Instruction Manual

Tektronix

OI1125 E/O Transmitter

071-1052-00

Warning
The servicing instructions are for use by qualified personnel only. To avoid personal injury, do not perform any servicing unless you are qualified to do so. Refer to all safety summaries prior to performing service.

www.tektronix.com

Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077

WARRANTY

Tektronix warrants that the products that it manufactures and sells will be free from defects in materials and workmanship for a period of one (1) year from the date of purchase from an authorized Tektronix distributor. If any such product proves defective during this warranty period, Tektronix, at its option, either will repair the defective product without charge for parts and labor, or will provide a replacement in exchange for the defective product. Batteries are excluded from this warranty.

In order to obtain service under this warranty, Customer must notify Tektronix of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. Customer shall be responsible for packaging and shipping the defective product to the service center designated by Tektronix, shipping charges prepaid, and with a copy of customer proof of purchase. Tektronix shall pay for the return of the product to Customer if the shipment is to a location within the country in which the Tektronix service center is located. Customer shall be responsible for paying all shipping charges, duties, taxes, and any other charges for products returned to any other locations.

This warranty shall not apply to any defect, failure or damage caused by improper use or improper or inadequate maintenance and care. Tektronix shall not be obligated to furnish service under this warranty a) to repair damage resulting from attempts by personnel other than Tektronix representatives to install, repair or service the product; b) to repair damage resulting from improper use or connection to incompatible equipment; c) to repair any damage or malfunction caused by the use of non-Tektronix supplies; or d) to service a product that has been modified or integrated with other products when the effect of such modification or integration increases the time or difficulty of servicing the product.

THIS WARRANTY IS GIVEN BY TEKTRONIX WITH RESPECT TO THE LISTED PRODUCTS IN LIEU OF ANY OTHER WARRANTIES, EXPRESS OR IMPLIED. TEKTRONIX AND ITS VENDORS DISCLAIM ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. TEKTRONIX' RESPONSIBILITY TO REPAIR OR REPLACE DEFECTIVE PRODUCTS IS THE SOLE AND EXCLUSIVE REMEDY PROVIDED TO THE CUSTOMER FOR BREACH OF THIS WARRANTY. TEKTRONIX AND ITS VENDORS WILL NOT BE LIABLE FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES IRRESPECTIVE OF WHETHER TEKTRONIX OR THE VENDOR HAS ADVANCE NOTICE OF THE POSSIBILITY OF SUCH DAMAGES.

Table of Contents

List of Figures

List of Tables

General Safety Summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products 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.

To Avoid Fire or Personal Injury

Use Proper Power Cord. Use only the power cord specified for this product and certified for the country of use.

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.

Observe All Terminal Ratings. To avoid fire or shock hazard, observe all ratings and markings on the product. Consult the product manual for further ratings information before making connections to the product.

Do Not Operate Without Covers. Do not operate this product with covers or panels removed.

Use Proper Fuse. Use only the fuse type and rating specified for this product.

Wear Eye Protection. Wear eye protection if exposure to high-intensity rays or laser radiation exists.

Do Not Operate With Suspected Failures. If you suspect there is damage to this product, have it inspected by qualified service personnel.

Do Not Operate in Wet/Damp Conditions.

Do Not Operate in an Explosive Atmosphere.

Keep Product Surfaces Clean and Dry.

Provide Proper Ventilation. Refer to the manual's installation instructions for details on installing the product so it has proper ventilation.

Symbols and Terms

Terms in this Manual. These terms may appear in this manual:

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 product or other property.*

Terms on the Product. These terms may appear on the product:

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:

Preface

This is the instruction manual for the OI1125 E/O Transmitter. This manual provides user information and performance verification procedures for the instrument.

Contacting Tektronix

Phone	1-800-833-9200*
Address	Tektronix, Inc. Department or name (if known) 14200 SW Karl Braun Drive P.O. Box 500 Beaverton, OR 97077 USA
Web site	www.tektronix.com
Sales support	1-800-833-9200, select option 1*
Service support	1-800-833-9200, select option 2*
Technical support	Email: techsupport@tektronix.com 1-800-833-9200, select option 3* 6:00 a.m. – 5:00 p.m. Pacific time

*** This phone number is toll free in North America. After office hours, please leave a voice mail message.
Outside North America, contact a Tektronix sales office or distributor; see the Tektronix web site for a list of offices.**

Getting Started

The OI1125 (Figure 1) is an electrical-to-optical transmitter that accepts serial electrical data from a BERT (Bit Error Rate Tester) at rates up to 12.5 Gb/s and outputs an equivalent high-speed serial optical signal.

The OI1125 Transmitter requires a continuous-wave optical input from a polarization-maintaining laser source. The transmitter has an internal optical source that can be used to drive the transmitter optical input, or an external, tunable laser can be used. You can use the transmitter in a test system with the OI2125 O/E Receiver to convert the optical signal from a DUT (Device Under Test) to an electrical signal used by a BERT.

Using the transmitter and receiver combined with a BERT, you can test the bit error rate of optical signals in DWDM, SONET/SDH, and other optical transmission systems.

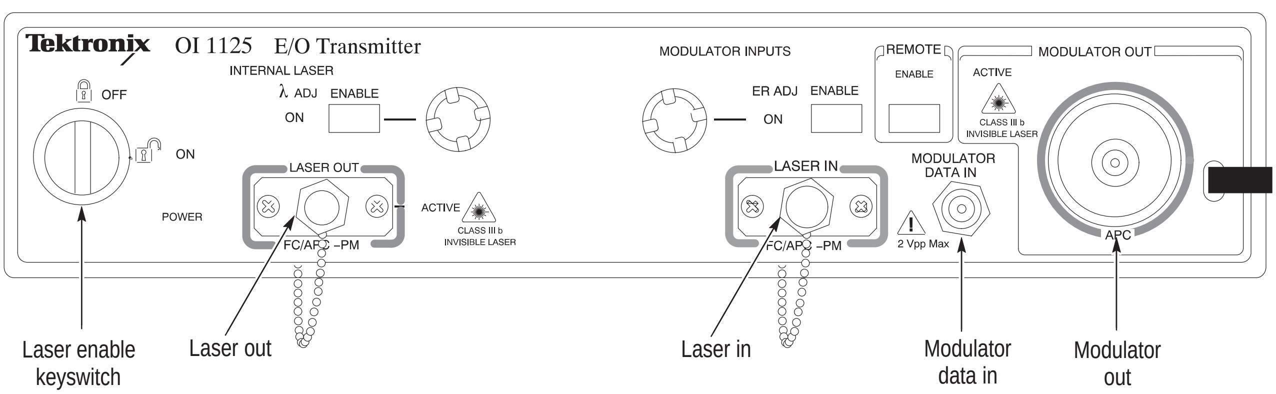

Figure 1: OI1125 E/O Transmitter

The OI1125 E/O Transmitter provides the following key features:

- Supports standard SONET data rates from OC48 to OC192 and FEC data rates up to 12.5 Gb/s
- Optical wavelength range designed to operate in C band (1530 nm to 1565 nm)
- High-quality optical eye pattern with low jitter
- High extinction ratio (≥12 dB)
- Polarization-controlled internal laser with +10 dBm output

Options

Table 1 lists the power cord options that are available for your OI1125 E/O Transmitter.

Table 1: Power cord options

Option	Description
A1	European power cord
A2	UK power cord
A3	Australian power cord
A5	Swiss power cord
AC	Chinese power cord
A99	No power cord

Table 2 lists the Tektronix service options. These options are modular, flexible, and easy to order with your instrument. Designed to support tracking of calibration to requirements of ISO9000 and to provide for extended repair coverage, these options help fix your long-term maintenance costs and eliminate unplanned expenditures.

Table 2: Service options

Option	Description
D1	Provides the initial Test Data Report from the factory on delivery.
C3	Provides factory calibration certification on delivery, plus two more years of calibration coverage. Throughout the coverage period, the instrument will be calibrated according to its Recommended Calibration Interval.
D3	Provides test data on delivery plus a Test Data Report for every calibration performed during three years of coverage (requires Option C3).
R3	Extends product repair warranty to a total of three years.
C5	Provides factory calibration certification on delivery, plus four more years of calibration coverage. Throughout the coverage period, the instrument will be calibrated according to its Recommended Calibration Interval.
D5	Provides test data on delivery plus a Test Data Report for every calibration performed during five years of coverage (requires Option C5).
R5	Extends product repair warranty to a total of five years.

Tektronix Service Options are available at the time you order your instrument. Contact your local Tektronix Sales Office for more information.

Standard Accessories

Table 3 lists the standard accessories that come with the OI1125 E/O Transmitter.

Table 3: Standard accessories

Accessory	Part number
US power cord	161-0066-00
PMF optical cable, FC/APC-PM, narrow key	174-4664-00
Optical cable, FC/APC-FC/PC, 2 M	174-4727-00
Low-loss SMA cable	015-0561-00
Laser Safety Interlock	131-7350-00
50 Ω terminator (preinstalled)	015-1022-01
FC/APC adapter (preinstalled)	119-5115-00
Optical connector cleaning kit	006-8217-00
Instruction manual	071-1052-XX
Certificate of Calibration	——

Optional Accessories

Table 4 lists the optional accessories that are recommended for the OI1125 E/O Transmitter.

Table 4: Optional accessories

Item	Part number
Side-By-Side Instrument Rack Adapter	TVGF13
SC/APC UCI adapter	119-5116-00
ST/APC UCI adapter	119-5888-00
DIN 47256 UCI adapter	119-5887-00
PMF optical cable, FC/APC-PM, 2 m, narrow key	174-4725-00

Installation

To properly install and power on the OI1125 E/O Transmitter, read this procedure first to acquaint yourself with the instrument before performing the procedure.

WARNING. *To prevent eye injury, do not look directly into any optical output port or cable attached to the port. Output power from the laser is Class IIIb, which can be harmful to your eyes. The wavelength output from the OI1125 internal laser is in the infrared band and is invisible to the human eye.*

1. Be sure the operating environment is within the specifications listed in Table 7 starting on page 21.

CAUTION. *To prevent damage to the transmitter, provide proper ventilation. Do not block the cabinet ventilation holes. Do not remove the cabinet feet; the feet provide proper clearance for ventilation.*

2. Leave space for cooling. Do this by verifying that the ventilation holes on the sides, top, and bottom of the cabinet are free of any airflow obstructions. Leave at least 5.1 cm (2 inches) free on each side.
3. Check that you have the proper electrical connections. The OI1125 E/O Transmitter requires 100 to 240 VAC_{RMS} ±10%, 47 Hz to 63 Hz, ≤40 W.
4. Connect the proper power cord from the rear-panel power connector (see Figure 7 on page 14) to the power system.

NOTE. *For the internal laser to function, either the laser safety interlock or an external control circuit must be connected to the remote connector on the rear panel. See* Using the Rear-Panel Remote Interface *on page* 15.

5. If you intend to use the internal laser as the optical source for the transmitter, connect the laser safety interlock to the remote connector on the rear panel, or connect your external control circuit to the connector.

NOTE. *You need to make optical connections in the next step. Before making any optical connection, clean your optical cables using the procedure on page 62.*

6. If you are using the internal laser as the optical source for the transmitter, connect the optical cable with FC/APC-PM connectors on both ends (standard accessory, Tektronix part number 174-4664-00), between the internal laser output and the modulator optical input. See Figure 1 on page 1.

CAUTION. *To prolong the life of your optical connectors and cables, use care when making optical connections. Refer to* Connecting Signals *on page 9 for instructions on connecting optical signals.*

If you are not using an optical connection, either on the transmitter, cable, or associated optical equipment, always leave the protective dust cover on the connector. The glass surface of the fiber optic core is easily contaminated by airborne dust particles.

Treat all optical connectors as you would a camera lens or other precision optical equipment.

7. If you are using an external laser source, connect it to the modulator Laser In port on the front panel.

CAUTION. *To prevent eye injury, do not look directly into the modulated output port or cable attached to the port. The modulated output from the transmitter may exceed Class I levels, depending on the power level of the external laser source you use.*

8. Leave the protective dust cover on the modulator output, or connect an optical cable from the modulator output to your system or measurement instrument.

Power on

To power on the OI1125 E/O Transmitter, first verify that the front-panel Laser Enable keyswitch is in the OFF (locked) position and then push the rear-panel power rocker switch to toggle it on. All LEDs will light briefly as the instrument initializes.

Enable the Internal Laser

If you are using the internal laser source, rotate the Laser Enable keyswitch clockwise to the ON (unlocked) position. The ON LED and the Laser Output Active LED light. The ON LED flashes if the laser safety interlock is not installed.

WARNING. *To prevent eye injury, do not look directly into any optical output port or cable attached to the port. Output power from the laser is Class IIIb, which can be harmful to your eyes. The wavelength output from the OI1125 internal laser is in the infrared band and is invisible to the human eye.*

Power off

To power off the OI1125 E/O Transmitter, first rotate the Laser Enable keyswitch counterclockwise to the off (locked) position, and then push the rear-panel power rocker switch to toggle it off.

Functional Check

To perform a functional check of the OI1125 E/O Transmitter, you must connect a setup as shown in Figure 2. This setup measures the optical output of the transmitter directly, requiring an oscilloscope or signal analyzer with optical input capabilities. This is the method that is used in the *Eye Pattern Test Matrix* in the *Performance Verification* on page 44.

The equipment required, besides the transmitter and the optical and electrical cables supplied as standard accessories, is listed below.

- A pattern generator capable of producing data rates from 2.4 Gb/s to 12.50 Gb/s, with output levels in the range of 0.25-1.5 V_{p-p}.
- An optical-input oscilloscope capable of measuring single-mode optical signals in the 1550 nm band at data rates up to 12.50 Gb/s.
- A 50 Ω SMA cable to connect the pattern generator divided-clock output as an oscilloscope trigger signal.

Alternatively, you can use an optical-to-electrical converter on the optical output of the transmitter, so that you can use a conventional, electrical-input oscilloscope or analyzer to measure the transmitter output.

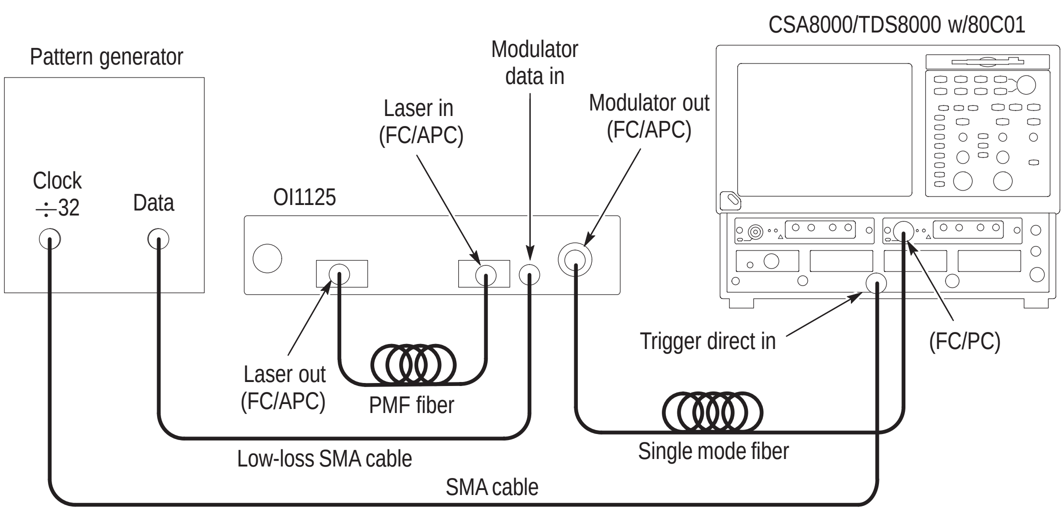

Figure 2: Basic functional test setup

Follow the *Displaying an Eye Pattern* procedure on the next page to do a functional check of the OI1125 E/O Transmitter. If you are unfamiliar with making fiber optic connections, refer to *Connecting Signals* on page 9.

Displaying an Eye Pattern

To display an eye pattern, do the following:

1. Connect the test setup as shown in Figure 2, and power on the equipment.
2. Set the BERT bit rate to 9.953280 Gb/s.
3. Set the pattern to PRBS–31.
4. Disable the adjustable duty cycle.
5. Set the mark ratio to 1/2.
6. Set the trigger to 1/32 clock.
7. Set the output mode to AC.
8. Turn the data output on and set the data amplitude to 1.0 $V_{p–p}$.
9. Enable the transmitter laser by turning the keyswitch clockwise (to the unlocked position). The Laser On LED and Laser Output Active LED light.
10. On the oscilloscope, press Autoset, and then adjust the horizontal scale to display an optical eye pattern (see Figure 3).

The oscilloscope displays an optical eye pattern as shown in Figure 3, indicating that the transmitter is functioning correctly. The internal laser source, coupled to the laser input port, is being modulated by the electrical data stream from the BERT. The modulated optical output signal is displayed on the oscilloscope.

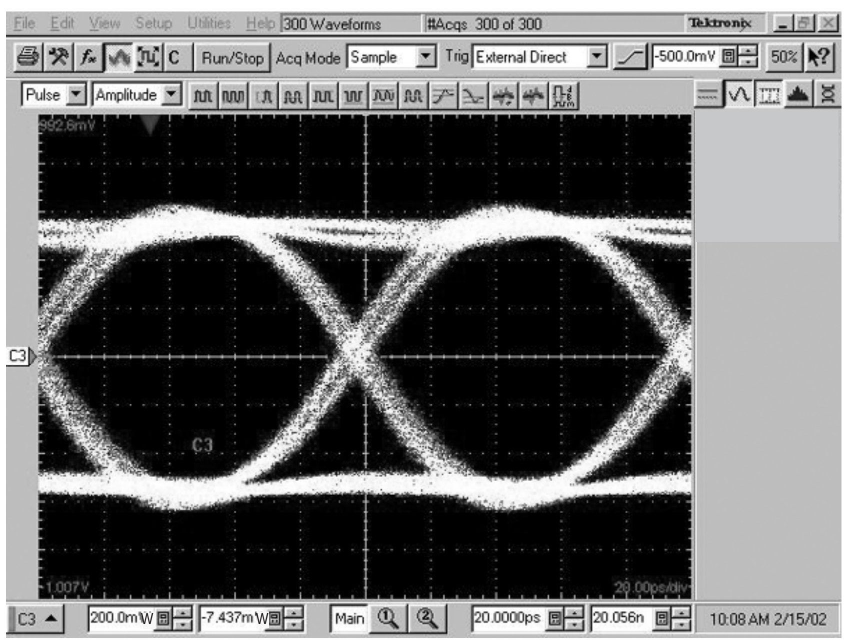

Figure 3: Oscilloscope display of an eye pattern

Operating Basics

This section describes the connectors and controls on the front and rear panels of the OI1125. Figure 5 on page 11 and Figure 7 on page 14 illustrate the front and rear panels of the instrument.

Handling

Handle the OI1125 E/O Transmitter carefully at all times. The instrument contains sensitive optical and electrical components that can be damaged by physical shocks.

WARNING. *To prevent eye injury, do not look directly into any optical output port or cable attached to the port. Output power from the laser is Class IIIb, which can be harmful to your eyes. The output wavelength from the OI1125 internal laser is in the infrared band and is invisible to the human eye.*

Connecting Signals

The OI1125 E/O Transmitter has two types of connectors for inputs and outputs.

Electrical Connectors

The OI1125 E/O Transmitter electrical input uses a high-performance SMA connector. Never attach a cable that has a worn or damaged connector because this may damage the OI1125 connector.

Use extra care when attaching or removing a cable from the connectors. Turn only the nut, not the cable. Use light finger pressure to make this initial connection. Then tighten the nut lightly with a wrench.

For best repeatability and to prolong the life of both the cable and instrument connectors, use a torque wrench and tighten the connection to the range of 79 to 112 N-cm (7 to 10 lb-in).

If the connectors will receive heavy use, such as in a production environment, you should install connector-saver adapters on the OI1125 E/O Transmitter to make connections to the device under test.

Optical Connectors

The output of the OI1125 E/O Transmitter can couple to optical fibers with a core diameter of up to 9 μm. Alternative optical connector types can be coupled by using the optional FC, ST, SC or DIN adapters. (Refer to *Optional Accessories* on page 3.)

If you connect fiber cores larger than 9 μm, the transmitter may still couple light, but the mismatch in core diameter will cause lower conversion gain and higher insertion loss.

All OI1125 optical connectors are angled physical contact (APC) connectors for improved return-loss performance. A keyway on the connectors ensures that the angled connectors mate together correctly.

A short, polarization-maintaining fiber (PMF) patch cord with FC/APC connectors is included with the transmitter. Use the patch cord when connecting the internal laser output to the modulator laser input.

To attach a fiber optic cable with FC/APC connectors to FC/APC input receptacles, refer to Figure 4 and do the following:

1. Unscrew the dust cover from the optical receptacle.
2. Clean your optical cables using the procedure on page 62.
3. Carefully align the keyway on the receptacle with the key on the connector.

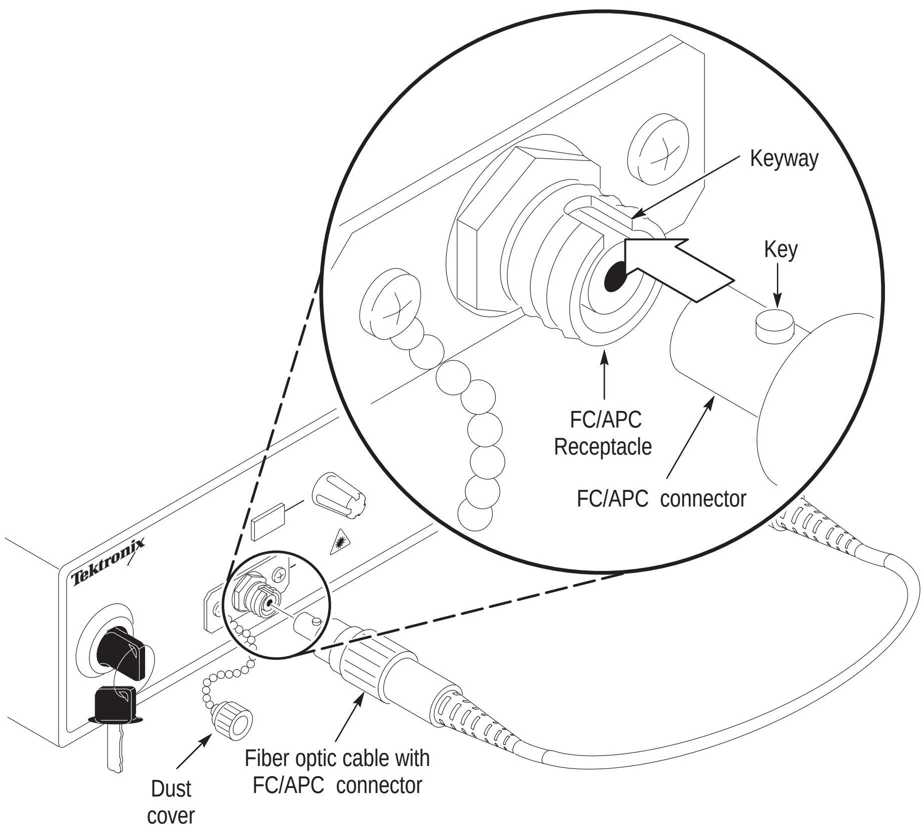

Figure 4: Connecting a fiber optic cable

4. Tighten the nut lightly with finger pressure only. Overtightening an optical connector may result in degraded optical signal performance.

Front Panel Connections and Controls

The front panel is functionally divided into two sections: the modulator and the internal DFB laser. The connectors for both sections are shown in Figure 5. Use the following descriptions to help you connect and use the transmitter in your system.

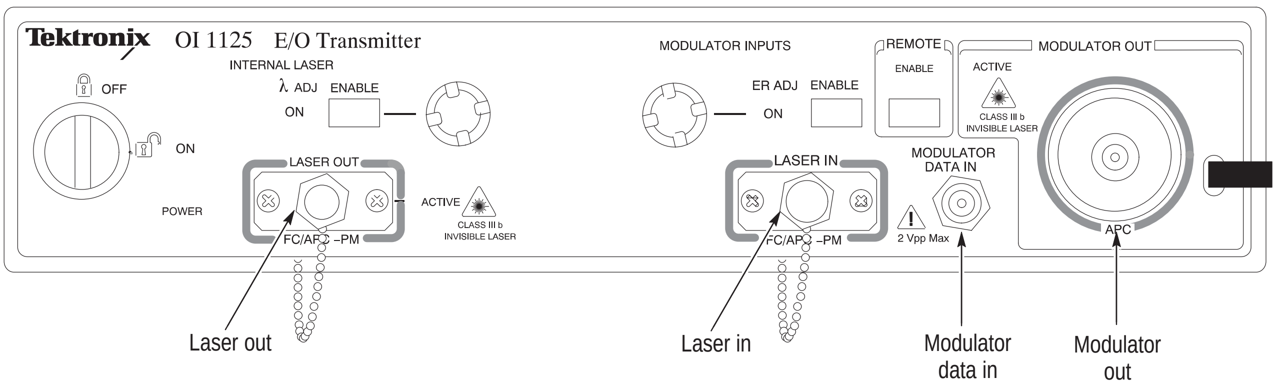

Figure 5: OI1125 front-panel connectors

Modulator Connectors

The modulator section has the following connectors:

MODULATOR DATA IN. This high-performance SMA connector is driven by a user-supplied electrical data source such as a BERT pattern generator. The Modulator Data In port is an AC-coupled connection that operates best with a balanced input data pattern, such as a SONET data stream or PRBS test pattern. When running high data-rate signals into this connector, use short, low-loss cables with high frequency connectors. Tektronix recommends the SMA cable that ships as a standard accessory with the transmitter for use with this connector.

LASER IN. This port can be driven by the internal laser or by a user-supplied external CW laser source. For correct operation of the modulator, the optical source must have a polarization-maintaining fiber (PMF) output and must be connected with a PMF fiber cable, terminated with an FC/APC optical connector keyed to the slow axis. A short PMF fiber patch cord is included as a standard accessory, and a 2 meter PMF cable is available as an optional accessory.

MODULATOR OUT. An angled, universal optical connector is used to allow greater flexibility in connector selection. An FC adapter is included with the transmitter as a standard accessory. Several different optical connector adapters are available as optional accessories. The Modulator Out Active LED illuminates when the Modulator Bias Control loop is stable. This LED may flash momentarily when either the optical or electrical inputs are first applied to the modulator.

Internal Laser Connectors

The Internal Laser section has the following connectors:

LASER OUT. The laser out connector provides the CW optical source from the internal DFB laser. The laser output is polarized for use by the modulator input and is sourced from an FC/APC connector. A PMF fiber cable must be used for this connection. If the internal laser is used as the optical source for the modulator, then use the PM jumper included with the transmitter.

The Internal Laser Active LED illuminates under the following conditions:

- The Internal Laser Off/On keyswitch is in the on position.
- The Laser Safety Interlock is attached to the rear-panel connector.
- The internal laser power and wavelength control feedback is stable.

When you power on the transmitter, the Internal Laser Active LED may flash momentarily while the internal laser power level and temperature stabilize. This LED may also flash momentarily when you adjust the internal laser wavelength.

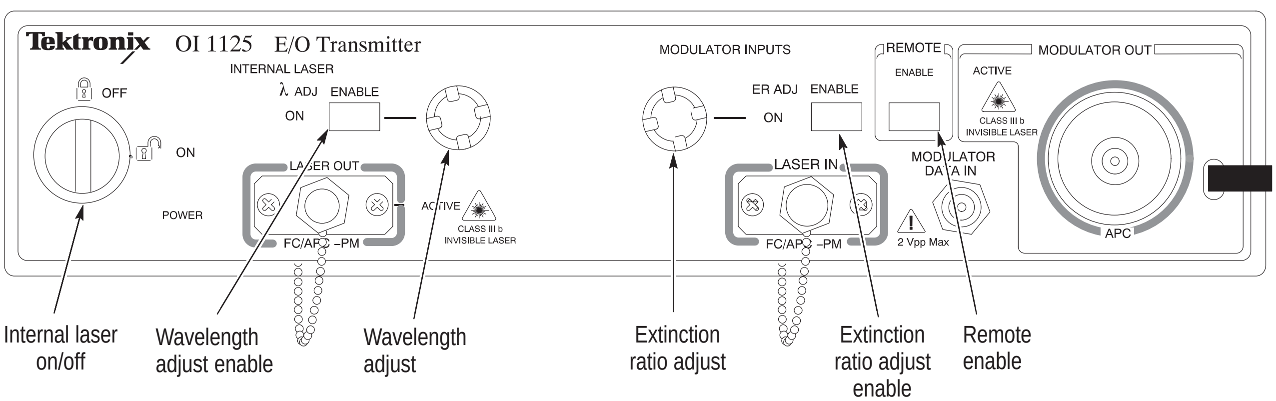

Figure 6: OI1125 front-panel controls

Use Figure 6 with the following descriptions of the front-panel controls.

Modulator Controls

There are two controls in the modulator section on the front panel of the OI1125. The controls are described below.

Extinction Ratio Adjust Enable. This momentary pushbutton switch allows you to switch between two modes of operation. When the switch is in the disabled mode, the enable LED is not lighted, and the calibrated extinction ratio setting is selected. This is the default mode when the instrument is powered on.

When the switch is in the enabled mode, the variable extinction ratio is enabled, and the LED next to the pushbutton switch illuminates. The extinction ratio adjust control is active in this mode. If this switch is pushed when the transmitter is in remote mode, the LED flashes momentarily.

Extinction Ratio Adjust. This control varies the extinction ratio of the transmitter output signal. The extinction ratio control allows you to optimize or degrade the extinction ratio (and to some extent, the jitter and eye quality). As you turn the control clockwise, the extinction ratio and eye pattern quality increase to an optimum point before you reach the extreme clockwise position. When the transmitter is in remote mode, this front-panel control is disabled.

Internal Laser Controls

Internal Laser controls are used to control the optical signal from the Laser Out connector. They are described in the following text.

Internal Laser Off/On. This keyswitch turns the DFB laser on and off. The rear panel laser safety interlock connector must be attached, or the laser disable signal on the laser remote port must be set to a logic low for the keyswitch to work.

When you rotate the keyswitch to the counterclockwise posititon, the key can be removed from the keyswitch to lock out operation of the internal laser.

The On LED illuminates when the keyswitch is rotated clockwise to the on position, and the laser safety interlock is attached. The On LED flashes if the keyswitch is rotated clockwise to the on position and the laser safety interlock has been removed.

λ Adj Enable. Use this pushbutton switch to switch from a calibrated wavelength to an adjustable wavelength. An LED next to the pushbutton illuminates when the adjustment is enabled. If you push this switch when the transmitter is in remote mode, the LED flashes momentarily.

λ Adjust. You control the wavelength of the internal DFB laser with this knob. The range of the control is ±1 nm. When the transmitter is in remote mode, this front panel control is disabled.

Remote Mode Controls

Use the remote mode controls to activate the rear-panel remote port.

Remote Enable. Use this pushbutton switch to toggle between local mode and remote mode. The default mode when you power on the instrument is local. When set to remote mode, the Remote Enable LED illuminates. The remote mode can be forced from the remote port with the Front Panel Unlock signal.

When the Front Panel Unlock signal is set to a logic low, remote mode is locked active. The Remote Enable LED will flash momentarily if you push the Remote Enable switch when attempting to return to local mode.

Rear Panel Connections and Controls

There are three connectors and one switch on the rear panel of the OI1125 E/O Transmitter. Use Figure 7 and the following descriptions to connect the transmitter to your system.

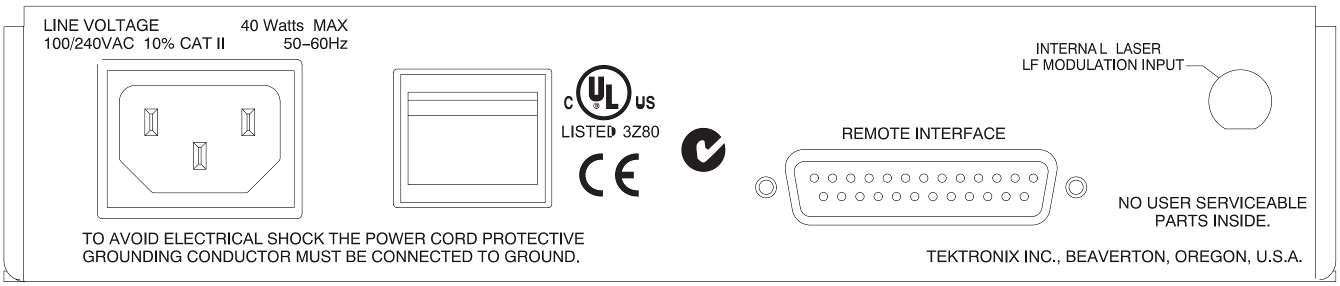

Figure 7: OI1125 rear panel

On/Off Switch

The on/off switch connects the line voltage from the power-in connector to the power supply in the instrument.

Power In

Plug the power cord into this connector. The connector accepts 90-240 VAC, 50-60 Hz, using any of the power cords available for the transmitter. The connector contains an integral AC power line filter.

Laser Modulator Input

This SMA connector accepts external 100 kHz to 10 MHz signals to modulate the optical output of the internal laser. This input can be used for low frequency modulation of the laser bias current.

Remote Interface

The remote interface allows for remote control of some of the instrument functions. For example, you can disable the internal laser remotely if someone enters the room in which the laser is being operated. Pins 1 and 2 provide the terminals to connect to a normally-closed remote door switch.

All of the front panel conntrols are available from the remote interface using a combination of TTL control signals for the switches and analog control signals for the adjustments. Status signals are available from the remote interface that monitor the modes of operation displayed on the front panel. Some control and status information for the OI1125 E/O Transmitter is only available from the remote interface.

See *Using the Rear-Panel Remote Interface* on page 15 for more information.

Using the Rear-Panel Remote Interface

This section describes using the rear-panel Remote Interface to select the transmitted signal.

NOTE*. For the internal laser to function, either the laser safety interlock or an external control circuit must be connected to the remote connector on the rear panel.*

Controlling Operation Locallly

When the REMOTE pushbutton switch on the front panel is in the disabled mode, the Remote Enable LED is not illuminated, and you can control the transmitter operation from the front-panel controls. To enable power to the internal laser, you must have the laser safety interlock plugged into the remote connector on the rear panel.

Laser Safety Interlock

The laser safety interlock connects pins 1 and 2 of the remote interface together, forcing the laser disable signal low, which activates the front-panel Laser Enable keyswitch. The laser safety interlock can be activated by installing this 25-pin male connector on the remote interface on the rear panel. See Figure 8.

The laser safety interlock is used together with the Laser Enable keyswitch on the front panel to provide a redundant laser enable control for safety purposes. When the laser safety interlock is removed from the remote interface, an internal pull-up resistor on pin 2 forces the laser disable signal high, which deactivates the front-panel Laser Enable keyswitch.

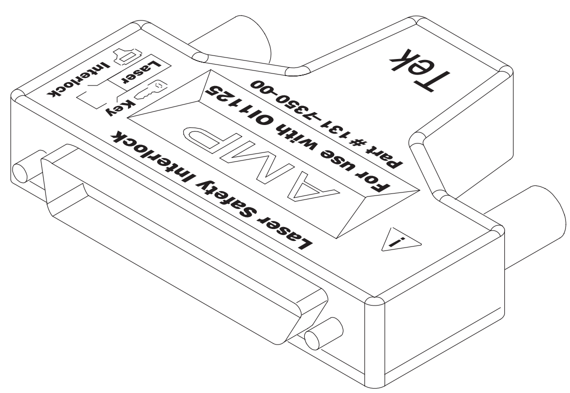

Figure 8: Laser safety interlock

Controlling Operation Remotely

When the REMOTE pushbutton switch on the front panel is in the enabled mode, the Enable LED is illuminated, and you control the transmitter operation through the rear-panel remote interface. Refer to Figure 9 and Table 5 for the connector pinout and signal descriptions.

In remote mode when no TTL signal is applied at the rear-panel connector, the default state of all remote control inputs is high due to internal pull-up resistors.

Remote Interface

The Remote Interface is implemented with a 25-pin, male D connector on the rear panel. Figure 9 illustrates the pinout. The interface uses +5 volt logic levels, and ±2.5 volt analog control levels. It allows the remote control and monitoring of the following parameters:

- Laser lockout, laser power, and temperature monitoring
- Variable extinction ratio enable, disable, and adjust
- Modulator input detect and bias stability monitoring
- Variable wavelength enable, disable, and adjust
- Variable % Crossing enable, disable, and adjust
- Front-panel control lockout
- Front-panel laser keyswitch status

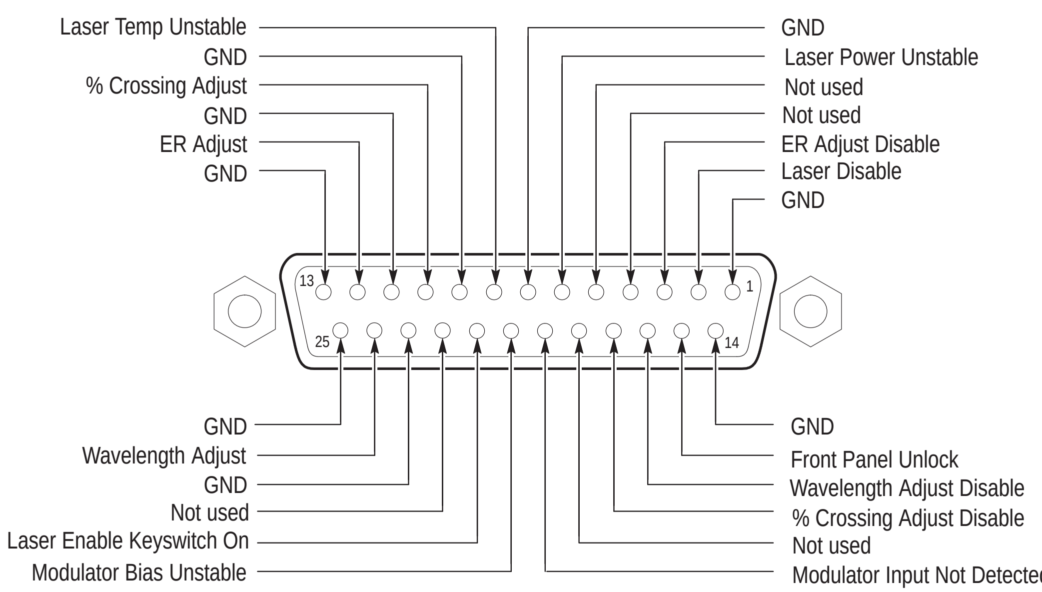

Figure 9: Remote Interface connector pinout

Table 5 lists the signal descriptions for the Remote Interface connector. Unless otherwise noted, the signals are active in both local and remote operating modes.

Table 5: Remote Interface signals

Pin num-ber	Signal name	Signal type	Description
Several	Ground	Analog, Digital	Pin numbers 1, 7, 9, 11, 13, 14, 23, 25
2	Laser Disable	Digital input	The internal laser is disabled when this signal is high. The Remote Safety Interlock, when connected for local operation, shorts this signal to ground.
Several	Not used	———	Pin numbers 4, 5, 18, 21, 22
6	Laser Power Unstable	Digital output	This status signal is driven high when the Internal Laser power control loop is detected to be in an unstable state, or the laser is powered off.
8	Laser Temperature Unstable	Digital output	This status signal is driven high when the Internal Laser temperature control loop is detected to be in an unstable state, such as momentarily when the wavelength is adjusted. This signal is low when the laser is powered off.
15	Front Panel Unlock	Digital input	When driven low, this input signal disables the front-panel controls and forces remote mode.
19	Modulator Input Not Detected	Digital output	This status signal is driven high when the modulator bias control loop optical signal photodetector detects a valid threshold. This signal is low when the laser is powered off.
20	Modulator Bias Unstable	Digital output	This status signal is driven high when the modulator bias control loop is detected to be in an unstable state, such as momentarily when the modulation signal is connected or removed. It is low when the modulation bias stabilizes or the laser is powered off.
3	ER Adjust Disable	Digital input	When driven low, this signal illuminates the front-panel Extinction Ratio Adjust LED, indicating that the Modulator Driver is not in the calibrated gain state. When this signal is high, the Modulator Driver is in the calibrated state and the ER Adjust Control signal is disabled. This signal is active in Remote mode only.
12	ER Adjust	Analog input	This control signal can be used to control the extinction ratio by varying the Modulator Driver gain. In Remote mode, the front panel ER Adjust control is inactive, and the ER is controlled by the analog signal. The input range is ±2.5 V, which adjusts the extinction ratio from <5 dB to >12dB. Due to component variation, the maximum extinction ratio may not be at +2.5 V. This signal is active in remote mode only.
16	Wavelength Adjust Disable	Digital input	When driven low, this signal illuminates the front-panel Wavelength Adjust Enable LED, indicating that the wavelength is not in its calibrated state. When this signal is high, the wavelength is in its calibrated state, and the Wavelength Adjust signal is disabled. This signal is active in Remote mode only.
24	Wavelength Adjust	Analog input	This signal can be used to control the internal laser wavelength. In Remote mode, the front-panel Wavelength Adjust control is inactive, and the wavelength is controlled by the analog signal. The input range is ±2.5 V, which adjusts the wavelength at least ±1 nm. This signal is active in Remote mode only.
17	% Crossing Adjust Disable	Digital input	When driven low, this input signal allows the % crossing adjustment to be controlled remotely through a ±2.5 V signal on pin #10. This signal is active in Remote mode only.
10	% Crossing Adjust	Analog input	The input range is ±2.5 V, which adjusts the % crossing at least 45% to 55%. This signal is active in Remote mode only.
21	Laser Enable Keyswitch On	Digital output	This signal is high when the front-panel Laser Enable keyswitch is rotated clockwise to the On position, and low when the keyswitch is rotated counterclockwise to the Off position.

Specifications

This section contains the specifications of the OI1125 E/O Transmitter. All specifications are guaranteed unless labeled “typical”. Typical specifications are provided for your convenience but are not guaranteed. All specifications marked with the ✓ symbol are guaranteed and have corresponding checks in the *Performance Verification* section on page 31.

Table 6: Specifications

Specification			Description
Modulator Data Input			
✓	Data Rate		2.488 Gb/s to 12.5 Gb/s (functional down to less than 622 Mb/s with degraded performance)
✓	Input Amplitude	Operating	Optical output specifications maintained over an input voltage range of 0.25 to 1.50 V_{p-p}, except where noted.
		Maximum AC	< 2 V_{p-p}
		Maximum DC	$< \pm 10$ V
	Input Impedance		50 Ω AC coupled
	Input Electrical Return Loss		> 10 dB, 100 MHz to 8 GHz
	Input Duty Cycle		45% to 55%
	Input Connector		Female SMA jack
	Data Pattern Run Length Limit		100 bits
Modulator Optical Input			
✓	Wavelength		1530 nm to 1565 nm
✓	Input Power	Operating	+5 dBm to +12 dBm
		Maximum	+16 dBm
	Input Return Loss		> 45 dB
	Input Connector		FC/APC with internal Panda-type PMF fiber and dust cover
Modulator Optical Output			
✓	Output Power		0 dBm to +4 dBm (with internal laser)
✓	Polarity		Noninverting
	Output Return Loss		> 45 dB
	Modulator Insertion Loss		< 8 dB
	Output Rise Time	20 - 80%	< 35 ps
	Extinction Ratio (AC)	variable	< 5 dB to > 12 dB
✓		nonvariable	> 12 dB (2.488 Gb/s to 9.953 Gb/s) > 10 dB (9.953 Gb/s to 12.50 Gb/s)
	Output Connector		Universal/APC with safety cover (FC adapter is standard)

Table 6: Specifications (Cont.)

Specification		Description
✓	Eye Crossing %	50% ± 5% (with input % crossing 48% to 52%)
✓	Mask Testing	No mask hits with 5% mask margin for OC-48, OC-192, and scaled 12.50 Gb/s SONET masks
	Output Overshoot	< 10%
✓	Jitter Generation p-p	0.15 UI $_{p-p}$, 2.488 Gb/s to 9.953 Gb/s (using PRBS 2^{31} –1 pattern)
		< 18 ps $_{p-p}$, 9.953 Gb/s to 12.50 Gb/s, with input amplitude 0.5 V $_{p-p}$ to 1.5 V $_{p-p}$
✓	Jitter Generation RMS	0.02 UI $_{rms}$, 2.488 Gb/s to 9.953 Gb/s (using 0000000011111111 pattern)
		< 2 ps $_{rms}$, 9.953 Gb/s to 12.50 Gb/s
	Chirp	< ± 4 GHz
Internal Laser Output		
✓	Wavelength	1550.92 nm ± 0.1 nm
✓	Wavelength Adjustment Range	> ± 1 nm
✓	Output Power	+10 dBm ± 1 dBm, Class III b
	Output Power Stability	< ± 0.02 dB over a one hour period at 25 °C ± 5 °C
	Output Return Loss	> 45 dB
	Output Connector	FC/APC with internal Panda-type PMF fiber and safety cover
	Spectral Width	< 10 MHz
	Side Mode Suppression	> 30 dB
	Output Optical Isolation	> 30 dB
	Optical Polarization Extinction Ratio	> 20 dB
Remote Port Interface Connector		
	TTL remote control logic control voltage levels	Input HIGH voltage (V_{IH}): 2.0 V minimum Input LOW voltage (V_{IL}): 0.8 V maximum Voltages are relative to GND on the 25-pin remote connector
		Output HIGH voltage (V_{IH}): 2.4 V minimum Output LOW voltage (V_{IL}): 0.5 V maximum Voltages are relative to GND on the 25-pin remote connector
	Analog Control Inputs	Analog Control Range: ± 2.5 V
	Remote Port ESD Protection	Each pin on the DB25 connector is protected with a 100 Ω series resistor followed by protection diodes tied to ground and +5 V
Power Supply		
	External AC levels	100 V to 240 V ± 10%, 50 to 60 Hz, < 40 W; CAT II

Table 7: Environmental characteristics

Specification	Description
Temperature, nonoperating	(–55 °C to +75 °C) The environmental exposure is the procedure stated in Tektronix Design Standard 062-2847-00 for Class 6 equipment.
Temperature, operating	0 °C to +40 °C (32 °F to 104 °F) This procedure conforms to the temperature portion of the test in MIL-T-28800E for Type III, Class 6 equipment, using the limits above.
Humidity, nonoperating	0% to 75% relative humidity from +30 °C to +60 °C.
Humidity, operating	0% to 80% relative humidity to +31 °C, decreasing at a linear rate to 50% at +40 °C, minimum.
Random vibration, nonoperating	2.46 g_{RMS}, from 5 to 500 Hz, 10 minutes each axis. Tektronix Standard 062-2858-00 rev. B modified, Random Vibration, Tektronix Class 3 with power spectral density break-points as follows: Constant 0.020 g^2/Hz from 5 Hz to 100 Hz, then falls at –3 dB/octave from 100 to 200 Hz, then constant 0.010 g^2/Hz from 200 to 350 Hz, then falls at –3 dB/octave from 350 to 500 Hz to 0.007 g^2/Hz @ 500 Hz.
Random vibration, operating	0.31 g_{RMS}, from 5 to 500 Hz, 10 minutes each axis. Tektronix Standard 062-2858-00 rev. B, Random Vibration, Tektronix Class 3
Packaged product vibration and shock	The packaged product qualifies under the Distribution Cycle 1 Assurance Level II for packaged products 0 to 20 lbs. Test 2 for Warehouse and Vehicle Stacking (compression) is omitted. Tektronix standard 062-2858-00, Rev. B.
Altitude, operating and nonoperating	Operating: 3000 m (9847 ft) Nonoperating: 12190 m (40,000 ft) MIL-T-2880E modified for more exposure time and more severe test levels than required for any Type III equipment regardless of Class.
Weight — instrument only	1.72 kg (3.79 lb.)
Weight — shipping	5.22 kg (11.5 lb.), including standard accessories
Dimensions	45 mm x 204 mm x 331 mm (1.75 in x 8.0 in x 13 in) (H x W x D)

1 **The humidity limits are derived from a psychrometric chart using a maximum wet bulb temperature of 29 °C. The highest RH (20%) at the maximum temperature (+60 °C) diverges from the psychrometric chart (which would indicate 6%). The 20% number is a practical limit. Test chambers cannot be set below this number.**

Table 8: Electromagnetic compatibility (EMC)

<table>
<tr><th>Specification</th><th>Description</th></tr>
<tr><td>Emissions</td><td>Emissions shall be within the limits specified by the following requirements.

Enclosure:
EN 55011 Class A limits for radiated emissions
AC Mains:
EN 55011 Class A limits for conducted emissions
Emissions:
EN 61000-3-2 AC power line harmonic emissions
EN 61000-3-2 AC power line fluctuation
AS/NZS 2064, Australian emission standard for Industrial, Scientific, and Medical Equipment

Use only high quality shielded interface cables having a reliable, continuous outer shield (braid and foil) that has low impedance connections to shielded connector housings at both ends.</td></tr>
<tr><td>Immunity, enclosure, electrostatic discharge (ESD)</td><td>Up to 8 kV air discharge and 4 kV contact discharge with no change to control settings, no impairment of normal operation, and no damage that prevents recovery of normal operation by the user.</td></tr>
<tr><td>Immunity, fast transients, electrical</td><td>No loss of stored data, change to control settings, degradation of performance, or temporary loss of function will occur when the system is subjected to the transients as described below:
<table>
<tr><th>Port</th><th>Peak Voltage (kV)</th><th>Tr/Th (ns)</th><th>Rep. Freq. (kHz)</th></tr>
<tr><td>Signal and Control</td><td>0.5</td><td>5/50</td><td>5</td></tr>
<tr><td>AC Power</td><td>1.0</td><td>5/50</td><td>5</td></tr>
</table>
IEC 61000-4-4</td></tr>
<tr><td>Immunity, AC power line source voltage dips and interruptions</td><td>Voltage Dips:
30% reduction/10 ms, as per EN 61000-4-11
60% reduction/100 ms, as per EN 61000-4-11
Voltage Interruptions:
> 95% reduction/5 seconds as per EN 61000-4-11
100% reduction/1 cycle as per EN 61326</td></tr>
<tr><td>Immunity, AC power line transients</td><td>No loss of stored data, change to control settings, degradation of performance, or temporary loss of function will occur when the system is subjected to the transients as described below:
<table>
<tr><th>Mode</th><th>Peak Voltage[1]</th></tr>
<tr><td>Common</td><td>2 kV</td></tr>
<tr><td>Differential</td><td>1 kV</td></tr>
</table>
IEC 61000-4-5</td></tr>
</table>

Table 8: Electromagnetic compatibility (EMC) (cont.)

Specification	Description
Immunity, conducted disturbances induced by RF fields	No instrument failures when the instrument power leads are injected with a 150 kHz to 80 MHz, 3 V_{RMS} signal 80% amplitude modulated at 1 kHz. IEC 61000-4-6

1 **2/50 us Tr/Th voltage into open circuit, 8/20 us Tr/Th current into short circuit.**

Table 9: Safety characteristics

Specification	Description
Power consumption	<40 W when powered from AC line
Source frequency	47 to 63 Hz
Safety certifications	UL3111-1, CAN/CSA-C22.2 No. 1010.1
EC Declaration of Conformity - Low Voltage	Compliance was demonstrated to the following specification as listed in the Official Journal of the European Communities:
	Low Voltage Directive 73/23/EEC, amended by 93/68/EEC
	EN 61010-1/A2:1995 Safety requirements for electrical equipment for measurement control and laboratory use.

Laser Safety Label

The label shown in Figure 10 is affixed to the top of the instrument cabinet. To prevent personal injury, it is important that you heed all cautions when working with laser equipment.

Figure 10: Laser warning label

WARNING

The following servicing instructions are for use only by qualified personnel. To avoid injury, do not perform any servicing other than that stated in the operating instructions unless you are qualified to do so. Refer to all safety summaries before performing any service.

Theory of Operation

This section describes the electrical and optical circuit operation of the transmitter at the block diagram level. Refer to Figure 11 as you read the circuit description.

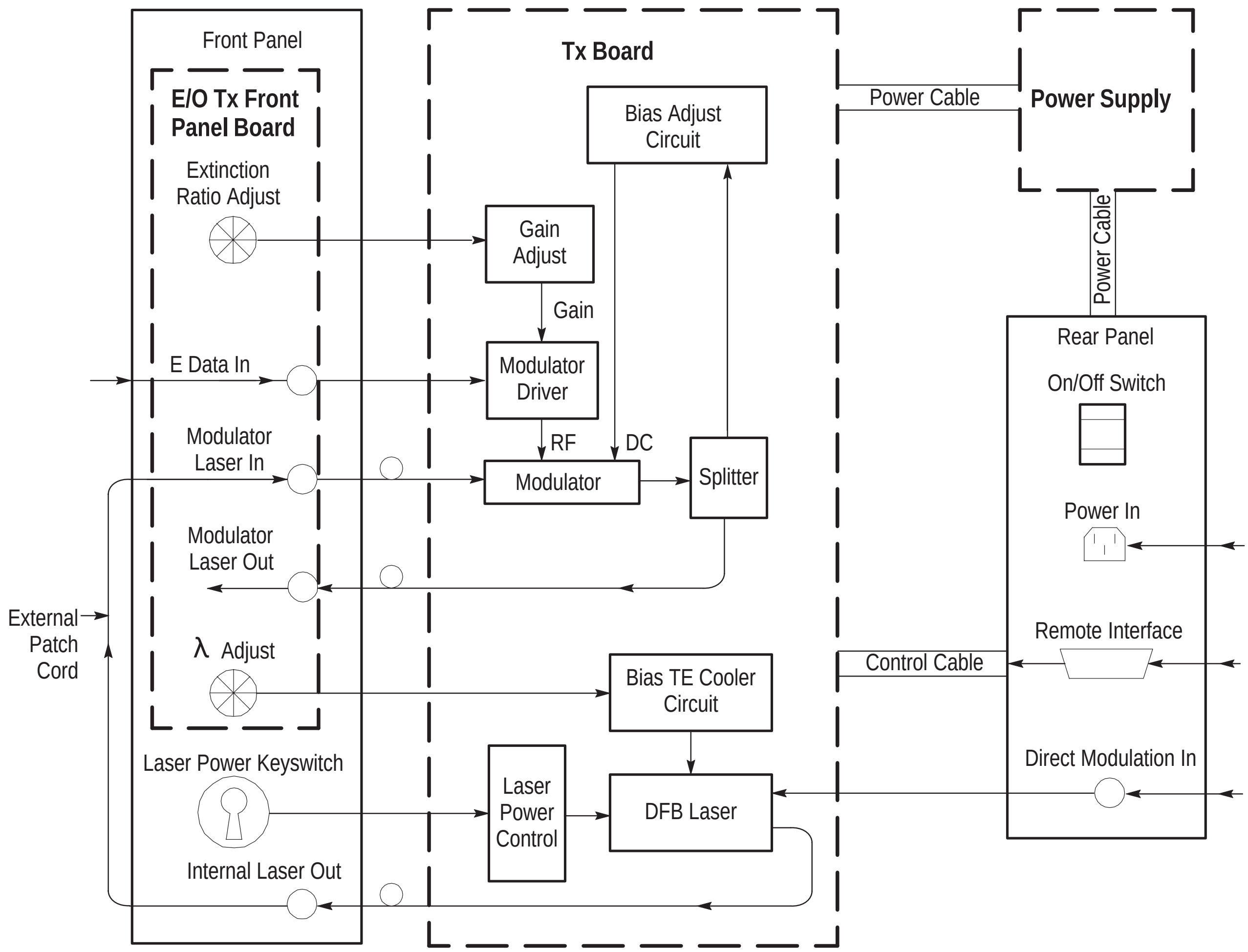

Figure 11: Transmitter interconnect diagram

The OI1125 E/O Transmitter is made up of four interconnected assemblies: the front and rear panels, the main transmitter board, and the DC power supply.

Front Panel

The front panel of the transmitter provides access to most of the connectors and the manual controls for the instrument. FC/APC-PM connectors are used for both the internal laser output and the modulator laser input. An external optical patch cord connects the two when the internal laser is used as the optical source.

A modulated electrical data signal connects to a high-quality SMA connector and is routed internally to the modulator driver on the transmitter board. The modulated optical signal is routed to a single-mode fiber, universal optical output connector.

A keyswitch with a removable key enables the internal laser, and laser status is displayed with indicators backlit by green LEDs. Potentiometers and pushbutton switches control the front-panel adjustments.

Rear Panel

The rear panel of the transmitter has four components: the AC line cord connector, the power on/off switch, the laser direct modulation input connector, and the remote interface connector.

When any of the international power cords available for the transmitter are connected to the AC connector, the power is passed through to the power on/off switch. When the switch is turned on, the AC line is connected to the power supply input.

The laser direct modulation input connector is an SMA connector that accepts a low frequency (<10 MHz) electrical signal. This signal can be used to directly modulate the internal optical signal for identification or other special purposes.

The remote interface is a 25-pin D-connector that provides remote control of all the front panel control features, as well as access to all status indicators. The remote port is primarily a TTL control/status interface with analog voltage control of the front panel control knobs.

The laser safety interlock control, which provides a redundant shutoff capability for the internal laser, is also implemented with a control pin on the remote interface connector.

Transmitter Board

The transmitter board is comprised of two main circuits: the internal laser, and the modulator and related support circuitry.

Internal Laser. The internal laser is a distributed feedback (DFB) laser module with an output power level high enough for Class IIIb rating. The laser module includes a polarization-maintaining fiber (PMF) connection to the front panel so that either the internal laser or an external, tunable laser can be used to drive the modulator. The modulator requires that its input optical source has the correct orientation of its polarization to operate properly.

Both the internal laser power level and wavelength are stabilized by feedback control circuits. The power level is controlled with a laser power supply that is adjusted in response to a photodetector in the laser module.

The wavelength of the internal laser is internally calibrated, or it can be adjusted over a small range using the front panel λ control. The wavelength is controlled by varying the temperature of the laser diode with a thermoelectric cooler and thermistor temperature sensor.

Modulator. The modulator is an electro-optic transducer that modulates the optical input in response to an electrical modulation signal. The modulator used is a titanium-diffused, lithium niobate modulator designed for 10 Gb/s operation. The modulation is done with a Mach-Zehnder technique, where the electric fields from the modulation input interact with the optical signal as it propagates down the optical waveguide, causing interferometer effects. The use of the Mach-Zehnder modulator results in high-performance optical modulation with low chirp.

The electrical interface to the modulator requires both DC control and RF signal inputs. The DC control input to the modulator is designed to maintain a quadrature bias condition for optimal output signal quality. The quadrature bias point is automatically controlled with a bias feedback control circuit that adjusts for bias drift with temperature and time. The RF signal input to the moduator requires a modulator driver amplifier to decrease the required drive level of the electrical modulation input.

The modulator driver in the transmitter is a limiting amplifier with gain control capability. The limiting response of the modulator driver gives a flat output signal for a relatively broad input amplitude range. The gain control feature of the modulator driver allows for variable control of the optical output extinction ratio. The modulator driver also features an internal bias control circuit that allows for eye pattern crossing point adjustment. This crossing point adjustment is only available from the remote port.

DC Power Supply

The AC line voltage from the rear panel is fed to the power supply input, through the rear-panel power switch. The DC power supply is a switching supply that converts the line voltage (100 – 240 VAC ±10%) to DC supply voltages that are used by the circuitry on the transmitter board.

Performance Verification

Use the following procedures to verify the warranted specifications of the OI1125 E/O Transmitter. The recommended calibration interval is one year. These procedures test the specifications listed in Table 10. Some specifications, such as the modulator inputs, are checked indirectly in the eye pattern test matrix.

Table 10: PV checks

Characteristic	Specification
Internal Laser Output	Output Power
	Output Wavelength (Calibrated)
	Output Wavelength (Variable)
Modulator Checks	Jitter (RMS)
	Modulator Polarity
Eye Pattern Test Matrix	
Input Parameters	
Modulator Data Input	Data Rate
	Input Amplitude
Modulator Optical Input	Input Wavelength
	Input Power
Modulator Output Measurements	
Using internal laser input:	Average Output Power
	Extinction Ratio (Calibrated)
	Jitter (p-p)
	% Crossing
	Eye Pattern Mask Testing
Using external laser input:	Average Output Power
	Extinction Ratio (Calibrated)
	Jitter (p-p)
	% Crossing
	Eye Pattern Mask Testing

Prerequisites

The tests in this section comprise an extensive, valid confirmation of performance and functionality when the following requirements are met:

- The instrument must have been last calibrated and adjusted at an ambient temperature between +20 °C and +30 °C, must have been operating for a warm-up period of at least 30 minutes, and must be operating in an environment with temperature, altitude, humidity, and vibration within the operating limits described in *Environmental characteristics* on page 21.
- The test equipment (oscilloscope, pattern generator, tunable laser and optical meters), must be operating for a warm-up period of at least 30 minutes.

Equipment Required

Table 11 lists the equipment required to perform the performance verification procedure. The types and quantities of connectors may vary depending on the specific equipment you use.

CAUTION. *To prevent damage to your equipment and cables, use the proper type optical connectors. The optical connection styles shown in the test setups are correct for the equipment called out in Table 11 below. If you use alternative equipment, verify the connection style of the alternative equipment, and use the appropriate cable or adapter.*

Table 11: Test equipment

Description	Minimum requirements	Example product
Sampling oscilloscope with optical sampling head	Bandwidth: 20 GHz with limiting filters for OC 48, OC192, and 12.5 Gb/s Jitter: < 1 ps at min samp delay	Tektronix TDS8000 with 80C01 optical sampling head
Pattern generator	< 2.4 Gb/s to > 12.5 Gb/s, PRBS 2^{31-1}	Advantest D3186 with options 13 and 72
Wavelength meter	1530 nm to 1565 nm	Burleigh WA-1100
Optical power meter with optical power head	1550 nm, +15 dBm to –40 dBm, 0.01 dBm resolution, ±5% accuracy	Advantest Q8221 with Q82227 power head
Tunable Laser	10 dBm output power over 1530 nm to 1565 nm range, PMF-style output connector	Tunics BT-1560 w/high power option
Cable, low-loss coax (2)	50 Ω, SMA male each end, ~1 m	Tektronix part number 015-0561-00
Cable, coax	50 Ω, SMA male each end, 1 m	Tektronix part number 174-1341-00

Table 11: Test equipment (cont.)

Description	Minimum requirements	Example product
Optical cable, PM	FC-APC Single mode, 18 cm	Tektronix part number 174-4664-00
Optical cable, PM	FC-APC Single mode, 2 m	Tektronix part number 174-4725-00
Optical cable	FC-APC to FC/PC, Single mode, 2 m	Tektronix part number 174-4727-00
Attenuator, electrical	6 dB, 50 Ω, SMA	Tektronix part number 015-1001-00
Torque wrench	5/16-in, 7-10 in-lb. (8 mm, 79 to 112 N-cm)	Pasternack Enterprises PE 5011-1

Setup For PV

1. Before beginning these procedures, photocopy the test record on page 57 and use it to record the performance test results.
2. Install the laser safety interlock on the back of the instrument, or short pins 1 and 2 of the DB-25 remote port connector. (See Figure 9 on page 16.)

Internal Laser

The following procedures check the output power and wavelength of the internal laser circuit.

CAUTION. *To prevent eye damage, always disable the laser with the front-panel keyswitch when making optical connections.*

Output Power

Check the output power of the internal laser in the transmitter by doing the following:

1. If the optical patch cord between the internal laser output and the modulator optical input is connected, disconnect it from the front of the instrument.
2. Connect the internal laser output to the optical power meter input, using the FC/APC-to-FC single mode cable. See Figure 12.
3. Enable the laser by turning the keyswitch clockwise (to the unlocked position). The Laser On LED and Laser Output Active LED both light.
4. Set the power meter to display units in dBm.
5. Check that the measured optical power is within the limits on the test record, and record the value of the measured optical power on the test record.
6. Disable the laser by turning the keyswitch counterclockwise to the locked position. The Laser On LED and Laser Output Active LED both turn off.

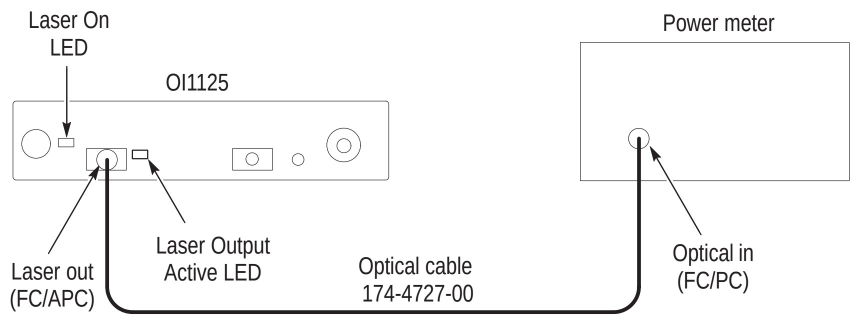

Figure 12: Setup for the output power test

Output Wavelength

Check the output wavelength of the internal laser by doing the following:

CAUTION. *To prevent eye damage, always disable the laser with the front-panel keyswitch when making optical connections.*

1. Connect the internal laser output to the wavelength meter input, using the FC/APC-to-FC/PC single mode cable. See Figure 13.
2. Enable the laser by turning the keyswitch clockwise (to the unlocked position). The Laser On LED and Laser Output Active LED both light.
3. Verify that the λ Adj Enable pushbutton switch is disabled (the λ Adj On LED to the left of the switch is not lighted).

NOTE. *The Laser Output Active LED may flash briefly while the laser stabilizes.*

4. Check that the wavelength displayed on the meter is within the limits on the test record, and record the wavelength on the test record.
5. Push the λ Adj Enable switch to enable the adjustment knob (the LED to the left of the switch lights).
6. Vary the λ Adjust control on the front panel, from fully counterclockwise (minimum), to fully clockwise (maximum). Check that the wavelength displayed at both extremes is within the limits on the test record, and record the measured wavelengths on the test record.

NOTE. *The Laser Output Active LED may flash briefly while the laser stabilizes.*

7. Disable the laser by turning the keyswitch counterclockwise to the locked position. The Laser On LED and Laser Output Active LED both turn off.
8. Disconnect the cable from the wavelength meter.

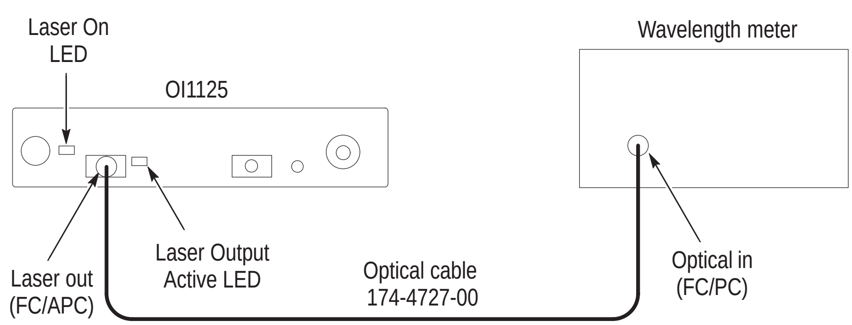

Figure 13: Setup for the output wavelength test

Modulator Checks

The following procedures check the RMS jitter and the polarity of the laser waveform in the modulator circuit.

RMS Jitter

This test checks the RMS jitter on a histogram display of the leading edge of the modulator output optical waveform.

Test Overview.

1. Set up the equipment as shown in Figure 14.
2. Set the BERT parameters.
3. Compensate the oscilloscope.
4. Set the oscilloscope measurement parameters.
5. Preview the waveform.
6. Take measurements.

Test Setup.

1. Connect the equipment as shown in Figure 14. A torque wrench is recommended for securing the SMA connections to 7 to 10 lb-in (79 to 112 N-cm).

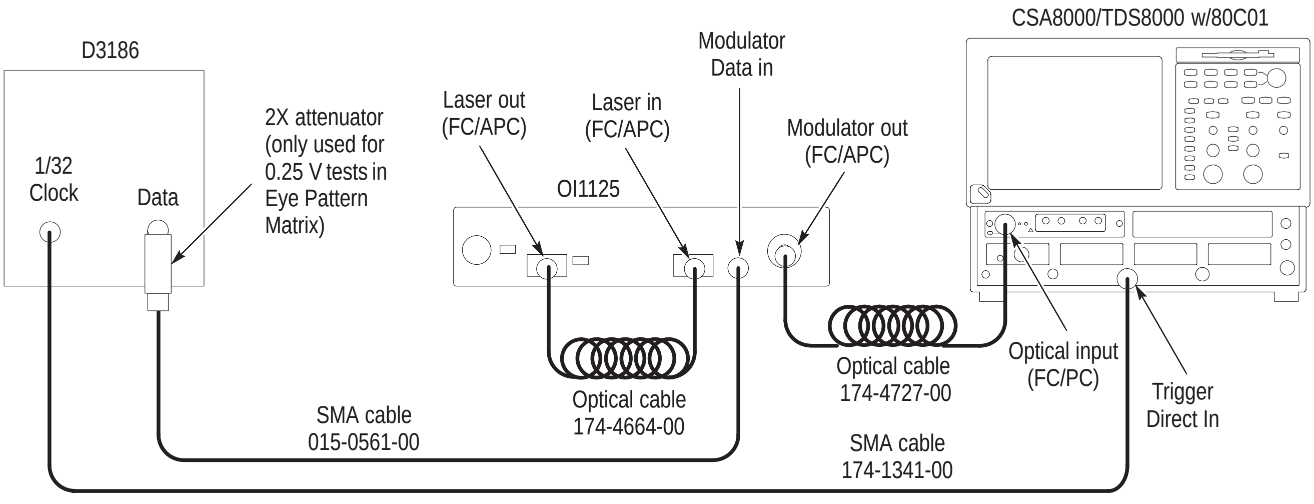

Figure 14: Setup for the RMS Jitter test

BERT. Set the BERT settings as follows:

2. Set the BERT bit rate to 2.48832 Gb/s (SONET OC-48 rate):

   a. In the CLK ADJ section, select Memory # to assign a number to the bit rate. This is the memory number that you will use to recall this bit rate. Suggestion: Use 1 for 2.48832, 2 for 9.95328, and 3 for 12.50000 Gb/s.

NOTE*. Store the bit rate settings so that you can recall them when completing other tables in the PV procedure.*

---

   b. Press Edit.

   c. Use the dial or arrow keys to input the bit rate. The left and right arrow keys select the digit to be changed. An annunciation dot appears to the left of the digit to be changed. The up and down arrow keys select the value of the digit selected.

   d. When you have the correct bit rate entered (2.48832 Gb/s), press Store and Edit to assign this bit rate to the memory number that you selected in step **a**.

3. Repeat steps 2a through 2d for 9.95328 Gb/s and 12.50000 Gb/s bit rates.

4. Recall the 2.48832 Gb/s bit rate.

5. Set the word pattern to 16 bit, 0-0-0-0-0-0-0-0-1-1-1-1-1-1-1-1:

   a. In the Pattern Mode section, press the Word button.

   b. Using the arrow keys, select Patt Data.

   c. In the Pattern section, press Edit.

   d. In the Pattern Length section, set the word length to 16.

   e. Set bits 1-8 to 0, and set bits 9-16 to 1.

6. Disable the crossing point adjust.

7. Set the trigger output to 1/32 clock.

8. Set the output mode to AC.

9. Turn the data output on, and set the data amplitude to 1.5 $V_{p\text{–}p}$.

Compensate the Oscilloscope. The optical sampling heads are susceptible to temperature fluctuations. Therefore, do the following prior to taking measurements:

1. Disconnect the optical cable from the input to the oscilloscope.
2. Execute a compensation of the optical sampling head as soon as the sampling head has reached operation equilibrium (that is, after a 30 minute warm-up). Compensation for the entire system or for an individual optical module can be initiated from the Utilities menu Compensation command. For more information, see *Optimizing Measurement Accuracy* in the main instrument user manual.

Oscilloscope. Set the TDS8000 Vertical settings as follows:

***NOTE**. Due to differences in oscilloscope firmware, your setup steps may differ slightly.*

---

3. From the toolbar, select Setup→Vertical.
4. Click the Optical>> button.
5. Set the Signal Conditioning mode:
   a. In the Wavelength field, select 1550 from the drop-down menu.
   b. In the Filter field, select OC-48 from the drop-down menu.

***NOTE**. You must change the Filter field setting when you take measurements at other data rates. See Table 12.*

A filter is not used for the 12.50 Gb/s data rate. Instead, set the Filter field to None, and set the bandwidth to 12.50 GHz.

Table 12: Signal conditioning mode settings

Data rate, Gb/s	Wavelength field setting	Filter field setting	Bandwidth setting, GHz
2.488320	1550	OC-48	———
9.953280	1550	OC-192	———
12.500000	1550	None	12.50

6. Select the Horz tab to set the horizontal parameters.

   a. In the All Timebases box, set the Mode field to Short Term Jitter from the drop-down menu.
   b. Set Units to Seconds.

7. Select the Trig tab to set the trigger parameters.
   a. In the Trigger Source box, select External Direct.
8. Close the Setup window.

Preview the Waveform.

9. Enable the laser by turning the keyswitch clockwise (to the unlocked position). The Laser On LED and Laser Output Active LED both light.
10. Turn on the channel that the optical module is plugged into.
11. Press Autoset.
12. Press the Clear Data button and then the Run/Stop button on the oscilloscope to display a waveform as shown in Figure 15 on page 40.

***NOTE**. You may need to adjust the location of the rising edge of the waveform, and the size of the histogram box to have your display resemble Figure 15.*

Follow the procedure in Take Measurements *to get the correct display.*

---

13. Select the Hist tab to set the histogram parameters.
    a. In the source box, set Source to the optical channel you are using.
    b. Check the Enable Histogram box.
    c. Check the Horizontal box.
    d. Check the Use Waveform Database box.
    e. In the Display box, check Histogram and Linear.

Take Measurements. Refer to Figure 15 as you align the waveform.

1. Press the Clear Data button, and then the Run/Stop button on the oscilloscope to display a waveform as shown in Figure 15.
2. Align the rising edge of the waveform with the center of the oscilloscope graticules.
3. Reduce the vertical size of the histogram box as small as possible.

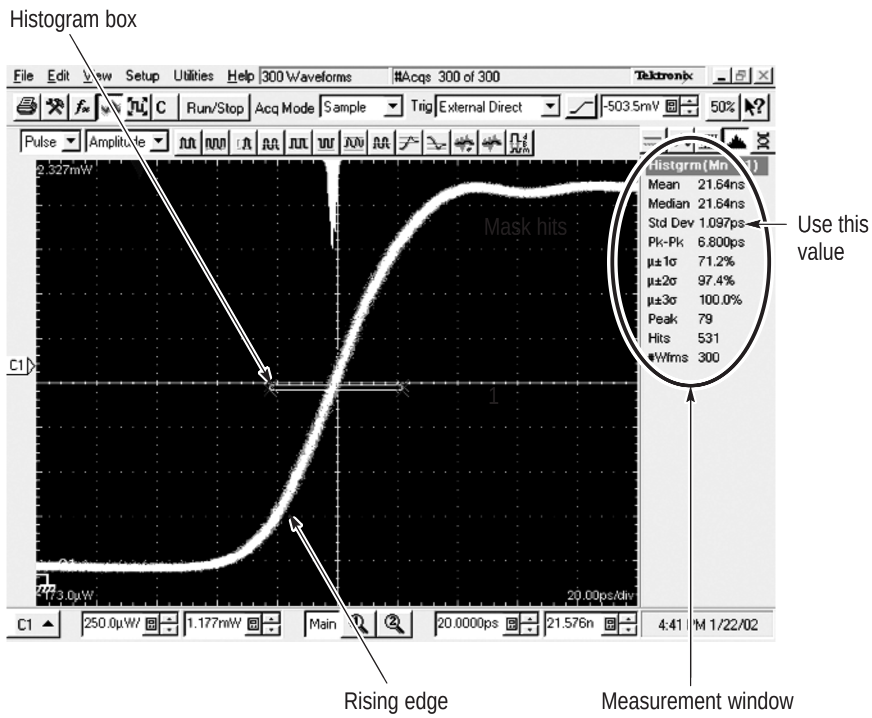

Figure 15: RMS Jitter measurement

4. Select the Acq tab to set the acquisition parameters.
   - **a.** In the Stop After box, select Condition.
   - **b.** In the Condition field, select Number of Acquisitions from the drop-down menu.
   - **c.** Enter 300 (# of acquisitions) in the field below the Condition field.
   - **d.** In the Stop Action box, select None.
5. Press the Clear Data button and then the Run/Stop button on the oscilloscope to take a measurement. The measured jitter value for the 2.488 Gb/s rate is displayed in the window as shown in Figure 15.
6. Check that the measured jitter is within the limits on the test record, and record the measured jitter in Table 17 of the test record.
7. Set the Filter field on the oscilloscope to OC-192 by using the procedure that begins with step 3 on page 38, then recall the 9.953 Gb/s bit rate on the BERT and repeat steps 1 through 6 for the 9.953 Gb/s bit rate.
8. Set the Filter field on the oscilloscope to None by using the procedure that begins with step 3 on page 38.

9. In the Bandwidth field, select 12.50 GHz from the drop-down menu.
10. Recall the 12.500 Gb/s bit rate on the BERT and repeat steps 1 through 6 for the 12.500 Gb/s bit rate.
11. Keep the test setup connected for the next test.

Modulator Polarity

The modulator polarity test uses an eye pattern for a pass/fail test. The eye pattern crossing point is adjusted with the BERT, and the crossing point shift direction is observed on the oscilloscope.

Test Overview.

1. Keep the equipment setup as shown in Figure 14 on page 36.
2. Set the BERT parameters.
3. Set the oscilloscope measurement parameters.
4. Preview the eye pattern.
5. Take measurements.

BERT. Set the BERT parameters as follows:

1. Recall the 9.953280 GB/s bit rate.
2. Set the pattern to PRBS–31.
3. Disable the adjustable duty cycle.
4. Turn off the Data Crossing Point Adjust.
5. Set the mark ratio to 1/2.
6. Set the trigger output to 1/32 clock.
7. Turn the data output on, and set the data amplitude to 1.5 V_{p-p}.

Oscilloscope. Set the TDS8000 settings as follows:

***NOTE**. Due to differences in oscilloscope firmware, your setup steps may differ slightly.*

1. From the toolbar, select Setup→Vertical.
2. Click the Optical>> button.

3. Set the Signal Conditioning mode:

   a. In the Wavelength field, select 1550 from the drop-down menu.

   b. In the Filter field, select OC-192 from the drop-down menu.

4. Select the Horz tab to set the horizontal parameters.

   a. In the All Timebases box, set the Mode field to Short Term Jitter from the drop-down menu.

5. Select the Acq tab to set the acquisition parameters.

   a. In the Stop After box, select Run/Run Stop.

6. Select the Trig tab to set the trigger parameters.

   a. In the Trigger Source box, select External Direct.

Preview the Eye Pattern.

1. Set the BERT data and clock outputs on.

2. Enable the transmitter.

3. Turn on the channel that the optical module is plugged into.

4. Press Autoset.

The oscilloscope displays an eye pattern as shown in Figure 16 on page 43.

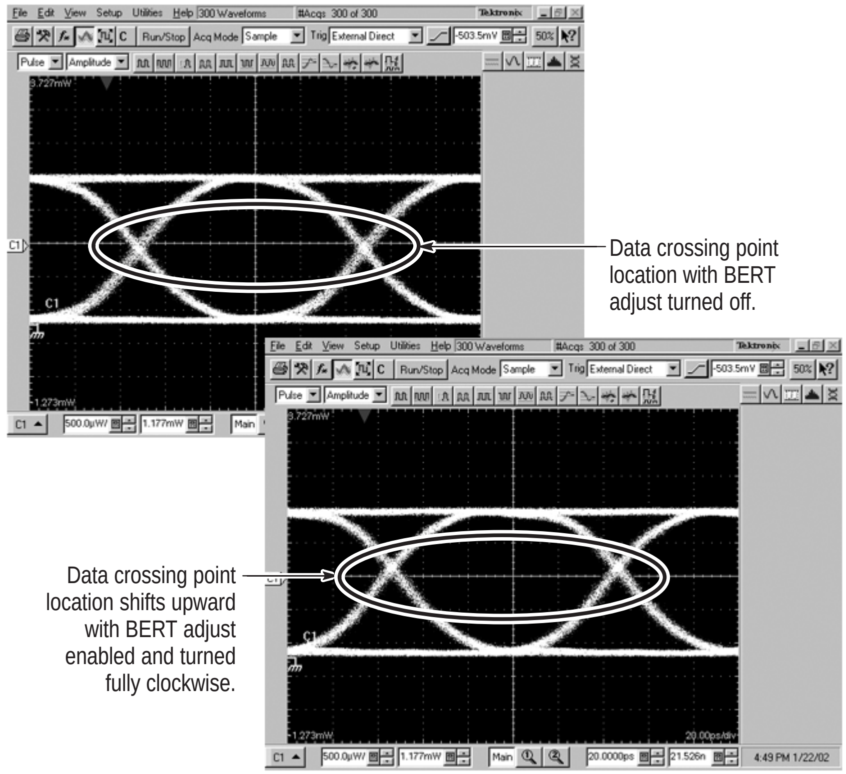

Figure 16: Using an eye pattern to check modulator polarity

Take Measurements. The equipment is now set up for recording the test results in Table 17 in the Test Record.

1. Verify that the Data Crossing Point Adjust on the BERT is turned off.
2. Verify that the eye pattern is vertically centered approximately around zero (about a 50% duty cycle).
3. Turn on the Data Crossing Point Adjust on the BERT.
4. Turn the Data Crossing Point Adjust on the BERT to the fully clockwise position (maximum).

   The crossing point of the eye pattern will shift upward if the modulator polarity is noninverting. This is a pass condition for the test. Record the result in Table 17 in the Test Record.

You have now completed Table 17 in the Test Record. The remainder of Table 17 lists the specification limits for the remaining tests in these performance verification procedures. Use the limits as a reference when filling out Tables 19 through 21 in the Test Record.

Modulator Optical Output Using the Internal Laser

Check the specifications of the modulator output by doing the following procedure.

Eye Pattern Test Matrix

These procedures direct you to set up the equipment to display an eye pattern using the internal laser as the optical source. Use the eye pattern to measure the parameters listed in Table 18 in the Test Record.

Test Overview.

1. Keep the equipment setup as shown in Figure 14 on page 36.
2. Set the BERT parameters.
3. Set initial oscilloscope settings.
4. Preview the Eye Pattern.
5. Set the oscilloscope measurement parameters.
6. Perform an oscilloscope compensation and dark level compensation.
7. Take measurements.

The following parameters are set up to measure the data for the first row in Table 18 in the Test Record. As you progress through the table, you must change the bit rate of the BERT and the signal conditioning mode in the oscilloscope setup, according to the row you are completing.

BERT. Set the BERT parameters as follows:

1. Recall the 2.48832 Gb/s bit rate.
2. Set the pattern to PRBS–31.
3. Disable the adjustable duty cycle.
4. Set the mark ratio to 1/2.
5. Set the trigger to 1/32 clock.
6. Set the data amplitude to 1.5 $V_{p–p}$.

Oscilloscope Setup. Set the TDS8000 Vertical settings as follows:

***NOTE**. Due to differences in oscilloscope firmware, your setup steps may differ slightly.*

1. From the toolbar, select Setup→Vertical.
2. Click the Optical>> button.
3. Set the Signal Conditioning mode:
   a. In the Wavelength field, select 1550 from the drop-down menu.
   b. In the Filter field, select OC-48 from the drop-down menu.

***NOTE**. You must change the Filter field setting when you take measurements at other data rates. See Table 13.*

A filter is not used for the 12.50 Gb/s data rate. Instead, set the Filter field to None, and set the bandwidth to 12.50 GHz.

Table 13: Signal conditioning mode settings

Data rate, Gb/s	Wavelength field setting	Filter field setting	Bandwidth setting, GHz
2.48832	1550	OC-48	————
9.95328	1550	OC-192	————
12.50000	1550	None	12.50

4. Select the Trig tab to set the trigger parameters.
   a. In the Trigger Source box, select External Direct.

Preview the Eye Pattern.

1. Turn the BERT data and clock outputs on.
2. Enable the transmitter.
3. Turn on the channel that the optical module is plugged into.
4. Press Autoset and then adjust the horizontal scaling to display an eye pattern.

The oscilloscope displays an eye pattern as shown in Figure 17 on page 47.

Oscilloscope Measurement. Set the TDS8000 Vertical settings as follows:

1. Select the Horz tab to set the horizontal parameters.

  a. In the All Timebases box, set the Mode field to Short Term Jitter from the drop-down menu.

2. Select the Mask tab to set the mask parameters.

  a. Set Source to the optical channel you are using.

  b. Check the Enable Mask Counts box.

  c. Check the Use Waveform Database box.

  d. In the Display box, check the Mask box.

  e. Set Communication Standard to SONET→OC-48.

  f. In the Mask Margins box, check the On box, and set the Margin field to 5%.

3. Select the Meas tab to set the measurement parameters.

Steps 3a through e assign measurement functions to generic oscilloscope measurement names. For example, you assign Extinction Ratio (dB) to Meas 1. (See Table 14).

  a. In the Meas x field, select Meas 1.

  b. In the source tab, in the Signal Type box, click NRZ.

  c. Click Select Meas.

  d. From the drop-down menus, select NRZ Amplitude→Extinction Ratio (dB). Meas 1 is now renamed Extinction Ratio (dB).

  e. Repeat steps a through d for Meas 2 through Meas 4. When doing step d, refer to Table 14 below for the correct menu path and function.

Table 14: Measurement function menu paths

Generic name	Parent menu name	Measurement function
Meas 1	NRZ Amplitude	Extinction Ratio (dB)
Meas 2	NRZ Timing	Pk-Pk Jitter
Meas 3	NRZ Amplitude	Crossing %
Meas 4	NRZ Amplitude	Average Optical Power (dBm)

After you rename Meas 1 to Meas 4, when you take measurements, the data displays on the right side of the oscilloscope screen, from Extinction Ratio (dB) down to Average Optical Power (dBm). This measurement order is repeated left to right in the rows in Table 18 in the Test Record.

4. Select the Acq tab to set the acquisition parameters.
   a. In the Stop After box, select Condition.
   b. In the Condition field, select Number of Acquisitions from the drop-down menu.
   c. Enter 300 (# of acquisitions) in the field below the Condition field.
   d. In the Stop Action box, select None.
5. Close the Setup window.
6. Press the Run/Stop button on the oscilloscope to begin a measurement.

The oscilloscope displays an eye pattern as shown in Figure 17.

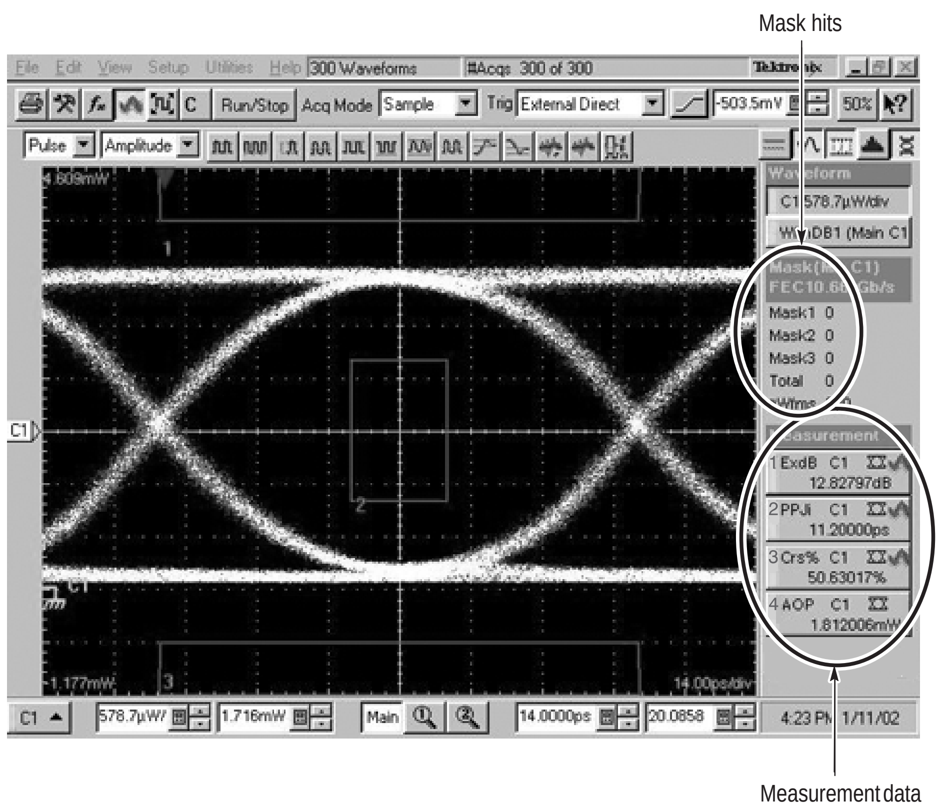

Figure 17: Measurements taken from the eye pattern

Compensate the Dark Level on the Oscilloscope. The optical sampling heads are susceptible to temperature fluctuations. Therefore, do the following prior to taking measurements:

NOTE. *Repeat the dark level compensation routines between every table in these tests. The extinction ratio measurements rely on accurate oscilloscope compensations. Perform the compensations more frequently if the ER measurements are failing.*

---

1. Disconnect the optical cable from the input to the oscilloscope.
2. Execute a dark level compensation. The Vertical menu of the TDS8000 lets you access the optical module Dark Level and User Wavelength Gain Compensation procedures.

   First select the channel you want to calibrate in the Waveform section of the menu. Select the Setup Optical, Dark Level or User Wavelength Gain Compensation boxes to start the compensation. Follow the displayed instructions to complete the compensation. For more information, consult the instrument online help.
3. Connect the optical cable to the oscilloscope.

Take Measurements. The equipment is now set up for recording measurements in Table 18 in the Test Record:

1. Press the Clear Data button and then the Run/Stop button on the oscilloscope to begin a measurement. You may need to adjust the horizontal position slightly to center the eye pattern around the center mask boundary.
2. Verify that the eye pattern does not violate the mask boundaries.
3. Record the measurement data from the oscilloscope display (see Figure 17), in the first row of Table 18 (2.488 Gb/s, 1.5 V). Check that the data meets the limits in Table 17.

NOTE. *You must connect an attenuator on the BERT output to take the 0.25 V measurements in Table 18. Therefore, it is easier to take the 1.5 V measurements first, and then connect the attenuator and complete the 0.25 V rows in Table 18.*

---

4. Recall the 9.953 Gb/s data rate that you stored in the BERT.
5. Set the filter field on the oscilloscope to OC-192. See steps 1 through 3 in the *Oscilloscope Setup* on page 45.
6. Repeat steps 1 through 3 for the 9.953 Gb/s, 1.5 V row in Table 18.
7. Recall the 12.500 Gb/s data rate that you stored in the BERT.

8. Set the Filter field on the oscilloscope to None.
9. Set the bandwidth field on the oscilloscope to 12.50 GHz. See steps 1 through 3 in the *Oscilloscope Setup* on page 45.
10. Repeat steps 1 through 3 for the 12.50 Gb/s, 1.5 V row in Table 18.
11. Disconnect the optical cable from the oscilloscope and perform another dark level compensation. Reconnect the cable when the compensation is done.
12. Disconnect the cable from the BERT output and connect the 2X attenuator to the BERT output. Connect the cable to the attenuator.
13. Set the BERT amplitude to 0.5 V.
14. Repeat steps 1 through 3 for the 12.50 Gb/s, 0.25 V row in Table 18.
15. Complete the remaining 0.25 V rows in Table 18, making sure to set the proper filter field on the oscilloscope for each row.
16. Keep the test setup connected for the next test.

Modulator Optical Output Using an External Laser

Check the specifications of the modulator output by doing the following procedures.

Eye Pattern Test Matrix

These procedures direct you to set up the equipment to display an eye pattern using the external, tunable laser as the optical source. Use the eye pattern to measure the parameters listed in Tables 19 through 21 in the Test Record.

Test Overview.

1. Connect the test circuit.
2. Set the BERT parameters.
3. Set up the tunable laser.
4. Set initial oscilloscope settings.
5. Preview the eye pattern.
6. Set the oscilloscope measurement parameters.
7. Perform an oscilloscope compensation and dark level compensation.
8. Take measurements.

Test Circuit. Connect the equipment as shown in Figure 18 on page 51:

1. Beginning with the test setup from the previous test, disconnect the attenuator from the BERT output, and connect the cable to the BERT.
2. Disconnect the optical cable from the internal laser out and the laser in connectors on the transmitter. Connect the external tunable laser to the laser in connector.
3. The equipment is now connected as shown in Figure 18 on page 51.

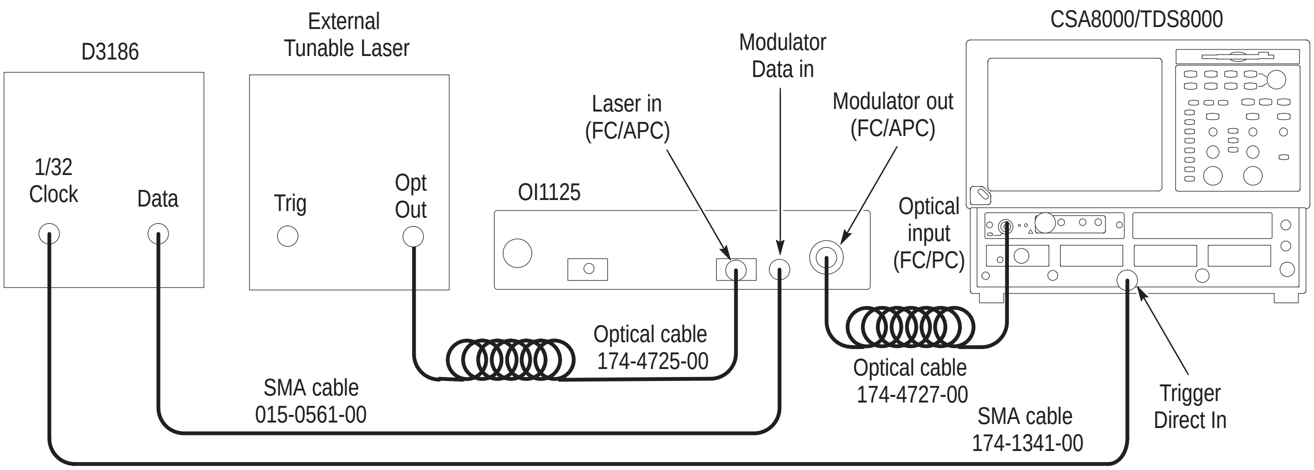

Figure 18: Setup for the eye pattern test matrix

The following parameters are set up to measure the data for the first row in Table 19 in the Test Record. As you progress through the tables, you must change the bit rate of the BERT, the laser wavelength and amplitude settings, and the signal conditioning mode in the oscilloscope, according to the table and row you are completing.

BERT. Set the BERT parameters as follows:

1. Recall the 2.48832 Gb/s bit rate.
2. Set the pattern to PRBS–31.
3. Disable the adjustable duty cycle.
4. Set the mark ratio to 1/2.
5. Set the trigger to 1/32 clock.
6. Set the data amplitude to 1.5 V_{p-p}.

Tunable Laser. Set the tunable laser parameters as follows:

1. Set the wavelength to 1530 nm.
2. Set the amplitude to 5 dBm.

Oscilloscope Setup. Set the TDS8000 Vertical settings as follows:

***NOTE**. Due to differences in oscilloscope firmware, your setup steps may differ slightly.*

1. From the toolbar, select Setup→Vertical.
2. Click the Optical>> button.
3. Set the Signal Conditioning mode:
   a. In the Wavelength field, select 1550 from the drop-down menu.
   b. In the Filter field, select OC-48 from the drop-down menu.

***NOTE**. You must change the Filter field setting when you take measurements at other data rates. See Table 15.*

A filter is not used for the 12.50 Gb/s data rate. Instead, set the Filter field to None, and set the bandwidth to 12.50 GHz.

Table 15: Signal conditioning mode settings

Data rate, Gb/s	Wavelength field setting	Filter field setting	Bandwidth setting, GHz
2.488320	1550	OC-48	———
9.953280	1550	OC-192	———
12.500000	1550	None	12.50

4. Select the Trig tab to set the trigger parameters.
   a. In the Trigger Source box, select External Direct.

Preview the Eye Pattern.

1. Turn on the BERT data and clock outputs.
2. Enable the tunable laser.
3. Enable the transmitter.
4. Turn on the channel that the optical module is plugged into.
5. Press Autoset.

The oscilloscope displays an eye pattern as shown in Figure 19 on page 54.

Oscilloscope Measurement Setup. Set the TDS8000 Vertical settings as follows:

1. Select the Horz tab to set the horizontal parameters.
   a. In the All Timebases box, set the Mode field to Short Term Jitter from the drop-down menu.
2. Select the Mask tab to set the mask parameters.
   a. Set Source to the optical channel you are using.
   b. Check the Enable Mask Counts box.
   c. Check the Use Waveform Database box.
   d. In the Display box, check the Mask box.
   e. Set the Communication Standard to SONET→OC-48.
   f. In the Mask Margins box, check the On box, and set the Margin field to 5%.
3. Select the Meas tab to set the measurement parameters.

Steps 3a through e assign measurement functions to generic oscilloscope measurement names. For example, you assign Extinction Ratio (dB) to Meas 1. (See Table 16).

   a. In the Meas x field, select Meas 1.
   b. In the source tab, in the Signal Type box, click NRZ.
   c. Click Select Meas.
   d. From the drop-down menus, select NRZ Amplitude→Extinction Ratio (dB). Meas 1 is now renamed Extinction Ratio (dB).
   e. Repeat steps a through d for Meas 2 through Meas 4. When doing step d, refer to Table 14 below for the correct menu path and function name.

Table 16: Measurement function menu paths

Generic name	Parent menu name	Measurement function name
Meas 1	NRZ Amplitude	Extinction Ratio (dB)
Meas 2	NRZ Timing	Pk-Pk Jitter
Meas 3	NRZ Amplitude	Crossing %
Meas 4	NRZ Amplitude	Average Optical Power (dBm)

After you rename Meas 1 to Meas 4, when you take measurements, the data displays on the right side of the oscilloscope screen, from Extinction Ratio (dB) down to Average Optical Power (dBm). (See Figure 19). This measurement order is repeated left to right in the rows in Tables 19 through 21 in the Test Record.

4. Select the Acq tab to set the acquisition parameters.

- **a.** In the Stop After box, select Condition.
- **b.** In the Condition field, select Number of Acquisitions from the drop-down menu.
- **c.** Enter 300 (# of acquisitions) in the field below the Condition field.
- **d.** In the Stop Action box, select None.

5. Close the Setup window.

6. Press the Run/Stop button on the oscilloscope to begin a measurement.

The oscilloscope displays an eye pattern as shown in Figure 19.

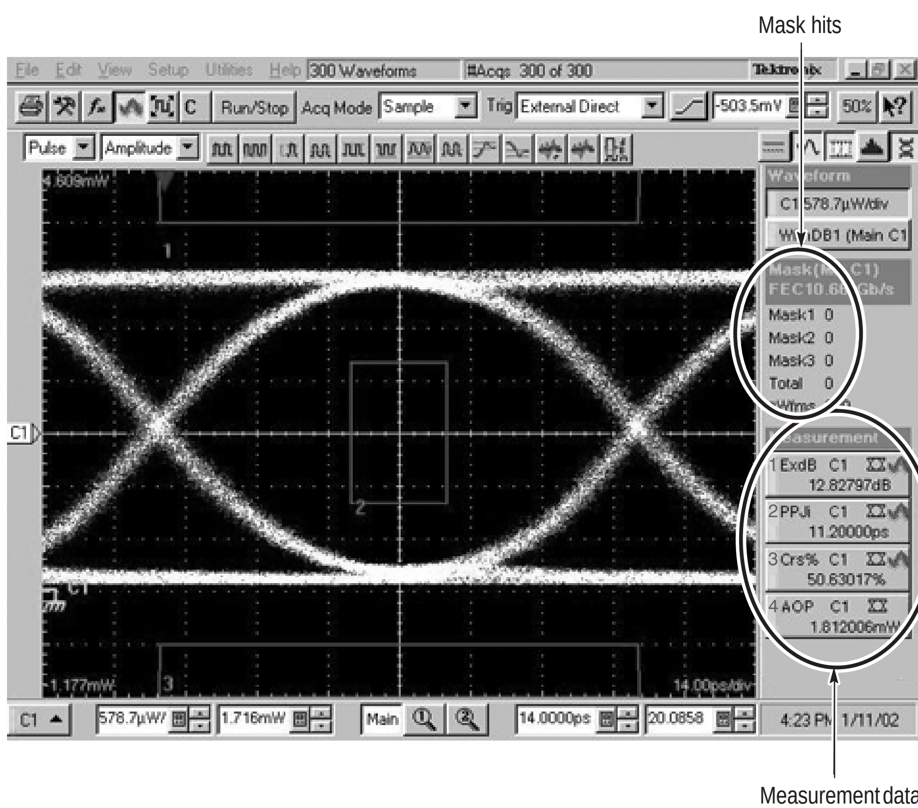

Figure 19: Measurements taken from the eye pattern

Compensate the Oscilloscope Perform a Dark Level Compensation on the Oscilloscope, as described on page 48.

NOTE. *Repeat the dark level compensation routine between every table in these tests. The extinction ratio measurements rely on accurate dark level compensations. Perform the compensation more frequently if the ER measurements are failing.*

Take Measurements

The equipment is now set up for recording measurements in Table 19:

1. Press the Clear Data button, and then the Run/Stop button on the oscilloscope to begin a measurement. You may need to adjust the horizontal position slightly to center the eye pattern around the center mask boundary.
2. Verify that the eye pattern does not violate the mask boundaries.
3. Record the measurement data (Figure 17) in the first row of Table 19. Check that the data meets the limits in Table 17.
4. Adjust the tunable laser and BERT to the remaining wavelengths and power levels in the 1.5 V rows in Table 19. Repeat steps 1 through 3 to complete the 1.5 V rows in Table 19.

NOTE. *You must connect an attenuator on the BERT output to take the 0.25 V measurements in Tables 19 through 21. Therefore, it is easier to take the 1.5 V measurements first, and then connect the attenuator. Next, complete the 0.25 V rows in Table 21 and work backward to Table 19.*

---

5. Recall the 9.953 Gb/s data rate on the BERT.
6. Set the filter field on the oscilloscope to OC-192. See steps 1 through 3 in the *Oscilloscope Setup* on page 45.
7. Repeat steps 1 through 4 for Table 20.
8. Recall the 12.500 Gb/s data rate on the BERT.
9. Set the filter field on the oscilloscope to None. See steps 1 through 3 in the *Oscilloscope Setup* on page 45.
10. Repeat steps 1 through 4 for Table 21.
11. Disconnect the cable from the BERT output, and connect the 2X attenuator to the BERT output. Connect the cable to the attenuator.
12. Set the BERT amplitude to 0.5 V.

13. Repeat steps 1 through 4 for the 0.25 V rows in Table 21.

14. Repeat steps 1 through 4 for the 0.25 V rows in Table 20, after setting the filter field on the oscilloscope to OC-192.

15. Repeat steps 1 through 4 for the 0.25 V rows in Table 19, after setting the filter field on the oscilloscope to OC-48.

This completes the performance verification for the transmitter.

OI1125 E/O Transmitter Test Record

Photocopy the following pages and use them to record the test results.

Table 17: OI1125 E/O Transmitter test record

Instrument Serial Number: ____________________ Certificate Number: ____________________
Temperature: ____________________ Relative Humidity %: ____________________
Date of Calibration: ____________________ Technician: ____________________

Performance Test		Minimum	Measured	Maximum
<Circuit>	<Test name>			
Internal Laser Output	Output Power	+9 dBm		+11 dBm
	Wavelength (calibrated)	1550.82 nm		1551.02 nm
	Wavelength (variable, knob fully CCW)	1549.82 nm		—
	Wavelength (variable, knob fully CW)	—		1552.02 nm
Modulator Optical Output	Jitter, RMS, 2.488 Gb/s	—		0.01 UI
	9.953 Gb/s	—		0.01 UI
	12.50 Gb/s	—		2 ps
	Modulator Polarity	Pass/fail		—
Eye Pattern Test Matrix				
Modulator Optical Output	Output Power	0 dBm	Use these Min/Max values as limits for the measured values recorded in Tables 18 to 21.	+4 dBm
	Extinction Ratio (calibrated)	+12 dBm		—
	Jitter, p-p ≤9.953 Gb/s	—		0.15 UI
	@12.50 Gb/s	—		18 ps
	% Crossing	45%		55%

Table 18: Internal laser @1550 nm, optical power @10 dBm (±1 dBm)

BERT Data Rate	BERT Amplitude	Extinction Ratio	Jitter, p–p	% Crossing	Average Optical Power	Mask hit
2.488 Gb/s	1.5 V					
	0.25 V					
9.953 Gb/s	1.5 V					
	0.25 V					
12.500 Gb/s	1.5 V					
	0.25 V					

Table 19: External tunable laser input, BERT input @2.488 Gb/s bit rate

Wave-length	Optical Input Power	BERT Amplitude	Extinction Ratio	Jitter, p–p	% Crossing	Average Optical Power	Mask hit
1530 nm	5 dBm	1.5 V					
		0.25 V					
	10 dBm	1.5 V					
		0.25 V					
1565 nm	5 dBm	1.5 V					
		0.25 V					
	10 dBm	1.5 V					
		0.25 V					

Table 20: External tunable laser input, BERT input @9.953 Gb/s bit rate

Wave-length	Optical Input Power	BERT Amplitude	Extinction Ratio	Jitter, p–p	% Crossing	Average Optical Power	Mask hit
1530 nm	5 dBm	1.5 V					
		0.25 V					
	10 dBm	1.5 V					
		0.25 V					
1565 nm	5 dBm	1.5 V					
		0.25 V					
	10 dBm	1.5 V					
		0.25 V					

Table 21: External tunable laser input, BERT input @12.50 Gb/s bit rate

Wave-length	Optical Input Power	BERT Amplitude	Extinction Ratio	Jitter, p–p	% Crossing	Average Optical Power	Mask hit
1530 nm	5 dBm	1.5 V					
		0.25 V					
	10 dBm	1.5 V					
		0.25 V					
1565 nm	5 dBm	1.5 V					
		0.25 V					
	10 dBm	1.5 V					
		0.25 V					

Maintenance

This section contains the information needed to do periodic and corrective maintenance on the instrument. The following subsections are included:

- *Inspection and Cleaning* — information and procedures for inspecting and cleaning the instrument and connectors.
- *Repackaging Instructions* — information on returning an instrument for service.

Inspection and Cleaning

Inspection and Cleaning describes how to inspect for dirt and damage. It also describes how to clean the exterior of the instrument. Inspection and cleaning are done as preventive maintenance. Preventive maintenance, when done regularly, may prevent instrument malfunction and enhance its reliability.

Preventive maintenance consists of visually inspecting and cleaning the instrument and using general care when operating it.

General Care

The cabinet helps keep dust out of the instrument and should be in place when operating the instrument.

Always keep the connectors on the instrument and optical cables covered with the protective caps when not in use. Treat optical connections the same as you would a camera lens or other precision optical gear.

Exterior Cleaning

Clean the exterior surfaces of the chassis with a dry, lint-free cloth or a soft-bristle brush. If any dirt remains, use a cloth or swab dipped in a 75% isopropyl alcohol solution. Use a swab to clean narrow spaces around controls and connectors. Do not use abrasive compounds on any part of the chassis that may damage the chassis. Do not attempt to clean the interior of the instrument.

Clean the On/Off switch using a dampened cleaning towel. Do not spray or wet the switch directly.

CAUTION. *Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Use only deionized water when cleaning the menu buttons or front-panel buttons. Use a 75% isopropyl alcohol solution as a cleaner and rinse with deionized water. Before using any other type of cleaner, consult your Tektronix Service Center or representative.*

Inspection

Inspect the outside of the instrument for damage, wear, and missing parts, using Table 22 as a guide. Immediately repair defects that could cause personal injury or lead to further damage to the instrument.

Table 22: Inspection check list

Item	Inspect for	Repair action
Cabinet, cabinet feet, front panel, and cover	Cracks, scratches, deformations, damaged hardware	Repair or replace defective module
Front-panel knobs	Missing, damaged, or loose knobs	Repair or replace missing or defective knobs
Connectors	Broken shells, cracked insulation, and deformed contacts. Dirt in connectors	Repair or replace defective connectors. Clear or blow out dirt. See *Cleaning Optical Connectors*
Accessories	Missing items or parts of items, bent pins, broken or frayed cables, and damaged connectors	Repair or replace damaged or missing items, frayed cables, and defective modules

Cleaning Optical Connectors

To prolong the life of the optical connectors on your instrument, observe the following handling and cleaning instructions.

Small dust particles and oils can easily contaminate optical connectors and reduce or block the signal. Take care to preserve the integrity of your connectors by keeping them free of contamination.

CAUTION. *To prevent loss of optical power or damage to the optical connectors, keep the connectors clean at all times.*

To reduce the need for cleaning, always keep the connectors covered with protective caps when not in use.

Use only high-quality cleaning supplies that are nonabrasive and leave no residue.

Equipment Required

Use the following items to clean the optical connectors:

- Cleaner tape dispenser (standard accessory included with the transmitter)
- Canned compressed gas (Do not use compressed air from an in-house facility, as oil in the system may contaminate the connector.)

Procedure To clean the optical connectors, refer to Figure 20 and follow these steps:

1. Advance the tape by grasping the tape and pulling in a new section to the wiping surface.
2. Grasp the connector to be cleaned with one hand, being careful not to touch the fiber core.
3. Hold the cleaner tape dispenser firmly with your other hand.
4. Wipe the connector tip once across the exposed tape surface, being careful to use a firm, steady motion without tearing the tape. The tip should be perpendicular to the tape surface for optimal results. When the tip is perpendicular to the tape, the tip will move smoothly and easily across the tape without tearing it.

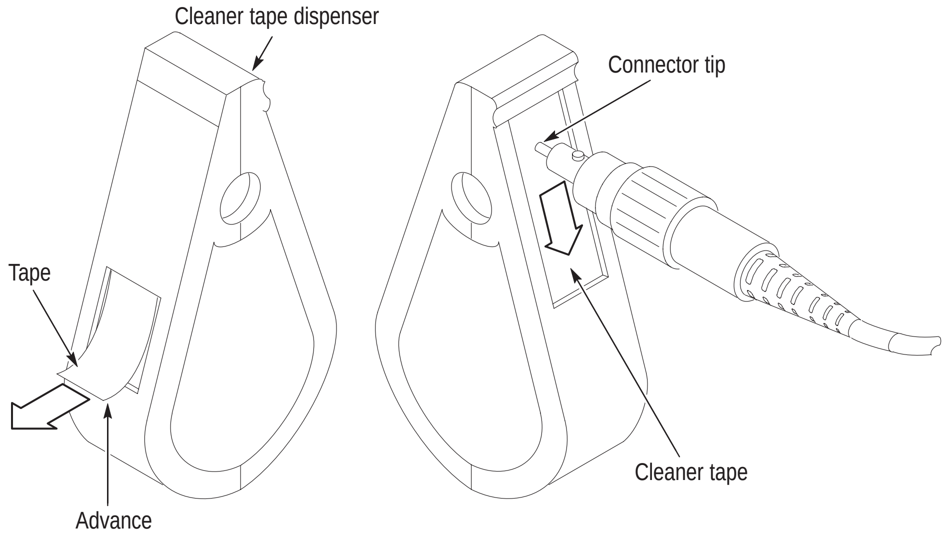

Figure 20: Cleaning an optical connector

5. If you cannot use the cleaner tape dispenser, apply a short burst of compressed gas to the connector.
6. Carefully attach the connector to the instrument or cable, and check for proper operation.

NOTE. *Cleaning kits for optical connectors are available from a number of suppliers.*

Repackaging Instructions

This section contains the information needed to repackage the instrument for shipment or storage.

Packaging

When repacking the instrument for shipment, use the original packaging. If the packaging is unavailable or unfit for use, contact your local Tektronix representative to obtain new packaging.

Seal the shipping carton with an industrial stapler or strapping tape.

Shipping to the Service Center

Contact the Service Center to get an RMA (return material authorization) number, and any return or shipping information you may need.

If the instrument is being shipped to a Tektronix Service Center, enclose the following information:

- The RMA number.
- The owner's address.
- Name and phone number of a contact person.
- Type and serial number of the instrument.
- Reason for returning.
- A complete description of the service required.

Mark the address of the Tektronix Service Center and the return address on the shipping carton in two prominent locations.

Replaceable Parts

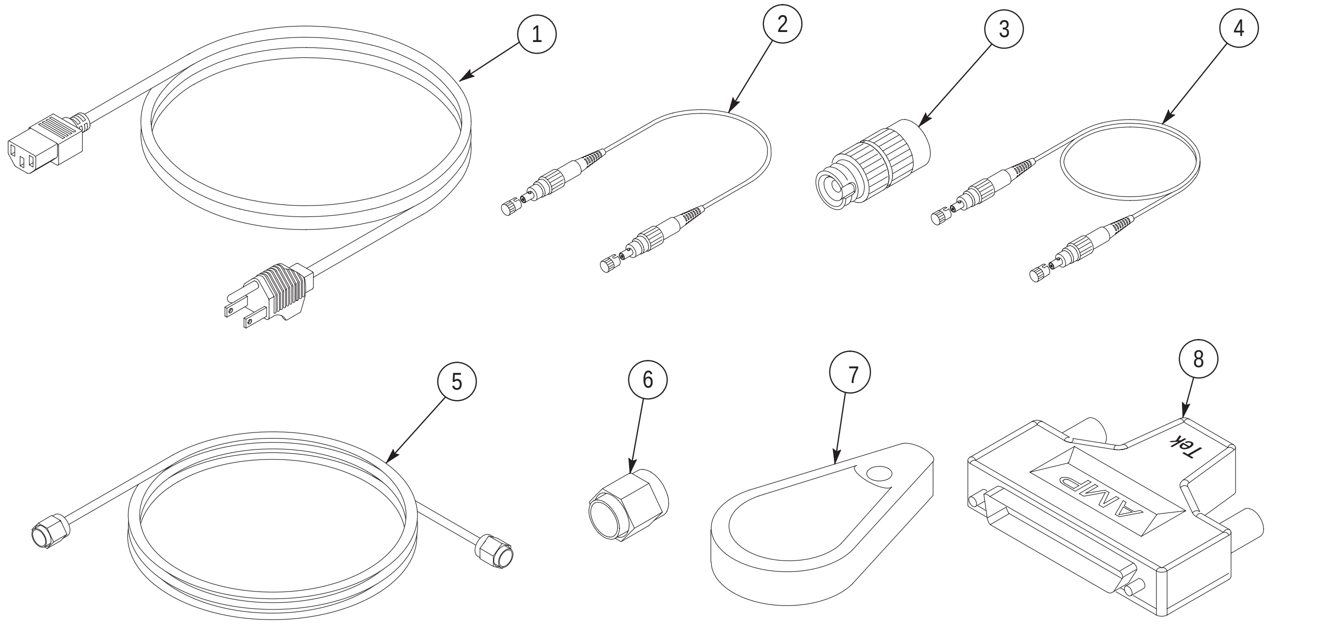

Figure 21: Standard accessories

Standard Accessories

Fig. & index number	Tektronix part number	Serial no. effective	Serial no. discont'd	Qty	Name & description	Mfr. code	Mfr. part number
21–1	161–0066–00			1	CA ASSY,PWR:3,18 AWG,250V/10A,98 INCH,STR,IEC320,RCPT X NEMA 5–15P,US	0B445	ECM–161–0066–00
–2	174–4664–00			1	CABLE ASSY,SP:FIBER OPTIC,P15 FIBER,DUAL ENDED FC–APC/PM WIDE KEY	TK2491	2424–1P5–1F
–3	119–5115–00			1	ADAPTER,FC/APC:OPTICAL CONNECTOR,APC–108	TK2491	APC–108
–4	174–4727–00			1	CA ASSY,SP:SINGLEMODE,FC/PC TO FC/APC,0.114 OD,2 METERS	TK6184	62–00110–36–02001
–5	015–0561–00			1	CABLE,DLY,COAX:50 OHM,4NS,W/CONN,SMA,MALE,EACH END	0GZV8	SF104PE,920MM,2X1 1SMA–451
–6	015–1022–00			1	TERMINATOR,COAX:50 OHM, 0.5W,SMA	26805	2001–4401–00
–7	006–8217–00			1	CONN CLEANER:FIS CONNECTOR CLEANER	0CKD9	F1–7111
–8	131–7350–00			1	CONN,BOX:LASER SAFETY INTERLOCK FOR TRANSMITTER		131–7350–00
	071–1052–00			1	MANUAL,TECH:INSTRUCTION,E/O TRANSMITTER,OI1125	TK2548	071–1052–00

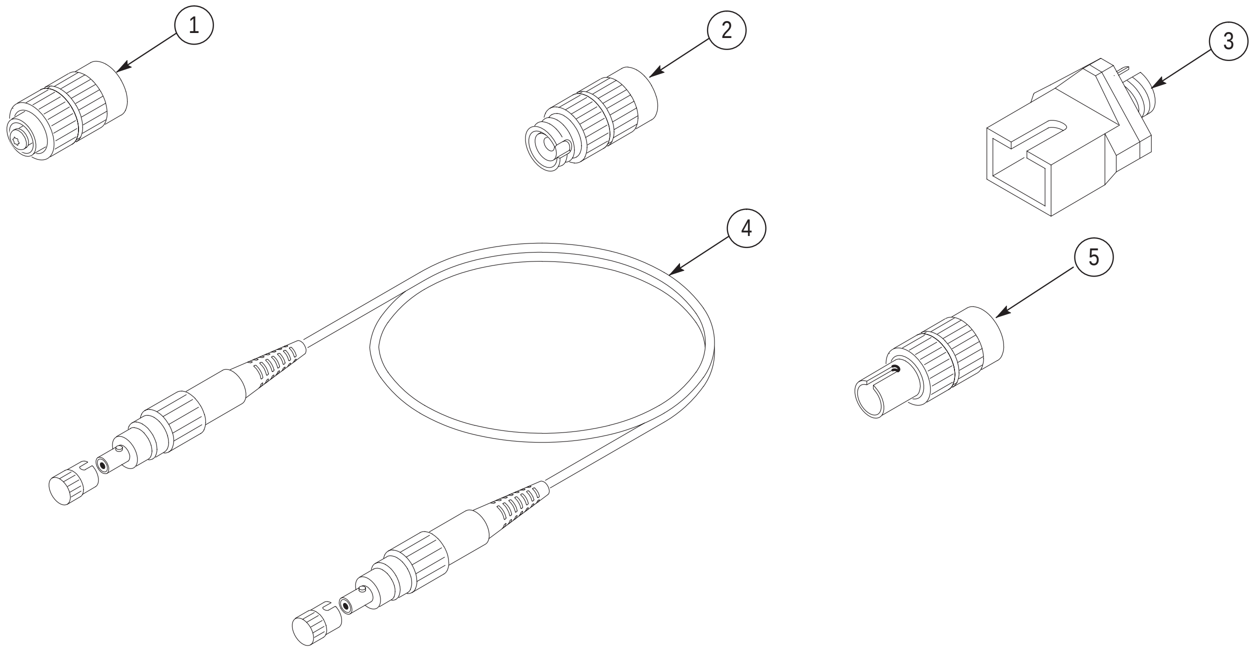

Figure 22: Optional accessories

Optional Accessories

Fig. & index number	Tektronix part number	Serial no. effective	Serial no. discont'd	Qty	Name & description	Mfr. code	Mfr. part number
22–1	119–5887–00			1	ADAPTER,UCI:OPTICAL CONNECTOR, ADT–UNI.S8/ DIN.2	TK2491	AD–108, DIN/APC
–2	119–5115–00			1	ADAPTER,FC/APC:OPTICAL CONNECTOR,APC–108	TK2491	APC–108
–3	119–5116–00			1	ADAPTER,SC/APC:OPTICAL CONNECTOR,ASC–108	TK2491	ASC–108
–4	174–4725–00			1	CABLE ASSY,SP:FIBER OPTIC,P15 FIBER,DUAL ENDED FC–APC/PM NARROW KEY, 2L 2L–1P5–2M	TK2491	2L 2L–1P5–2M
–5	119–5888–00			1	ADAPTER,UCI:OPTICAL CONNECTOR,UNIVERSAL CONNECTOR INTERFACE,ADT–UNI/ST,TOP160	80009	119–5880–00
——	TVGF13			1	DUAL RACK MOUNT KIT	80009	

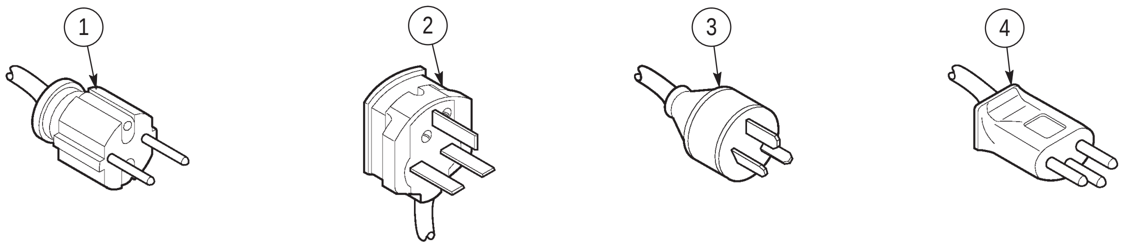

Figure 23: Optional power cords

Optional power cords

Fig. & index number	Tektronix part number	Serial no. effective	Serial no. discont'd	Qty	Name & description	Mfr. code	Mfr. part number
23–1	161–0066–09			1	CA ASSY,PWR:3,0.75MM SQ,250V/10A,99 INCH,STR,IEC320,RCPT,EUROPEAN	2W733	ORDER BY DESC
–2	161–0066–10			1	CA ASSY,PWR:3,1.0 MM SQ,250V/10A,2.5 METER,STR,IEC320,RCPT X 13A,FUSED UK PLUG(13A FUSE),UNI	TK2541	ORDER BY DESC
–3	161–0066–11			1	CA ASSY,PWR:3,1.0MM SQ,250V/10A,2.5 METER,STR,IEC320,RCPT,AUSTRALIA	80126	ORDER BY DESC
–3	161–0304–00			1	CA ASSY,PWR:3,1.0MM SQ,250V/10A,2.5 METER,STR,IEC320,RCPT,CHINA	0B445	E13.900.098.A01
–4	161–0154–00			1	CA ASSY,PWR:3,1.0MM SQ,250V/10A,2.5 METER,STR,IEC320,RCPT,SWISS	5F520	86515030

Manufacturers cross index

Mfr. code	Manufacturer	Address	City, state, zip code
26805	M/A COM OMNI SPECTRA INC	MICROWAVE CONNECTOR DIV 140 4TH AVE	WALTHAM, MA 02254
2W733	BELDEN WIRE & CABLE COMPANY	2200 US HWY 27 SOUTH PO BOX 1980	RICHMOND, IN 47374
5F520	PANEL COMPONENTS CORP	PO BOX 115	OSKALOOSA, IA 52577–0115
80009	TEKTRONIX INC	14150 SW KARL BRAUN DR PO BOX 500	BEAVERTON, OR 97077–0001
80126	PACIFIC ELECTRICORD CO	747 WEST REDONDO BEACH PO BOX 10	GARDENA, CA 90247–4203
0B445	ELECTRI–CORD MFG CO INC	312 EAST MAIN STREET	WESTFIELD, PA 16950
0CKD9	FIBER INSTRUMENT SALES INC	161 CLEAR ROAD	ORISKANY, NY 13424
0GZV8	HUBER & SUHNER INC	19 THOMPSON DRIVE	ESSEX JUNCTION, VT 05452–3408
TK2491	TEMPO–CAMARILLO	1340 FLYNN RD	CAMARILLO, CA 93012
TK2541	AMERICOR ELECTRONICS LTD	UNIT–H 2682 W COYLE AVE	ELK GROVE VILLAGE, IL 60007
TK2548	XEROX CORPORATION	14181 SW MILLIKAN WAY	BEAVERTON, OR 97005
TK6184	GOULD FIBER OPTICS	1121 BENFIELD RD	MILLERSVILLE, MD 21108

Glossary

Accuracy
The closeness of the indicated value to the true value.

Attenuation
A decrease in magnitude of current, voltage, or power of a signal.

Attenuator
A transducer that reduces the amplitude of a signal.

Bandwidth
The difference between the high and low frequencies of a transmission band. The range of frequencies handled by a device or system. Bandwidth is a measure of network capacity. Analogue bandwidth is measured in cycles per second. Digital bandwidth is measured in bits of information per second.

BER
An acronym for Bit Error Ratio (or Rate). The principal measure of quality of a digital transmission system. BER is defined as:

BER = Number of Errors/Total Number of Bits

BER is usually expressed as a negative exponent. For example, a BER of 10^{-7} means that on average 1 bit out of 10^{7} bits is in error.

BER Floor
A limiting of the bit-error-ratio in a digital system as a function of received power due to the presence of signal degradation mechanisms or noise.

Bit Error
An incorrect bit. Also known as a coding violation.

Bit Rate
The number of bits transmitted in a specified (usually 1 second) time.

Channel
A communications path or the signal sent over a channel.

Channel capacity
The maximum usable data rate for a given channel.

Chirp
Optical frequency chirp is a transient change in optical frequency (wavelength) when a laser or optical modulator is transitioned quickly between zero and one power levels.

Clock

A signal that provides a timing reference.

Clock recovery

Recovering the clock from the incoming data.

dB

Decibel: a method of expressing power or voltage ratios. The decibel scale is logarithmic. It is often used to express the efficiency of power distribution systems when the ratio consists of the energy put into the system divided by the energy delivered (or in some cases, lost) by the system. One milliwatt is usually the reference for 0 decibels. The formula for decibels is:

$$dB_{level} = 10\log\left(\frac{level}{reference}\right)$$

In the electrical domain:

$$dB_{power} = 10log\left(\frac{P_{out}}{P_{ref}}\right) = 10log\left(\frac{\frac{V^2{}_{out}}{R}}{\frac{V^2{}_{ref}}{R}}\right) = 20log\left(\frac{V_{out}}{V_{ref}}\right)$$

$$\frac{V^2{}_{ref}}{50ohm} = 1mW$$

In optical:

$$dBm_{power} = 10log\left(\frac{P_o}{P_{ref}}\right)$$

$$P_{ref} = 1mW = 0dBm$$

dBm

The symbol for power level in decibels relative to 1 mW.

DFB laser

Distributed Feedback Laser-a type of laser designed for stable single-mode operation. Internal waveguides select one of several possible laser modes and suppress all others.

Demodulation

A process whereby a modulated signal is returned to its original form.

DWDM

Dense Wavelength Division Multiplexing-a higher capacity version of WDM, which is a way to increase the capacity of fiber optic transmission systems through multiplexing up to 40 wavelengths of light.

Deterministic jitter

The difference between the maximum and minimum deviations from the expected timing positions of data after removing the random jitter.

Digital Signal
A signal made up of a series of on and off pulses.

Digital Transmission System
A transmission system where information is transmitted in a series of on and off pulses.

Dispersion (example in fiber)
In an optical system, the broadening and distortion of a pulse due to multipath waveform propagation.

Electro-optic effect
A change in the refractive index of a material under the influence of an electric field.

ES
An acronym for Errored Second. A second with at least one error.

Error Detection
Checking for errors in data transmission. A calculation is made on the data being sent and the results are sent along with it. The receiving station then performs the same calculation and compares its results with those sent. Each data signal conforms to specific rules of construction so that departures from this construction in the received signals can be detected. Any data detected as being in error is either deleted from the data delivered to the destination, with or without an indication that such deletion has taken place, or delivered to the destination together with an indication that it is in error.

Extinction Ratio
The ratio of the high-level optical power to the low-level optical power in a transmission system.

Error Rate
The ratio of the number of data units in error to the total number of data units.

Fiber optics
A method of transmitting information in which light is modulated and transmitted over high-purity filaments of glass. The bandwidth of fiber optic cable is much greater than that of copper wire.

Fiber Optics Transmission System (FOTS)
A transmission system transmitting light through thin glass fibers.

FEC: Forward Error Correction
Additional bits and/or coding added to a data stream to allow for automatic error detection and correction at the receiving end. These extra bits and/or coding tend to increase a serial data rate above the original non-FEC data stream in order to accommodate the extra information added by the FEC.

Insertion Loss
The loss of power in a system as a result of inserting a coupler or cable.

Index of Refraction
The ratio of the speed of light in a vacuum to the speed of light in a material.

Laser Safety Class IIIb
Laser light that can emit dangerous radiation is classified IIIb. Requirements for equipment employing a Class IIIb laser include having a keyswitch with a removable key to control the laser power. Also required is a means for remotely disabling the laser output, and labels indicating the location of the laser aperture.

Link
A transmission path between two stations, channels, or parts of a system.

Long wavelength
The spectrum from 1200 to 1600 nanometers.

LOS
An acronym for Loss of Signal.

Mach-Zehnder Interferometer
A method of measurement optical interference by splitting an optical signal into two branches and manipulating one. The two branches are then recombined, producing variable optical interference for analysis.

Modulation
A process of varying the frequency, phase, or amplitude of a signal so it is suitable for transmission over the medium between the transmitter and the receiver.

Multimode
A fiber that has a larger core than single mode, it allows light to enter from several angles, enabling it to connect to broader light sources such as LEDs. However, the multiple paths that the light takes through multimode fiber causes dispersion.

Multiplexer
Equipment that combines two or more signals into one.

Multiplexing
Combine several communications signals into one.

Noise
Any unwanted energy that interferes with a signal or measurement.

NRZ
No Return to Zero-When a digital data pattern that has zeroes as lows and ones as highs, does not return to zero when the pattern has consecutive ones.

Optical coupler/splitter
A device that couples or splits power from fiber optic cables.

Photocurrent
The current that flows through a photosensitive device as the result of exposure to radiant power.

Photodiode
An electro-optic component that converts optical energy to electrical current.

PMF
Polarization maintaining fiber-fiber optic cable with a core that has been pre-stressed to create two independent optical axes. Light is transmitted through these two optical axes without exchanging energy with each other.

PRBS
Pseudo-random binary-pulse sequence. A repeating bit pattern that appears to be random. The bit pattern is used for telecommunications system testing.

Protocol
Formal conventions that govern the format and control of signals in a communication process.

Pulse modulation
The modulation of a series of pulses to represent the information.

Random jitter
Abrupt, spurious variations in the timing or amplitude of a signal, whose value at a future instant cannot be predicted.

Recovered Clock
A clock signal derived from and synchronous with a received data sequence.

Refraction
The bending of light as it passes between materials having different refractive indices.

Residual Error Rate
The error rate remaining after attempts at correction are made.

RZ
Return to Zero-When a digital data pattern that has zeroes as lows and ones as highs, returns to zero when the pattern has consecutive ones.

Rx
An abbreviation for receiver.

Short wavelength
The spectrum from 800 to 1000 nanometers.

Single mode
A fiber, designed to carry light of a single wavelength, that confines the light to a single path.

SONET
Synchronous Optical Network-a standard for fiber optic transmission. Boundary masks are used to define eye pattern limits generated by the optical waveforms..

Telecommunications
The transmission or reception of signals by wire, radio, optical, or other system.

Transmission system
Facilities to transfer information from one location to another using copper conductors, fiber, or microwave radio.

Tunable Laser
A laser that has a variable wavelength and power output level.

Tx
An abbreviation for transmitter

Index

A

B

C

D

E

F

H

I

L

M