Setup menu.
2. Using the LEFT/RIGHT cursors, select FACTORY DEFAULT and then press ENTER. *Note: Whenever you make a change in a menu, the red LED within the ENTER key will flash. This signifies that if you wish that change to occur, you must save it by pressing ENTER.*
3. The display now reads "Restore Factory Default?". Using the LEFT/RIGHT cursors, select YES and press ENTER. The display flashes a message stating that all settings have been returned to factory defaults, then it returns to the STORE/RECALL Setup menu.
4. Once the factory default settings have been restored, observe that all the error lights within the 2.4 Gb/s STATUS section of the receiver front panel are lit. This is because the default settings set the laser to OFF, so the unit is no longer linked.

Now that the unit has been correctly defaulted, you may continue with the next section of the procedure.

STM-16 (SDH) Quick Setup

This section of the procedure verifies that the SDH mode for STM-16 is functioning properly. The quick setup places the unit into a default mode which selects specific settings for the unit. These default settings are preprogrammed and therefore consistent from unit to unit. Leave everything as it was in the last section of the procedure. There are nine steps in this section of the procedure. Before any connections are made, use the optical cleaning kit to clean the cable ends, the attenuator ends, and the optical connectors on the front panel of the unit. *Note: The last section of the procedure provides an equipment list and simple instructions on how to clean the optical connectors.*

1. On the front panel, remove protective covers from the 2.4Gb/s IN and OUT connectors.
2. Connect a fiber-optic cable with an in-line 15db attenuator between transmitter side (left side) 2.4Gb/s OUT to receiver side (right side) 2.4Gb/s IN.
3. On the front panel, press SETUP until the display shows the Auxiliary Setup menu and press ENTER.
4. On the front panel, press SETUP until the display shows the System Configuration menu.
5. Using the LEFT/RIGHT cursors, select SDH and then press ENTER. The display then flashes a message stating that the measurement mode has changed and to cycle power to enable. *Note: Whenever the measurement mode is changed, power must be cycled for the change to be enabled.*
6. Cycle the power of the unit (i.e., turn the unit off and then on). The unit is now in SDH mode.

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7. On the front panel, press SETUP until the display shows the 2.4 Gb/s LASER (1310nm) menu.
8. Using the LEFT/RIGHT cursors, select ON and then press ENTER. *Note: On the transmitter side of the front panel, the red LED under LASER ON is now lit. Refer to Figure 1 below to identity the transmitter and receiver side of the front panel.*
9. The transmitter and receiver sides should now be linked error-free. *Note: Error-free means that you see no lit LEDs in the 2.4Gb/s STATUS section on the receiver side of the front panel.*

***Note:** If you have software versions of revision 2.2 or older, you may see a solid B2 error light. If so, simply cycle the power (turn the power off and on again). This should clear the error light. If the B2 error light persists, please contact Tektronix Customer Sales and Support Center (CSSC) at 1-800-835-9433 x2400 or 503-627-2400 for assistance.*

Parity and Random Errors (SDH)

At this point, you have determined that the unit links error-free. The next step is to inject some errors and verity that the unit responds correctly. This section is split into two parts: Single Error Inject Test and Error Rate Inject Test. Leave the setup as it was in the last section.

Single Error Inject Test

In this part, the transmitter injects single errors into the receiver and verifies the responses of the receiver. There are twenty-one steps in this section of the procedure.

1. On the transmitter side of the front panel, press ERROR until the display shows the Single Error Inject menu.
2. On the front panel, press RUN/STOP once. Observe that the green LED inside the button is now lit.

   Note: The unit is now in RUN mode. If the green LED within the switch is not lit, then the RUN mode is not active and no errors will be counted (i.e. a STOP condition exists).
3. Using the LEFT/RIGHT cursors, select B1 and then press ENTER twice.
4. In the 2.4Gb/s STATUS section, observe that error light for B1 flashes twice. Press HISTORY VIEW. Observe that the red LED for B1 flashes again.

   Note: HISTORY VIEW reflects the past history or the last series of error conditions that existed. Putting the unit in STOP mode and then returning it to RUN mode clears all past history.
5. On the receiver side of the front panel, press ERROR until the display shows B1 on the bottom left corner. Observe that BBE and EB are both equal to two.
6. On the transmitter side of the front panel, press ERROR until the display shows the Single Error Inject menu.
7. Using the LEFT/RIGHT cursors, select BIT and then press ENTER twice.
8. In the 2.4Gb/s STATUS section, observe that the error lights for B1 and B2 flash twice.

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9. On the receiver side of the front panel, press ERROR until the display shows B1 on the bottom left corner. Observe that BBE and EB are both equal to four.
10. On the receiver side of the front panel, press ERROR until the display shows B2 on the bottom left corner. Observe that BBE and EB are both equal to two.
11. On the transmitter side of the front panel, press ERROR until the display shows the Single Error Inject menu.
12. Using the LEFT/RIGHT cursors, select MS-REI and then press ENTER twice.
13. In the 2.4Gb/s STATUS section, observe that the error light for REI/FEBE flashes twice.
14. On the receiver side of the front panel, press ERROR until the display shows REI on the bottom left corner. Observe that BBE and EB are both equal to two.
15. On the receiver side of the front panel, press ERROR until the display shows RS-B1, MS-B2, and MS-REI across the top line. Observe that RS-B1 is equal to four. Also, observe that both MS-B2 and MS-REI are equal to two.
16. On the front panel, press RUN/STOP twice. Observe that the errors have now been reset to zero.

    Note: Whenever errors are being cleared, verify that you are still in RUN mode after the errors are cleared.
17. On the transmitter side of the front panel, press ERROR until the display shows the Single Error Inject menu.
18. Using the LEFT/RIGHT cursors, select CHAN 1 and then press ENTER twice.
19. In the 2.4Gb/s STATUS section, observe that the error lights for B1 and B2 flash twice.
20. On the receiver side of the front panel, press ERROR until the display shows RS-B1, MS-B2, and MS-REI across the top line. Observe that MS-REI is equal to zero. Also, observe that both RS-B1 and MS-B2 are equal to two.
21. On the front panel, press RUN/STOP twice to clear all errors.

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Error Rate Inject Test

In this part, the transmitter injects an error rate into the receiver and verify the receiver's responses. There are eighteen steps in this section of the procedure.

1. On the transmitter side of the front panel, press ERROR until the display shows the Random BER Inject menu.
2. Using the LEFT/RIGHT cursors, select 1.0E-3 and then press ENTER.
3. In the 2.4Gb/s STATUS section, observe that the error lights for B1, B2, and REI/FEBE remain lit. You have now injected an error rate into the receiver.
4. On the receiver side of the front panel, press ERROR until the display shows RS-B1, MS-B2, and MS-REI across the top line. Observe that all of them have increasing error rates.

   On the front panel, press PAUSE/RESUME once. *Note: The red LED within the switch should be lit.*
5. On the display, observe that the error rates are no longer increasing, but are fixed at one value. Also, in the 2.4Gb/s STATUS section, observe that the error lights for B1, B2, and REI/FEBE remain lit.

   Note: When the red LED within the PAUSE/RESUME switch is lit, the unit is in PAUSE mode and will freeze all error conditions. When the red LED is within the PAUSE/RESUME switch is turned off, the unit will RESUME normal functioning.
6. On the display, press PAUSE/RESUME once. *Note: The red LED within the switch is no longer lit.*
7. On the display, observe that the error rates are once again increasing. Also, in the 2.4Gb/s STATUS section, observe that the error lights for B1, B2, and REI/FEBE still remain lit.
8. On the transmitter side of the front panel, press ERROR until the display shows the Random BER Inject menu.
9. Using the LEFT/RIGHT cursors, select OFF and then press ENTER.
10. In the 2.4Gb/s STATUS section, observe that the error lights for B1, B2, and REI/FEBE are now off.
11. On the receiver side of the front panel, press ERROR until the display shows RS-B1, MS-B2, and MS-REI across the top line. Observe that all of the errors have stopped increasing.
12. On the front panel, press RUN/STOP twice to clear all errors.
13. On the transmitter side of the front panel, press ERROR until the display shows the MS-REI Inject menu.
14. Using the LEFT/RIGHT cursors, select 1/FRAME, position the cursor directly to the left of the one.
15. Using the INC/DEC keys and the LEFT/RIGHT cursors, make the selection 10/FRAME and then press ENTER.
16. In the 2.4Gb/s STATUS section, observe that the error light for REI/FEBE flashes once.
17. On the receiver side of the front panel, press ERROR until the display shows RS-B1, MS-B2, and MS-REI across the top line. Observe that the MS-REI error equals ten.
18. On the front panel, press RUN/STOP twice to clear all errors.

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Transport Overhead/Path Overhead (SDH)

This section of the procedure ensures that the editing function is working accurately. Leave the setup as it was in the last section. There are twenty-seven steps in this section of the procedure.

1. On the transmitter side of the front panel, press OVHD until the display shows J0 on the top right side.
2. Using the LEFT/RIGHT cursors, select SET.
3. Using the INC/DEC keys, change J0 to 51 and then press ENTER.
4. On the receiver side of the front panel, press OVHD until the display shows A1, A2, and J0 on the top right side.
5. On the display, observe that J0 equals 51.
6. On the transmitter side of the front panel, press OVHD until the display shows J0 on the top right side.
7. Using the LEFT/RIGHT cursors, select PASS and then press ENTER.
8. On the receiver side of the front panel, press OVHD until the display shows A1, A2, and J0 on the top right side.
9. On the display, observe that J0 equals 01.
10. On the transmitter side of the front panel, press OVHD until the display shows D7, D8, and D9 on the top right side.
11. Using the LEFT/RIGHT cursors, select SET and select D7.
12. Using the INC/DEC keys and the LEFT/RIGHT cursors, change D7 to AA.
13. Using the LEFT/RIGHT cursors, select D8.
14. Using the INC/DEC keys and the LEFT/RIGHT cursors, change D8 to 11.
15. Using the LEFT/RIGHT cursors, select D9.
16. Using the INC/DEC keys and the LEFT/RIGHT cursors, change D9 to 05 and then press ENTER.
17. On the receiver side of the front panel, press OVHD until the display shows D7, D8, and D9 on the top right side.
18. On the display, observe that D7, D8, and D9 all reflect the values you placed into the transmitter (i.e. D7 = AA, D8 = 11, and D9 = 05).
19. On the transmitter side of the front panel, press OVHD until the display shows D7, D8, and D9 on the top right side.
20. Using the LEFT/RIGHT cursors, select SET and select D7.
21. Using the INC/DEC keys and the LEFT/RIGHT cursors, change D7 to 00.
22. Using the LEFT/RIGHT cursors, select D8.
23. Using the INC/DEC keys and the LEFT/RIGHT cursors, change D8 to 00.
24. Using the LEFT/RIGHT cursors, select D9.
25. Using the INC/DEC keys and the LEFT/RIGHT cursors, change D9 to 00 and then press ENTER.

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26. On the receiver side of the front panel, press OVHD until the display shows D7, D8, and D9 on the top right side.
27. On the display, observe that the values of D7, D8, and D9 are once again zero.

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Continuous Alarms (SDH)

This section of the procedure ensures that the continuous alarm settings are functioning properly. There are five parts, each part checking a different alarm. Leave the setup as it was in the last section.

Loss of Signal Alarm

In this part, the transmitter creates a loss of signal alarm and you verify the responses of the receiver. There are eight steps in this section of the procedure.

1. On the transmitter side of the front panel, press ALARM until the display shows the Loss of Signal menu.
2. Using the LEFT/RIGHT cursors, select 2.5SEC.
3. Using the INC key, increase the time until it switches to CONT and then press ENTER.
4. On the display, observe that the top right corner now says "*ACTIVE".

   Note: The red LED within the ALARM switch is now lit. Whenever an alarm is active, this LED will turn on.
5. In the 2.4Gb/s STATUS section, observe that all of the error lights are now lit.
6. Using the LEFT/RIGHT cursors, select OFF and then press ENTER.
7. In the 2.4Gb/s STATUS section, observe that all of the error lights are now off.
8. On the front panel, press RUN/STOP twice to clear all errors.

Errored Frame Alarm

In this part, the transmitter creates an errored frame alarm and you verify the responses of the receiver. There are eight steps in this section of the procedure.

1. On the transmitter side of the front panel, press ALARM until the display shows the Errored Frame menu.
2. Using the LEFT/RIGHT cursors, select 2.5SEC.
3. Using the INC key, increase the time until it switches to CONT and then press ENTER.
4. On the display, observe that the top right corner now says "*ACTIVE".
5. In the 2.4Gb/s STATUS section, observe that the error lights for LOF, OOF, B1, B2, REI/FEBE, AIS, and RDI/FERF are now lit.
6. Using the LEFT/RIGHT cursors, select OFF and then press ENTER.
7. In the 2.4Gb/s STATUS section, observe that all of the error lights are now off.

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8. On the front panel, press RUN/STOP twice to clear all errors.

RDI Alarm

In this part, the transmitter creates an RDI alarm and you verify the responses of the receiver. There are eight steps in this section of the procedure.

1. On the transmitter side of the front panel, press ALARM until the display shows the MS-RDI menu.
2. Using the LEFT/RIGHT cursors, select 2.5SEC.
3. Using the INC key, increase the time until it switches to CONT and then press ENTER.
4. On the display, observe that the top right corner now says "*ACTIVE".
5. In the 2.4Gb/s STATUS section, observe that the error light for RDI/FERF is now lit.
6. Using the LEFT/RIGHT cursors, select OFF and then press ENTER.
7. In the 2.4Gb/s STATUS section, observe that the error light for RDI/FERF is now off.
8. On the front panel, press RUN/STOP twice to clear all errors.

AIS Alarm

In this part, the transmitter creates an AIS alarm and you verify the responses of the receiver. There are eleven steps in this section of the procedure.

1. On the transmitter side of the front panel, press ALARM until the display shows the MS-AIS menu.
2. Using the LEFT/RIGHT cursors, select 2.5SEC.
3. Using the INC key, increase the time until it switches to CONT and then press ENTER.
4. On the display, observe that the top right corner now says "*ACTIVE".
5. In the 2.4Gb/s STATUS section, observe that the error lights for REI/FEBE and AIS are now lit.
6. On the receiver side of the front panel, press ERROR until the display shows RS-B1, MS-B2, and MS-REI across the top line.
7. On the display, observe that MS-B2 has an error reading and MS-REI is actively counting errors.
8. On the transmitter side of the front panel, press ALARM until the display shows the MS-AIS menu.
9. Using the LEFT/RIGHT cursors, select OFF and then press ENTER.
10. In the 2.4Gb/s STATUS section, observe that the error lights for REI/FEBE and AIS are now off.
11. On the front panel, press RUN/STOP twice to clear all errors.

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Inject LOS Alarm

In this part, the transmitter injects a loss of signal alarm and you verify the responses of the receiver. There are eight steps in this section of the procedure.

1. On the transmitter side of the front panel, press ALARM until the display shows the Inject LOS menu.
2. Using the LEFT/RIGHT cursors, select ENABLE and then press ENTER.
3. On the display, observe that the "s" and the "*" after "2.5" on the right side of the display change places.
5. In the 2.4Gb/s STATUS section, observe that all of the error lights flash on and off continuously.
6. Using the LEFT/RIGHT cursors, select OFF and then press ENTER.
7. In the 2.4Gb/s STATUS section, observe that all of the error lights now remain off.
8. On the front panel, press RUN/STOP twice to clear all errors.

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OC48 (SONET) Quick Setup

This section of the procedure verifies that the SONET mode for OC48 is functioning properly. The quick setup places the unit into a default mode which selects specific settings for the unit. These default settings are preprogrammed and therefore consistent from unit to unit. Leave the setup as it was in the last section. There are seven steps in this section of the procedure.

1. On the front panel, press SETUP until the display shows the Auxiliary Setup menu. Press ENTER.
2. On the front panel, press SETUP until the display shows the System Configuration menu.
3. Using the LEFT/RIGHT cursors, select SONET and then press ENTER. The display then shows a message stating that the measurement mode has changed and to cycle power to enable.
4. Cycle the unit power (i.e., turn the unit off and than back on). The unit is now in SONET mode.
5. On the front panel, press SETUP until the display shows the 2.4Gb/s LASER menu.
6. Using the LEFT/RIGHT cursors, select ON and then press ENTER.
7. The transmitter and the receiver sides should now be linked error-free.

Parity and Random Errors (SONET)

At this point, you have determined that the unit links error-free. The next step is to inject some errors and verify that the unit responds correctly. This section is split into two parts: Single Error Inject Test and Error Rate Inject Test. Leave the setup as it was in the last section.

Single Error Inject Test

In this part, the transmitter injects single errors into the receiver and verifies the responses of the receiver. There are twenty steps in this section of the procedure.

1. On the transmitter side of the front panel, press ERROR until the display shows the Single Error Inject menu.
2. On the front panel, verify that the RUN mode is active.
3. Using the LEFT/RIGHT cursors, select B1 and then press ENTER twice.
4. In the 2.4Gb/s STATUS section, observe that error light for B1 flashes twice.
5. On the receiver side of the front panel, press ERROR until the display shows B1 on the bottom left corner. Observe that TOT is equal to two. Also, observe that the value of SECT ES is equal to, or less than, two.
6. On the transmitter side of the front panel, press ERROR until the display shows the Single Error Inject menu.
7. Using the LEFT/RIGHT cursors, select BIT and then press ENTER twice.

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8. In the 2.4Gb/s STATUS section, observe that the error lights for B1 and B2 flash twice.
9. On the receiver side of the front panel, press ERROR until the display shows B1 on the bottom left corner. Observe that TOT is equal to four. Also, observe that the value of SECT ES is equal to, or less than, four.
10. On the receiver side of the front panel, press ERROR until the display shows B2 on the bottom left corner. Observe that TOT is equal to two. Also, observe that the value of LINE ES is equal to, or less than, two.
11. On the transmitter side of the front panel, press ERROR until the display shows the Single Error Inject menu.
12. Using the LEFT/RIGHT cursors, select FEBE-L and then press ENTER twice.
13. In the 2.4Gb/s STATUS section, observe that the error light for REI/FEBE flashes twice.
14. On the receiver side of the front panel, press ERROR until the display shows B1, B2, and FEBE-L across the top line. Observe that B1 is equal to four. Also, observe that both B2 and FEBE-L are equal to two.
15. On the front panel, press RUN/STOP twice. Observe that the errors have now been reset to zero.
16. On the transmitter side of the front panel, press ERROR until the display shows the Single Error Inject menu.
17. Using the LEFT/RIGHT cursors, select CHAN 1 and then press ENTER twice.
18. In the 2.4Gb/s STATUS section, observe that the error lights for B1 and B2 flash twice.
19. On the receiver side of the front panel, press ERROR until the display shows B1, B2, and FEBE-L across the top line. Observe that FEBE-L is equal to zero. Also, observe that both B1 and B2 are equal to two.
20. On the front panel, press RUN/STOP twice to clear all errors.

Error Rate Inject Test

In this part, the transmitter injects an error rate into the receiver and verifies the responses of the receiver. There are nineteen steps in this section of the procedure.

1. On the transmitter side of the front panel, press ERROR until the display shows the Random BER Inject menu.
2. Using the LEFT/RIGHT cursors, select 1.0E-3 and then press ENTER.
3. In the 2.4Gb/s STATUS section, observe that the error lights for B1, B2, and REI/FEBE remain lit. You have now injected an error rate into the receiver.
4. On the receiver side of the front panel, press ERROR until the display shows RS-B1, MS-B2, and MS-REI across the top line. Observe that all of them have increasing error rates.
5. On the front panel, press PAUSE/RESUME once. *Note: The red LED within the switch should now be lit.*
6. On the display, observe that the error rates are no longer increasing, but are fixed at one value. Also, in the 2.4Gb/s STATUS section, observe that the error lights for B1, B2, and REI/FEBE remain lit.

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7. On the display, press PAUSE/RESUME once. *Note: The red LED within the switch is no longer lit.*
8. On the display, observe that the error rates are once again increasing. Also, in the 2.4Gb/s STATUS section, observe that the error lights for B1, B2, and REI/FEBE still remain lit.
9. On the transmitter side of the front panel, press ERROR until the display shows the Random BER Inject menu.
10. Using the LEFT/RIGHT cursors, select OFF and then press ENTER.
11. In the 2.4Gb/s STATUS section, observe that the error lights for B1, B2, and REI/FEBE are now off.
12. On the receiver side of the front panel, press ERROR until the display shows RS-B1, MS-B2, and MS-REI across the top line. Observe that all of the errors have stopped increasing.
13. On the front panel, press RUN/STOP twice to clear all errors.
14. On the transmitter side of the front panel, press ERROR until the display shows the FEBE-L Inject menu.
15. Using the LEFT/RIGHT cursors, select 1/FRAME and position the cursor directly to the left of the one.
16. Using the INC/DEC keys and the LEFT/RIGHT cursors, make the selection 10/FRAME and then press ENTER.
17. In the 2.4Gb/s STATUS section, observe that the error light for REI/FEBE flashes once.
18. On the receiver side of the front panel, press ERROR until the display shows B1, B2, and FEBE-L across the top line. Observe that the FEBE-L error is equal to ten.
19. On the front panel, press RUN/STOP twice to clear all errors.

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Transport Overhead/Path Overhead (SONET)

This section of the procedure ensures that the editing function is working accurately. Leave the setup as it was in the last section. There are twenty-two steps in this section of the procedure.

1. On the transmitter side of the front panel, press OVHD until the display shows J0 on the top right side.
2. Using the LEFT/RIGHT cursors, select SET.
3. Using the INC/DEC keys, change J0 to 51 and then press ENTER.
4. On the receiver side of the front panel, press OVHD until the display shows A1, A2, and J0 on the top right side.
5. On the display, observe that J0 equals 51.
6. On the transmitter side of the front panel, press OVHD until the display shows J0 on the top right side.
7. Using the LEFT/RIGHT cursors, select PASS and then press ENTER.
8. On the receiver side of the front panel, press OVHD until the display shows A1, A2, and J0 on the top right side.
9. On the display, observe that J0 equals 01.
10. On the transmitter side of the front panel, press OVHD until the display shows D7, D8, and D9 on the top right side.
11. Using the LEFT/RIGHT cursors, select SET and select D7.
12. Using the INC/DEC keys and the LEFT/RIGHT cursors, change D7 to AA.
13. Using the LEFT/RIGHT cursors, select D8.
14. Using the INC/DEC keys and the LEFT/RIGHT cursors, change D8 to 11.
15. Using the LEFT/RIGHT cursors, select D9.
16. Using the INC/DEC keys and the LEFT/RIGHT cursors, change D9 to 05 and then press ENTER.
17. On the receiver side of the front panel, press OVHD until the display shows D7, D8, and D9 on the top right side.
18. On the display, observe that D7, D8, and D9 all reflect the values you placed into the transmitter (i.e. D7 = AA, D8 = 11, and D9 = 05).
19. On the transmitter side of the front panel, press OVHD until the display shows D7, D8, and D9 on the top right side.
20. Using the LEFT/RIGHT cursors, select PASS and then press ENTER.
21. On the receiver side of the front panel, press OVHD until the display shows D7, D8, and D9 on the top right side.
22. On the display, observe that the values of D7, D8, and D9 are once again zero.

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Continuous Alarms (SONET)

This section of the procedure ensures that the continuous alarm settings are functioning properly. This section is split into five parts. Each part checks a different alarm. Leave the setup as it was in the last section.

Loss of Signal Alarm

In this part, the transmitter creates a loss of signal alarm and you verify the responses of the receiver. There are eight steps in this section of the procedure.

1. On the transmitter side of the front panel, press ALARM until the display shows the Loss of Signal menu.
2. Using the LEFT/RIGHT cursors, select 2.5SEC.
3. Using the INC key, increase the time until it switches to CONT and then press ENTER.
4. On the display, observe that the top right corner now says "*ACTIVE".
5. In the 2.4Gb/s STATUS section, observe that all of the error lights are now lit.

   Note: The error lights for AIS and RDI/FERF may flash.
6. Using the LEFT/RIGHT cursors, select OFF and then press ENTER.
7. In the 2.4Gb/s STATUS section, observe that all of the error lights are now off.
8. On the front panel, press RUN/STOP twice to clear all errors.

Errored Frame Alarm

In this part, the transmitter creates an errored frame alarm and you verify the responses of the receiver. There are eight steps in this section of the procedure.

1. On the transmitter side of the front panel, press ALARM until the display shows the Errored Frame menu.
2. Using the LEFT/RIGHT cursors, select 2.5SEC.
3. Using the INC key, increase the time until it switches to CONT and then press ENTER.
4. On the display, observe that the top right corner now says "*ACTIVE".
5. In the 2.4Gb/s STATUS section, observe that the error lights for LOF, OOF, B1, B2, REI/FEBE, AIS, and RDI/FERF are now lit.

   Note: The error light for RDI/FERF may flash.
6. Using the LEFT/RIGHT cursors, select OFF and then press ENTER.
7. In the 2.4Gb/s STATUS section, observe that all of the error lights are now off.
8. On the front panel, press RUN/STOP twice to clear all errors.

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FERF Alarm

In this part, the transmitter creates a FERF alarm and you verify the responses of the receiver. There are eight steps in this section of the procedure.

1. On the transmitter side of the front panel, press ALARM until the display shows the FERF-L menu.
2. Using the LEFT/RIGHT cursors, select 2.5SEC.
3. Using the INC key, increase the time until it switches to CONT and then press ENTER.
4. On the display, observe that the top right corner now says "*ACTIVE".
5. In the 2.4Gb/s STATUS section, observe that the error light for RDI/FERF is now lit.
6. Using the LEFT/RIGHT cursors, select OFF and then press ENTER.
7. In the 2.4Gb/s STATUS section, observe that the error light for RDI/FERF is now off.
8. On the front panel, press RUN/STOP twice to clear all errors.

AIS Alarm

In this part, the transmitter creates an AIS alarm and you verify the responses of the receiver. There are eleven steps in this section of the procedure.

1. On the transmitter side of the front panel, press ALARM until the display shows the LINE-AIS menu.
2. Using the LEFT/RIGHT cursors, select 2.5SEC.
3. Using the INC key, increase the time until it switches to CONT and then press ENTER.
4. On the display, observe that the top right corner now says "*ACTIVE".
5. In the 2.4Gb/s STATUS section, observe that the error lights for REI/FEBE and AIS are now lit.
6. On the receiver side of the front panel, press ERROR until the display shows RS-B1, MS-B2, and MS-REI across the top line.
7. On the display, observe that B2 has an error reading and FEBE-L is actively counting errors.
8. On the transmitter side of the front panel, press ALARM until the display shows the LINE-AIS menu.
9. Using the LEFT/RIGHT cursors, select OFF and then press ENTER.
10. In the 2.4Gb/s STATUS section, observe that the error lights for REI/FEBE and AIS are now off.
11. On the front panel, press RUN/STOP twice to clear all errors.

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Inject LOS Alarm

In this part, the transmitter injects a loss of signal alarm and you verify the responses of the receiver. There are eight steps in this section of the procedure.

1. On the transmitter side of the front panel, press ALARM until the display shows the Inject LOS menu.
2. Using the LEFT/RIGHT cursors, select ENABLE and then press ENTER.
3. On the display, observe that the "s" and the "*" after "2.5" on the right side of the display change places.
5. In the 2.4Gb/s STATUS section, observe that all of the error lights flash on and off continuously.
6. Using the LEFT/RIGHT cursors, select OFF and then press ENTER.
7. In the 2.4Gb/s STATUS section, observe that all of the error lights now remain off.
8. On the front panel, press RUN/STOP twice to clear all errors.

You have now successfully verified that the unit is functional. If you had any problems with the unit while performing the tests, repeat the procedure paying careful attention to the setup of the units and the directions given. If the unit still has a problem, please call Tektronix Customer Sales and Support Center (CSSC) at 1-800-835-9433 x2400 or 503-627-2400 for assistance.

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Cleaning Optical Cables

Required Equipment

Clean Air Spray - Dust Free (suggested: Chemtronics E - Series Ultrajet)

Isopropyl Alcohol 70%

.035" Swab (suggested: Fisher Brand Cat.No. 14-959-77)

Kimwipes Laboratory Wipes (suggested: PN 34155)

Cleaning Procedure for Front Panel Optical Connectors

This procedure should be performed each time the fiber assemblies are to be used to prevent scratching the fiber.

1. Remove the protective optical cover from the connector to be cleaned.
2. Take a swab from the package and dip it into the clean Alcohol solution.
3. Gently insert the swab into the barrel (ferrule) opening of the fiber optic connector until it stops.
4. Gently spin the swab clockwise and the counter clockwise.
5. Remove the swab.
6. Using the clean air spray, spray the air into the barrel opening for at least three seconds. **Note:** Hold the can in an upright position. **DO NOT** tilt, invert, or shake the can during use. If a mist appears from the can, the cleaning process **must be performed again.**
7. **Do not** reuse the swab. Dispose of it immediately.

Cleaning Procedure for Unconnected Fiber Cables

This procedure should be performed each time the fiber cables are to be used to prevent scratching the fiber.

1. Hold the fiber optic connector to be cleaned in your hand.
2. Try not to put unnecessary strain on the fiber.
3. Take a clean Kimwipe from the box and dab it into the clean Alcohol.
4. Wipe the Alcohol soaked Kimwipe over the ends of the fiber optic cable gently.
5. Using the clean air spray, spray the air into the end of fiber for at least three seconds. **Note:** Hold the can in an upright position. **DO NOT** tilt, invert, or shake the can during use. If a mist appears from the can, the cleaning process **must be performed again.**
6. Dispose of the used Kimwipe immediately. **Do not** reuse it.

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SDH for Reference

Following ANSI's development of the SONET standard, the CCITT undertook to define a synchronization standard that would address interworking between the CCITT and ITU transmission hierarchies. That effort culminated in 1989 with CCITT's publication of the Synchronous Digital Hierarchy (SDH) standards. Synchronous Digital Hierarchy is a world standard, and as such, SONET can be considered a subset of SDH.

Transmission standards in the U.S., Canada, Korea, Taiwan, and Hong Kong (ANSI) and the rest of the world (ITU) evolved from different basic-rate signals in the non-synchronous hierarchy. Time Division Multiplexing (TDM) (ANSI) combines twenty four 64-kbps channels (DS0s) into one 1.54-Mb/s DS1 signal. ITU TDM multiplexes thirty-two 64-kbps channels (E0s) into one 2.048 Mb/s E-1 (CEPT format) signal.

The issues between ITU and CCITT standards-makers involved how to efficiently accommodate both the 1.5-Mb/s and the 2-Mb/s non-synchronous hierarchies in a single synchronization standard. The agreement reached specified a basic transmission rate of 52 Mb/s for SONET and a basic rate of 155 Mb/s for SDH.

Synchronous and Non-synchronous line rates and the relationships between each are shown in the two tables that follow.

Table D-1. SONET/SDH Hierarchies

SONET	Bit Rate	SDH	SONET Capacity	SDH Capacity
STS-1, OC-1	51.840 Mb/s	STM-0	28 DS1s or 1 DS3	21 E1s
STS-3, OC-3	155.520 Mb/s	STM-1	84 DS1s or 3 DS3s	63 E1s or 1 E4
STS-12, OC-12	622.080 Mb/s	STM-4	336 DS1s or 12 DS3s	252 E1s or 4 E4s
STS-48, OC-48	2488.320 Mb/s	STM-16	1344 DS1s or 48 DS3s	1008 E1s or 16 E4s
STS-192, OC-192	9953.280 Mb/s	STM-64	5376 DS1s or 192 DS3s	4032 E1s or 64 E4s

It must be noted that although an SDH STM-1 has the same bit rate as the SONET STS-3, the two signals contain different frame structures.

STM = Synchronous Transport Module (ITU)

STS = Synchronous Transfer Signal (ANSI)

OC = Optical Carrier (ANSI)

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Table D-2. Non-Synchronous Hierarchies

ANSI Rate			*ITU Rate*		
Signal	**Digital Bit Rate**	**Channels**	**Signal**	**Digital Bit Rate**	**Channels**
DS0	64 kbps	1 DS0	64-kbps	64 kbps	1 64-kbps
DS1	1.544 Mb/s	24 DS0s	E1	2.048 Mb/s	1 E1
DS2	6.312 Mb/s	96 DS0s	E2	8.45 Mb/s	4 E1s
DS3	44.7 Mb/s	28 DS1s	E3	34 Mb/s	16 E1s
not defined			E4	144 Mb/s	64 E1s

Convergence of SONET and SDH Hierarchies

SONET and SDH converge at SONET's 52-Mb/s base level, defined as STM-0 or "Synchronous Transport Module-0". The base level for SONET is STS-1 (or OC-1). Thus, SDH's STM-1 is equivalent to SONET's STS-3 (3 x 51.84 Mb/s = 155.5 Mb/s). Higher SDH rates of STM-4 (622 Mb/s), STM-16 (2.5 Gbps), and STM-64 (10 Gbps) have also been defined.

Multiplexing is accomplished by combining - or interleaving - multiple lower-order signals (1.5 Mb/s, 2 Mb/s, etc.) into higher-speed circuits (52 Mb/s, 155 Mb/s, etc.). By changing the SONET standard from bit-interleaving to byte-interleaving, it became possible for SDH to accommodate both transmission hierarchies. This modification allows an STM-1 signal to carry multiple 1.5-Mb/s or 2-Mb/s signals - and multiple STM signals to be aggregated to carry higher orders of SONET or SDH tributaries.

Asynchronous and Synchronous Tributaries

SDH does away with a number of the lower multiplexing levels, allowing non-synchronous 2-Mb/s tributaries to be multiplexed to the STM-1 level in a single step. SDH recommendations define methods of subdividing the payload area of an STM-1 frame in various ways so that it can carry combinations of synchronous and asynchronous tributaries. Using this method, synchronous transmission systems can accommodate signals generated by equipment operating from various levels of the non-synchronous hierarchy.

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Glossary and Standards

Three sets of terms are arranged at the beginning of this section because it is important to see that they are not equivalent terms, which is how they get used in normal discussions. They are:

- **Add/ Drop**

The process where a part of the information carried in a transmission system is demodulated (dropped) at an intermediate point and different information is entered (added) for subsequent transmission. The remaining traffic passes straight through the multiplexer without additional processing.

- **Map/ Demap**

A term for multiplexing, implying more visibility inside the resultant multiplexed bit stream than available with conventional asynchronous techniques.

- **Multiplex/ Demultiplex**

Multiplex (MUX) - To transmit two or more signals over a single channel. Demultiplex (DEMUX) - To separate two or more signals previously combined by compatible multiplexing equipment. Demultiplexing - A process applied to a multiplex signal for recovering signals combined within it and for restoring the distinct individual channels of the signals.

Add/Drop Multiplexer (ADM) - A multiplexer capable of extracting and inserting lower-rate signals from a higher-rate multiplexed signal without completely demultiplexing the signal.

AIS (Alarm Indicating Signal) - A code sent downstream indicating an upstream failure has occurred. SONET defines four categories of AIS: Line AIS; STS Path AIS; VT Path AIS; DSn AIS.

AMI - Alternate Mark Inversion. The line-coding format in transmission systems where successive ones (marks) are alternatively inverted (sent with polarity opposite that of the preceding mark).

ANSI (American National Standards Institute) - A membership organization which develops U.S. industry standards and coordinates U.S. participation in the International Standards Organization (ISO).

Asynchronous - A network where transmission system payloads are not synchronized and each network terminal runs on its own clock.

Asynchronous Transfer Mode (ATM) - A multiplexing/switching technique in which information is organized into fixed-length cells with each cell consisting of an identification header field and an information field. The transfer mode is asynchronous in the sense that the use of the cells depends on the required or instantaneous bit rate.

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Attenuation - Reduction of signal magnitude or signal loss, usually expressed in decibels.

Automatic Protection Switching (APS) - The ability of a network element to detect a failed working line and switch the service to a spare (protection) line. 1+1 APS pairs the protection line with each working line. 1:*n* APS provides one protection line for every *n* working lines.

Backhauling - Cumbersome traffic management technique used to reduce expense of multiplexing/demultiplexing.

Bandwidth - Information-carrying capacity of a communication channel. Analog bandwidth is the range of signal frequencies that can be transmitted by a communication channel or network.

Bidirectional - Operating in both directions. Bidirectional APS allows protection switching to be initiated by either end of the line.

Binary N-Zero Suppression (BNZS) - Line coding system that replaces N number of zeros with a special code to maintain pulse density required for synchronization. N is typically 3, 6, or 8.

BIP-8 (Bit Interleaved Parity-8) - A method of error checking in SONET which allows a full set of performance statistics to be generated. For example, a BIP-8 creates eight-bit (one-byte) groups, then does a parity check for each of the eight bit positions in the byte.

BISDN (Broadband Integrated Services Digital Network) - A single ISDN network which can handle voice, data, and eventually video services.

Bit - One binary digit; a pulse of data.

Bit Error vs. Block Error

Error rate statistics play a key role in measuring the performance of a network. As errors increase, user payload (especially data) must be re-transmitted. The end effect is creation of more (non-revenue) traffic in the network.

Bit Error Rate (BER) - The number of coding violations detected in a unit of time, usually one second. Bit Error rate (BER) is calculated with this formula:

BER = errored bits received/ total bits sent.

Block Error rate (BLER) - One of the underlying concepts of error performance is the notion of Errored Blocks, for examples blocks in which one or more bits are in error. A block is a set of consecutive bits associated with the path or section monitored by means of an Error Detection Code (EDC), such as Bit Interleaved Parity (BIP). Block Error rate (BLER) is calculated with this formula:

BLER = errored blocks received/ total block sent.

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Bit-Interleaved Parity (BIP) - A parity check that groups all the bits in a block into units (such as byte), then performs a parity check for each bit position in a group.

Bit Stuffing - In asynchronous systems, a technique used to synchronize asynchronous signals to a common rate before multiplexing.

Bit synchronous - A way of mapping payload into virtual tributaries that synchronizes all inputs into the VTs, but does not capture any framing information or allow access to subrate channels carried in each input. For example, bit synchronous mapping of a channeled DS1 into a VT1.5 does not provide access to the DS0 channels carried by the DS1.

Bits per second (bps) - The number of bits passing a point every second. The transmission rate for digital information.

Broadband - Services requiring 50-600 Mb/s transport capacity.

Byte-interleaved - Bytes from each STS-1 are placed in sequence in a multiplexed or concatenated STS-N signal. For example, for an STS-3, the sequence of bytes from contributing STS-1s is 1,2,3,1,2,3,...

Byte synchronous - A way of mapping payload into virtual tributaries that synchronizes all inputs into the VTs, captures framing information, and allows access to subrate channels carried in each input. For example, byte synchronous mapping of a channeled DS1 into a VT1.5 provides direct access to the DS0 channels carried by the DS1.

CCITT - The technical organs of the United Nations specialized agency for telecommunications, now the International Telecommunications Union. They function through international committees of telephone administrations and private operating agencies.

CEPT - European Conference of Postal and Telecommunications Administrations. The CEPT format defines the 2.048-Mb/s European T1/E1 signal made up of 32 voice-frequency channels.

Channel - The smallest subdivision of a circuit that provides a type of communication service; usually a path with only one direction.

Circuit - A communications path or network; usually a pair of channels providing bi-directional communication.

Circuit Switching - Basic switching process whereby a circuit between two users is opened on demand and maintained for their exclusive for the duration of the transmission.

Coding Violation (CV) - A transmission error detected by the difference between the transmitted and the locally calculated bit-interleaved parity.

Concatenate - The linking together of various data structures, for example two bandwidths joined to form a single bandwidth.

Concatenated STS-Nc - A signal in which the STS Envelope Capacities from the N STS-1s have been combined to carry an STS-Nc Synchronous Payload

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Envelope (SPE). It is used to transport signals that do not fit into an STS-1 (52 Mb/s) payload.

Concatenated VT - A virtual tributary (VT x Nc) which is composed of N x VTs combined. Its payload is transported as a single entity rather than separate signals.

CMI - Code Mark Inversion

Cyclic Redundancy Check (CRC) - A technique for using overhead bits to detect transmission errors.

Data Communications Channels - OAM&P channels in SONET that enable communications between intelligent controllers and individual network nodes as well as inter-node communications.

Defect - A limited interruption in the ability of an item to perform a required function.

Digital Cross-Connect (DCS) - An electronic cross-connect which has access to lower-rate channels in higher-rate multiplexed signals and can electronically rearrange (cross-connect) those channels.

Digital Signal - An electrical or optical signal that varies in discrete steps. Electrical signals are coded as voltages, optical signals are coded as pulses of light.

DSX-1 - May refer to either a cross-connect for DS1 rate signals or the signals cross-connected at an DSX-1.

DSX-3 - May refer to either a cross-connect for DS3 rate signals or the signals cross-connected at an DSX-1.

ECSA (Exchange Carrier Standards Association) - An organization that specifies telecommunications standards for ANSI.

EIA (Electronics Industry Association)

Envelope capacity - The number of bytes the payload envelope of a single frame can carry. The SONET STS payload envelope is the 783 bytes of the STS-1 frame available to carry a signal. Each virtual tributary has an envelope capacity defined as the number of bytes in the virtual tributary less the bytes used by VT overhead.

Failure - A termination of the ability of an item to perform a required function. A failure is cause by the persistence of a defect.

FEBE (Far End Block Error) - A message sent back upstream that receiving network element is detecting errors, usually a coding violation. See Remote Error Indication (REI).

FERF (Far End Receive Failure) - A signal to indicate to the transmit site that a failure has occurred at the receive site.

Fixed Stuff - A bit or byte whose function is reserved. Fixed stuff locations, sometimes called reserved locations, do not carry overhead or payload.

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Floating mode - A virtual tributary mode that allows the VT synchronous payload envelope to begin anywhere in the VT. Pointers identify the starting location of the VT SPE. VT SPEs in different superframes may begin at different locations.

Framing - Method of distinguishing digital channels that have been multiplexed together.

Frequency - The number of cycles of periodic activity that occur in a discrete amount of time.

Grooming - Consolidating or segregating traffic for efficiency.

Interleave - The ability of SONET to mix together and transport different types of input signals in an efficient manner, thus allowing higher-transmission rates.

Isochronous - All devices in the network derive their timing signal directly or indirectly from the same primary reference clock.

Jitter - Short waveform variations caused by vibration, voltage fluctuations, control system instability, etc.

Line - One or more SONET sections, including network elements at each end, capable of accessing, generating, and processing Line Overhead.

Line Alarm Indication Signal (AIS-L) - AIS-L is generated by Section Terminating Equipment (STE) upon the detection of an Loss of Signal or Loss of Frame defect, on an equipment failure. AIS-L maintains operation of the downstream regenerators, and therefore prevents generation of unnecessary alarms. At the same time, data and orderwire communication is retained between the regenerators and the downstream Line Terminating Equipment (LTE).

Line Remote Defect Indication (RDI-L) - A signal returned to the transmitting Line Terminating Equipment (LTE) upon detecting a Loss of Signal, Loss of Frame, or AIS-L defect. RDI-L was previously known as Line FERF.

Line Overhead (LOH) - 18 bytes of overhead accessed, generated, and processed by line terminating equipment. This overhead supports functions such as locating the SPE in the frame, multiplexing or concatenating signals, performance monitoring, automatic protection switching and line maintenance.

Line Terminating Equipment (LTE) - Network elements such as add/drop multiplexers or digital cross-connect systems which can access, generate, and process Line Overhead.

Locked Mode - A virtual tributary mode that fixes the starting location of the VT SPE. Locked mode has less pointer processing than floating mode.

Mapping - The process of associating each bit transmitted by a service into the SONET payload structure that carries the service. For example, mapping a DS1 service into a SONET VT1.5 associates each bit of the DS1 with a location in the VT1.5.

Multiplexer - A device for combining several channels to be carried by one line or fiber.

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Mesochronous - A network whereby all nodes are timed to a single clock source, thus all timing is exactly the same (truly synchronous).

Narrowband - Services requiring up to 1.5 Mb/s transport capacity.

Network Element (NE) - In SONET, the five basic network elements are:

add/drop multiplexer;
broadband digital cross-connect;
wideband digital cross-connect;
digital loop carrier; and ,
switch interface.

Any device which is part of a SONET transmission path and serves one or more of the section, line and path-terminating functions.

OAM - Operations, Administration, and Maintenance. Also called OAM&P.

OAM&P (Operations, Administration, Maintenance, and Provisioning) - Provides the facilities and personnel required to manage a network.

OC-1 (Optical Carrier Level 1) - The optical equivalent of an STS-1 signal.

OC-n (Optical Carrier Level n) - The optical equivalent of an STS-n signal.

Orderwire - A channel used by installers to expedite the provisioning of lines.

OS (Operations System) - Sophisticated applications software that overlooks the entire network.

OSI Seven-layer Model - A standard architecture for data communications. Layers define hardware and software required for multi-vendor information processing equipment to be mutually compatible. The seven layers from lowest to highest are: physical, link, network, transport, session, presentation, and application.

Overhead - Extra bits in a digital stream used to carry information besides traffic signals. Orderwire, for example, would be considered overhead information.

Packet Switching - An efficient method for breaking down and handling high-volume traffic in a network. A transmission technique that segments and routes information into discrete units. Packet switching allows for efficient sharing of network resources as packets from different sources can all be sent over the same channel in the same bitstream.

Parity check - An error-checking scheme which examines the number of transmitted bits in a block which hold the value one. For even parity, an overhead parity bit is set to either one or zero to make the total number of transmitted one in the block data plus parity bit an even number. For odd parity, the parity bit is set to make the total number of ones in the block an odd number.

Path - A logical connection between a point where an STS or VT is multiplexed to the point where it is demultiplexed.

Path Overhead (POH) - Overhead accessed, generated, and processed by path-terminating equipment. Path overhead includes nine bytes of STS Path Overhead and, when the frame is VT-structured, five bytes of VT Path Overhead.

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Path Terminating Equipment (PTE) - Network elements such as fiber optic terminating systems which can access, generate, and process Path Overhead.

Payload - The portion of the SONET signal available to carry service signals such as DS1, DS2, and DS3. The contents of an STS SPE or VT SPE.

Payload Pointer - Indicates the beginning of the Synchronous Payload Envelope.

Photonic - The basic unit of light transmission used to define the lowest (physical) layer in the OSI seven-layer model.

Plesiochronous - A network with nodes timed by separate clock sources with almost the same timing.

Pointer - A part of the SONET overhead that locates a floating payload structure. STS pointers locate the SPE. VT Pointers locate floating mode virtual tributaries. All SONET frames use STS pointers; only floating mode virtual tributaries use VT pointers.

Poll - An individual control message from a central controller to an individual station on a multipoint network inviting that station to send.

POP (Point-of-Presence) - A point in the network where inter-exchange carrier facilities like DS3 or OC-n meet with access facilities managed by telephone companies or other service providers.

Remote Alarm Indication (RAI) - A code sent upstream in a DSn network as a notification that a failure condition has been declared downstream. (RAI signals were previously referred to as Yellow signals.)

Remote Defect Indication (RDI) - A signal returned to the transmitting Terminating Equipment upon detecting a Loss of Signal, Loss of Frame, or AIS defect. RDI was previously known as FERF.

Remote Error Indication (REI) - An indication returned to a transmitting node (source) that an errored block has been detected at the receiving node (sink). This indication was formerly known as Far End Block Error (FEBE).

Remote Failure Indication (RFI) - A failure is a defect that persists beyond the maximum time allocated to the transmission system protection mechanisms. When this situation occurs, an RFI is sent to the far end and will initiate a protection switch if this function has been enabled.

Regenerator - Device that restores a degraded digital signal for continued transmission; also called a repeater.

SDH (Synchronous Digital Hierarchy) - The CCITT-defined world standard of synchronization whose base transmission level is 52 Mb/s (STM-0) and is equivalent to SONET's STS-1 or OC-1 transmission rate. SDH standards were published in 1989 to address interworking between the CCITT (ITU) and ANSI transmission hierarchies.

Section - The span between two SONET network elements capable of accessing, generating, and processing only SONET Section overhead. This is the lowest layer of the SONET protocol stack with overhead.

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Section Overhead - Nine bytes of overhead accessed, generated, and processed by section terminating equipment. This overhead supports functions such as framing the signal and performance monitoring.

Section Terminating Equipment (STE) - Equipment that terminates the SONET Section layer. STE interprets and modifies or creates the Section Overhead.

Slip - An overflow (deletion) or underflow (repetition) of one frame of a signal in a receiving buffer.

SONET (Synchronous Optical Network) - A standard for optical transport that defines optical carrier levels and their electrically equivalent synchronous transport signals. SONET allows for a multi-vendor environment and positions the network for transport of new services, synchronous networking, and enhanced OAM&P.

Stratum - Level of clock source used to categorize accuracy.

Superframe - Any structure made of multiple frames. SONET recognizes superframes at the DS1 level (D4 and extended superframe) and at the VT (500u STS superframes).

Synchronous - A network where transmission system payloads are synchronized to a master (network) clock and traced to a reference clock.

Synchronous Transfer Module (STM) - A measure of the SDH transmission hierarchy. STM-1 is SDH's base-level transmission rate equal to 155 Mb/s. Higher rates of STM-4, STM-16, and STM-48 are also defined.

SPE (Synchronous Payload Envelope) - The major portion of the SONET frame format used to transport payload and STS path overhead. A SONET structure that carries the payload (service) in a SONET frame or virtual tributary. The STS SPE may begin anywhere in the frame's payload envelope. The VT SPE may begin anywhere in a floating mode VT, but begins at a fixed location in a locked-mode VT.

STS Path Overhead (STS POH) - Nine evenly distributed Path Overhead bytes per 125 microseconds starting at the first byte of the STS SPE. STS POH provides for communication between the point of creation of an STS SPE and its point of disassembly.

STS Path Remote Defect Indication (RDI-P) - A signal returned to the transmitting STS Path Terminating Equipment (PTE) upon detection of certain defects on the incoming path.

STS Path Terminating Equipment (STS PTE) - Equipment that terminates the SONET STS Path layer. STS PTE interprets and modifies or creates the STS Path Overhead. An NE that contains STS PTE will also contain LTE and STE.

STS-1 (Synchronous Transport Signal Level 1) - The basic SONET building block signal transmitted at 51.84 Mb/s data rate.

STS-n (Synchronous Transport Signal Level n) - The signal obtained by multiplexing integer multiples (N) of STS-1 signals together.

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T1X1 Subcommittee - A committee within the ECSA that specifies SONET optical interface rates and formats.

VT (Virtual Tributary) - A signal designed for transport and switching of sub-STS-1 payloads.

VT Group - A 9 row x 12 column structure (108 bytes) that carries one or more VTs of the same size. Seven VT groups can be fitted into one STS-1 payload.

VT Path Overhead (VT POH) - Four evenly distributed Path Overhead bytes per VT SPE starting at the first byte of the VT SPE. VT POH provides for communication between the point of creation of an VT SPE and its point of disassembly.

VT Path Remote Defect Indication (RDI-V) - A signal returned to the transmitting VT PTE upon detection of certain defects on the incoming path.

VT Path Remote Failure Indication (RFI-V) - A signal, applicable only to a VT1.5 with the byte-synchronous DS1 mapping, that is returned to the transmitting VT PTE upon declaring certain failures. The RFI-V signal was previously known as the VT Path Yellow signal.

VT Path Terminating Equipment (VT PTE) - Equipment that terminates the SONET VT Path layer. VT PTE interprets and modifies or creates the VT Path Overhead. An NE that contains VT PTE will also contain STS PTE, LTE and STE.

Wander - Long-term variations in a waveform.

Wideband - Services requiring 1.5-50 Mb/s transport capacity.

Yellow Signal - See Remote Alarm Indication (REI) and VT Path Remote Failure Indication (RFI-V).

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SONET Reference Materials

Bellcore

GR-253-CORE

SONET Transport Systems: Common Generic Criteria

Consult this document for an up-to-date listing of:

Generic Requirements (GR)

Technical References)TR)

Technical Advisories (TA)

Special Reports (SR)

EIA/TIA Documents

American National Standards Institute (ANSI) documents

ITU-T and CCITT Recommendations

ISO documents

IEEE documents

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Index

-A-

Accessories, 1-6

Applications, 2-12

- Active Analysis Mode, 2-13
- Active Through Mode Analysis, 2-13
- Passive Monitoring, 2-12

-C-

CLEI Code, 1-3

-F-

First-Time Operation, 1-8

Front Panel, 2-1

- Display, Display Controls, Indicators, 2-2
- Setup Menu System, 2-2

-G-

General Menus, 3-7

GPIB front panel LED status, 2-9

-I-

Inspection Test, Incoming, B-1

-M-

Measurement Controls, Indicators, 2-9

- Run/Stop, 2-9
- Pause/Resume, 2-9

-P-

Power fail recovery, 3-5

-R-

Receiver, 2-7

- Connectors, 2-7
- Status Indicators, 2-8
- View History Key, 2-8
- Drop Select Key, 2-9
- Tributary Select Key, 2-9
- Overhead Key, 2-9

Receiver Menus, 3-20

- Error Measurements, 3-20
- Overhead Displays, 3-21
- ASCII Synchronization Messages - S1 byte, 3-22
- APS, 3-22
- Drop Select, 3-23
- Tributary Select, 3-23

Rear Panel

- Connectors, 2-11
- SYNC Output, 2-10
- Laser Lockout, 2-10
- Remote Interlock, 2-10

Remote Indicators (GPIB), 2-9

Resume Laser on, 3-5

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-S-

Safety Summary, ix

SDH for Reference, D-1

Setup Menu System, 3-1

Report/ Test Time, 3-4

Auxiliary Setup, 3-5

SONET Glossary, G-1

Specifications, SONET, A-1

-T-

Transmitter, 2-3

Connectors, 2-4

Status Indicators, 2-4

Mode Key, 2-4

Tributary, Input Select Keys, 2-5

Overhead Key, 2-5

Alarm Key, 2-6

Error Key, 2-6

Transmitter Menus, 3-8

Source Mode, 3-8

PRBS Mappings, 3-9

External Clock Synchronization, 3-8

Input Select, 3-11

Tributary Select, 3-11

Illegal Mode, 3-12

Alarm Generation, 3-13

Overhead, 3-15

Edit M1 Byte, 3-16

Error Generation, 3-17

B2 Error Inject, 3-18

Inject Random BER on one selectable channel, 3-19

-V-

Virtual Front Panel, 3-24

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