Instruction Manual

Tektronix

OI2125 O/E Receiver

071-1053-00

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.

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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 OI2125 O/E Receiver. This manual provides user information and performance verification procedures for the instrument.

This manual also provides specifications and performance verification procedures for the optional Clock Recovery Modules.

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 OI2125 (see Figure 1) is an optical-to-electrical receiver that converts a modulated optical input signal to an electrical data output signal at data rates up to 12.5 Gb/s. Using an amplified high-speed photodetector, the OI2125 O/E Receiver operates over a wavelength range of 1100 nm to 1650 nm.

You can use the receiver in a test system to convert the optical signal from a DUT (Device Under Test) to an electrical signal to be measured with an oscilloscope or used as a part of a BER (Bit Error Rate) test. When you use the receiver as part of a BER test, the BERT Pattern Generator supplies a data signal that is converted to a modulated optical signal by an OI1125 E/O Transmitter. The OI2125 O/E Receiver is used to convert the optical BER test pattern back to an electrical signal for analysis by the BERT Error Analyzer.

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

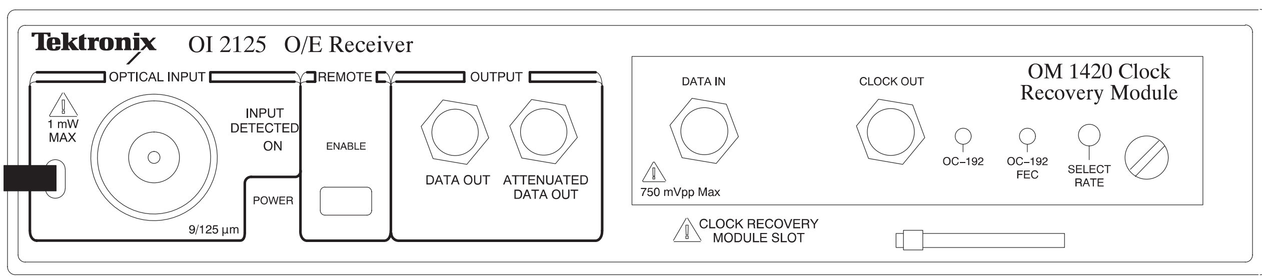

Figure 1: OI2125 Optical-to-Electrical Receiver

The OI2125 O/E Receiver provides the following 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), but is usable over an extended wavelength range of 1100 nm to 1650 nm.
- Optional clock recovery modules provide data rates for OC-192 and OC-192 FEC.

The OI2125 O/E Receiver provides a slot for an optional clock recovery module. Clock recovery modules currently available:

- The OM1420 clock recovery module provides clock recovery at one of two selectable data rates: OC-192 (9.953280 Gb/s), and OC-192 Forward Error Correction (10.66423 Gb/s).

Options

The AC power input to the OI2125 O/E Receiver is supplied through a standard IEC320 AC input connector. The internal power supply in the receiver operates with AC power from 100 to 240 VAC at either 50 or 60 Hz. The standard power cord supplied with the OI2125 O/E Receiver is a 120 VAC North American power cord.

Table 1 lists the power cord options that are available for your OI2125 O/E Receiver.

Table 1: Power cord options

Option	Description
A1	European power cord (240 V, 50 Hz)
A2	UK power cord (240 V, 50 Hz)
A3	Australian power cord (240 V, 50 Hz)
A5	Swiss power cord (240 V, 50 Hz)
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).

Table 2: Service options (Cont.)

Option	Description
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 OI2125 O/E Receiver.

Table 3: Receiver standard accessories

Accessory	Part number
US power cord	161-0066-00
Slot Cover Module (preinstalled)	119-6690-00
Low-loss SMA cable	015-0561-00
Optical cable, FC/PC-FC/PC, 2 M	174-3922-00
50 Ω terminator (2 ea, preinstalled)	015-1022-01
FC/PC adapter (preinstalled)	119-5115-00
Optical connector cleaning kit	006-8217-00
Instruction Manual	071-1053-XX
Certificate of Calibration	—

The Clock Recovery Modules are orderable separately. Table 4 lists the standard accessories that come with the modules.

Table 4: Clock Recovery Module standard accessories

Accessory	Part number	OM1420
Flexible SMA jumper cable	174-4699-00	✓
Low-loss SMA cable	015-0561-00	✓
50 Ω terminator (preinstalled)	015-1022-01	✓ (2 ea)
Certificate of Calibration	———	✓
Instructions		071-1055-XX

Optional Accessories

Table 5 lists the optional accessories that are recommended for the OI2125 O/E Receiver.

Table 5: Optional accessories

Item	Part number
SMA 2.5 UCI adapter	119-4517-00
DIAMOND 2.5 UCI adapter	119-4556-00
SMA UCI adapter	119-4557-00
DIAMOND 3.5 UCI adapter	119-4558-00
FC/PC adapter	119-5115-00
SC/APC adapter	119-5116-00
DIN/PC 47256 adapter	119-5887-00
ST/APC adapter	119-5888-00
FC/PC 5dB attenuator	131-7368-00
Side-By-Side Instrument Rack Adapter	TVGF13

Installation

To learn how to install, access the front panel, power on, and power off the OI2125 O/E Receiver, do the following procedures:

Preparation

To properly install and power on the receiver, do the following steps:

1. Be sure the operating environment is within the specifications listed in Table 11 starting on page 26.

CAUTION. *To prevent damage to the receiver, provide proper ventilation. A small fan is located on the bottom of the chassis. Do not block the cabinet ventilation holes, or disable the fan. Do not remove the cabinet feet; the feet provide proper clearance for ventilation.*

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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 OI2125 O/E Receiver requires 100 to 240 VAC_{RMS} $\pm$10%, 47 Hz to 63 Hz, and 40 W.
4. Connect the proper power cord from the rear-panel power connector (see Figure 9 on page 18) to the power system.

CAUTION. *To prevent damage to your module, do not install or remove a module while the receiver is powered on. Do not apply a voltage outside the Maximum Nondestructive Input Voltage for the module. Observe static precautions when handling the module and front panel electrical connectors.*

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5. Verify that the power is off by ensuring the rear-panel rocker power switch is in the off position.
6. Plug a clock recovery or slot cover module into the receiver: Slowly insert the module into the slot in the front panel until it meets the connector at the back of the module slot.
7. Firmly push the module in to seat it in the connector.
8. Once the module is seated, turn the hold-down screw clockwise to lock the module into place.

If you are not going to use a clock recovery module, install the slot cover module in the receiver to limit stray EMI emissions and to protect the receiver from ambient RF noise.

Power on

To power on the receiver, push the rear-panel rocker power switch to toggle it on (see Figure 9 on page 18).

Power off

To power off the receiver, push the rocker power switch to the off position.

Functional Check

To perform a functional check of the OI2125 O/E Receiver, you must connect a setup as shown in Figure 2. This setup creates an optical data source by combining a pattern generator with an electrical-to-optical transmitter (with an internal laser source). This optical data source is fed into the optical input of the receiver, and the converted data output is displayed as an electrical eye pattern on the oscilloscope. This is the method that is used in the *Eye Pattern Test Matrix* on page 45 of the *Performance Verification* procedures.

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

- A pattern generator capable of producing data rates from 2.48 Gb/s to 12.50 Gb/s, with output levels at about 1.0 $V_{p\text{-}p}$.
- An electrical-to-optical transmitter capable of providing 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.
- A 50 Ω low-loss SMA cable to connect the receiver output to the oscilloscope input.
- A 5 dB optical attenuator to limit the input power to the receiver to less than 0 dBm.

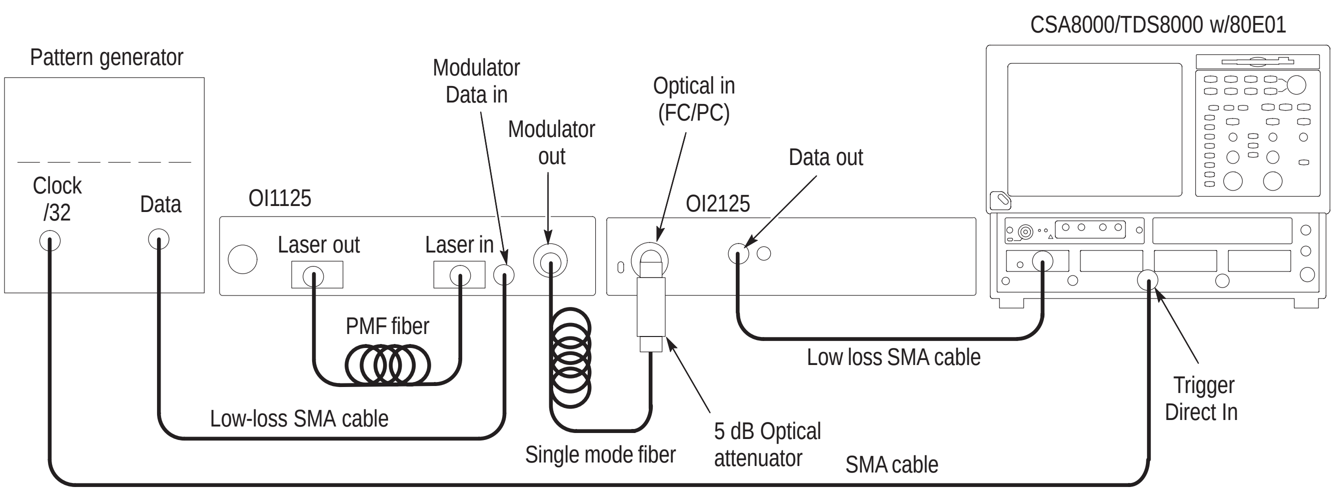

Figure 2: Functional test setup

Follow the *Displaying an Eye Pattern* procedure on the next page to do a functional check of the OI2125 O/E Receiver. 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 eye pattern (see Figure 3).

The oscilloscope displays an eye pattern as shown in Figure 3. This indicates that the receiver is functioning correctly—it is converting the modulated input optical signal to an electrical eye pattern that represents the data stream from the BERT.

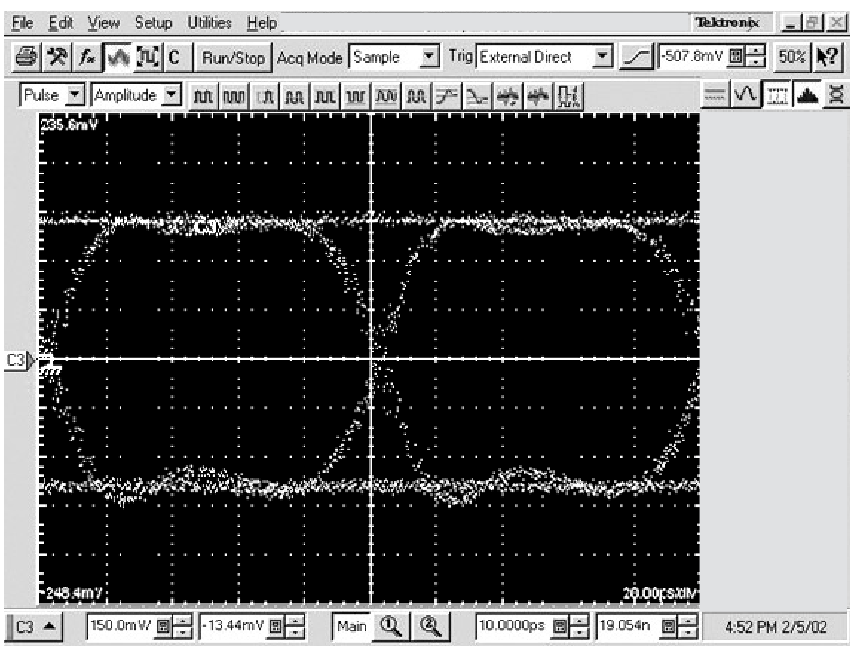

Figure 3: Oscilloscope display of an eye pattern

Operating Basics

This section describes the connectors and controls on the front and rear panels of the OI2125 O/E Receiver. Figures 5 and 9 illustrate the front and rear panels of the instrument.

Handling

Handle the OI2125 O/E Receiver 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. Laser light can be harmful to your eyes. Optical signals in the wavelength range used by the OI2125 O/E Receiver are in the infrared band and are invisible to the human eye.*

CAUTION.*To protect the module and instrument inputs, always use a wrist strap when handling the module and when making electrical signal connections. Always replace the terminators on the receiver and module when not in use.*

Connecting Signals

The OI2125 O/E Receiver has two types of connectors for inputs and outputs.

Electrical Connectors

The OI2125 O/E Receiver electrical outputs use high-performance SMA connectors. Never attach a cable if the cable has a worn or damaged connector because this may damage the OI2125 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 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 OI2125 O/E Receiver to make connections to the device under test.

Optical Connector

The optical input connector of the OI2125 O/E Receiver is a Universal-Style physical contact (PC) type that can couple to optical fibers with a core diameter of up to 9 μm. An FC/PC adapter is supplied as a standard accessory for use with the Universal-Style input connector. Alternative optical connector types can be coupled by using the optional accessory adapters. (Refer to *Optional Accessories* on page 4.)

If you connect fiber cores larger than 9 μm, the receiver may still couple light, but the mismatch in core diameter will result in significant optical attenuation.

To attach a fiber optic cable with an FC/PC connector to the FC/PC input receptacle, refer to Figure 4 on page 11 and do the following:

1. Remove the dust cover from the optical receptacle.

CAUTION. *Use care when making optical connections. If you are not using an optical connection, either on the receiver, 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.

2. Clean the connector on the fiber optic cable using the procedure on page 60.

3. Carefully align the keyway on the receptacle with the key on the connector.

4. Tighten the nut lightly with finger pressure only. If you overtighten an optical connector, you may get inconsistent optical signal performance.

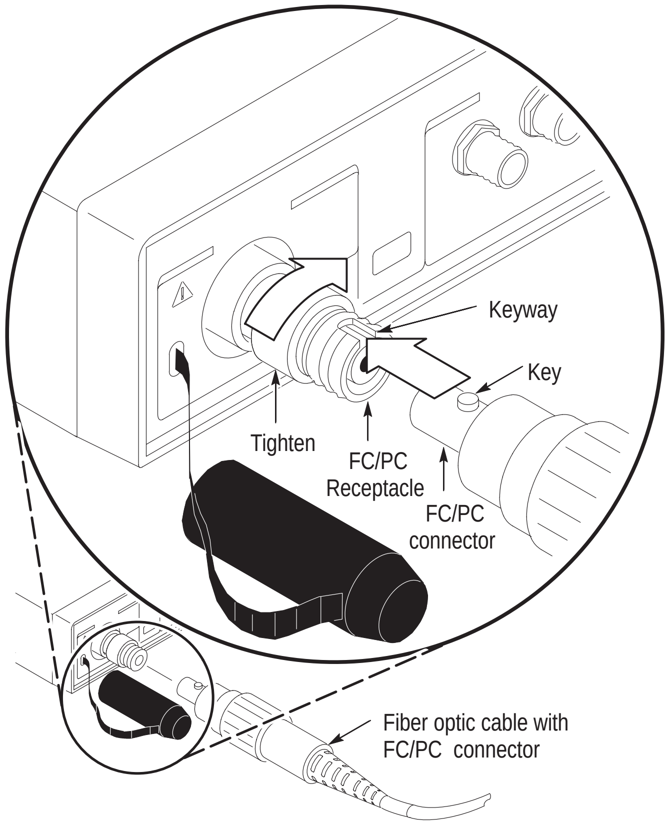

Figure 4: Connecting a fiber optic cable

Front Panel Description

The front panel is functionally divided into two sections: the O/E receiver section and the clock recovery module port. Use Figure 5 and the following descriptions to help you connect and operate the receiver.

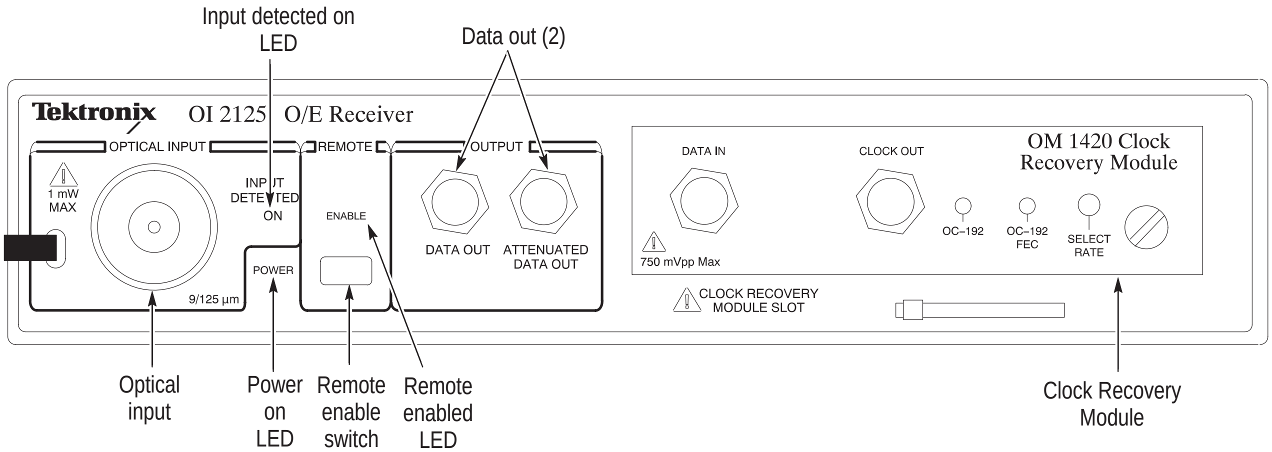

Figure 5: OI2125 front panel

O/E Receiver

The O/E receiver section is described here.

OPTICAL INPUT. The optical input port is designed to accept modulated optical signals over a range of digital data rates and optical wavelengths. The port has a single-mode fiber, universal optical input connector. To preserve the optical integrity of the connector, keep the dust cover on the connector when not in use.

POWER ON. This green LED illuminates when the receiver is powered on.

INPUT DETECTED ON. This green LED illuminates when the optical input signal on the input connector is above the optical power threshold of the internal photodetector.

REMOTE ENABLE. This switch toggles the remote mode of the receiver (and the LED indicator) on and off when the switch is pressed. All front-panel controls and status indicators, including Clock Recovery Module functions are accessible through the Remote Interface when in remote mode.

Remote Enabled. When power is first applied to the receiver, this green LED is off, unless the remote interface Front Panel Unlock signal is low (active). If the Front Panel Unlock signal is low, the LED is on, and will flash briefly when the Remote Enable switch is pressed.

When the Front Panel Unlock signal is high at power-on, pressing the Remote Enable switch toggles the LED on, indicating that the receiver is in remote mode. Pressing the switch again returns the receiver to local (front panel) mode, and the LED extinguishes.

DATA OUT (2). Two electrical data out connectors output the converted electrical data signal. One of the outputs provides a signal to the Clock Recovery Module Data input port, and the other output is available for measuring the quality of the input optical signal with an oscilloscope or BERT. Generally, the Attenuated Data Out signal from the receiver is connected to the Data In connector on the Clock Recovery Module to keep from exceeding the maximum input voltage of the module.

Clock Recovery Module Port

The receiver has a front panel slot that accepts optional clock recovery modules. A connector at the rear of the slot provides power and a control interface for the modules. A slot cover module is a standard accessory for the receiver that should remain installed in the receiver until a clock module is needed, to limit RF noise and stray EMI emissions.

Clock Recovery Modules

Clock Recovery Modules are available for the OI2125 O/E Receiver:

- The OM1420 clock recovery module provides clock recovery at one of two selectable rates–OC-192 data rate (9.95328 Gb/s), and an OC-192 Forward Error Correction data rate (10.66423 Gb/s).

The slot cover module is a standard accessory that plugs into the receiver module slot when a clock recovery module is not used. See Figure 6.

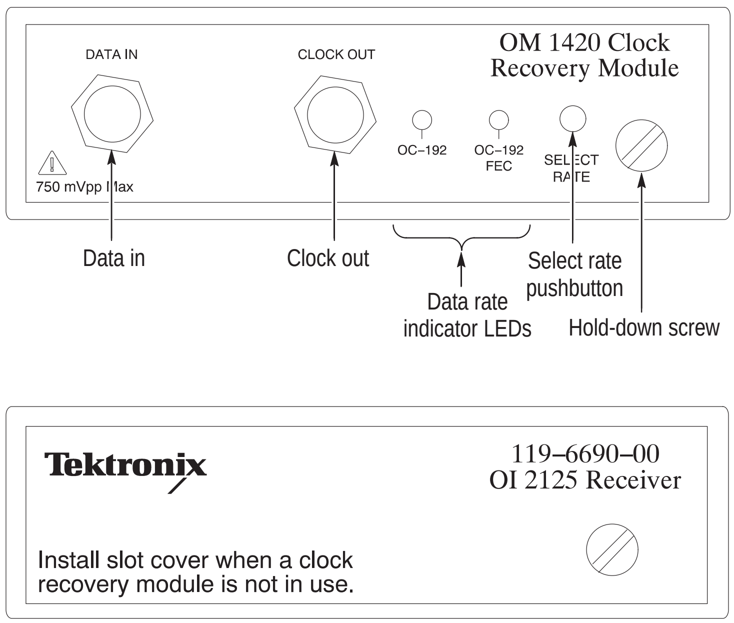

Figure 6: Clock Recovery Modules for the receiver

Clock Recovery Module Features

The Clock Recovery Module features are described as follows:

DATA IN. This SMA connector accepts electrical input from either the OI2125 O/E Receiver Attenuated Data Out port or from an external signal source. Use the short SMA cable included with the module to connect to the receiver Attenuated Data Out connector.

CLOCK OUT. The recovered clock from the input signal is output on this SMA connector.

SELECT RATE. A pushbutton switch selects between the data rates available in the module. When you repeatedly push this momentary pushbutton switch, the clock recovery module cycles through the data rates available in the module.

Data Rate Indicators. LEDs located to the left of the Data Rate Select switch indicate which data rate is selected.

Hold-Down Screw. The hold-down screw locks the module into place once the module is seated.

Installing a Clock Recovery Module

The OI2125 O/E Receiver will operate without a clock recovery module. However, if you do not need clock recovery in your application, you should install the slot cover module in the receiver to limit stray EMI emissions and to protect the receiver from ambient RF noise.

CAUTION. *To prevent damage to your module, do not install or remove the module while the receiver is powered on. Do not apply a voltage outside the Maximum Nondestructive Input Voltage for the module. Observe static precautions when handling the module and front panel electrical connectors.*

To install a module, refer to Figure 7 and do the following:

1. Power off the receiver.
2. Slowly insert the module into the slot in the front panel until it meets the connector at the back of the module slot.

   When the module contacts the connector in the back of the module slot, the front of the module is about an eighth-inch away from being flush with the front panel of the receiver.
3. Firmly push the module into the receiver to seat it in the connector.
4. Once the module is seated, turn the hold-down screw clockwise to lock the module into place.
5. Attach the short SMA cable from the attenuated data output of the receiver to the input of the module. This step is not necessary when using the module as a standalone instrument or when installing a slot cover module.

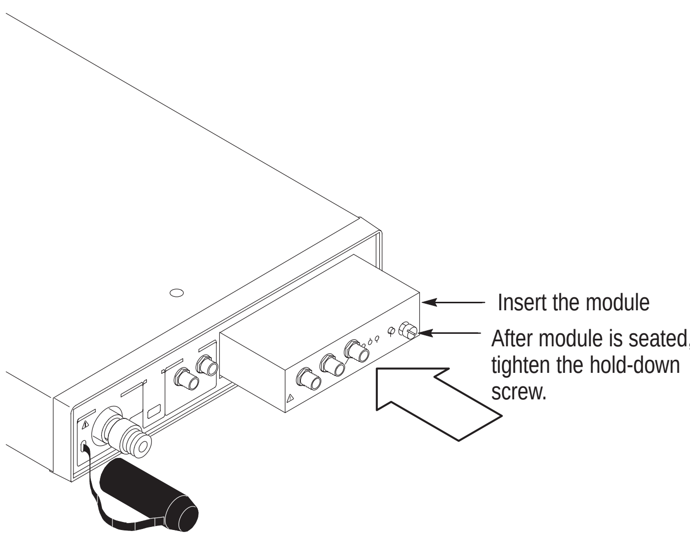

Figure 7: Installing a Clock Recovery Module

Removing a Clock Recovery Module

To remove a module, refer to Figure 8 and do the following:

1. Power off the receiver.
2. Remove any external cables from the the input of the module. This step is not necessary when removing a slot cover module.
3. Remove the short SMA cable from the output of the receiver and the input of the module, if necessary.
4. Turn the hold-down screw counterclockwise to unlock the module.
5. Move the latch to the right to release the module from the connector.
6. Pull the module out of the receiver, and store it in a safe location.
7. If you are not going to use another clock recovery module, install the slot cover module in the receiver to limit stray EMI emissions and to protect the receiver from ambient RF noise.

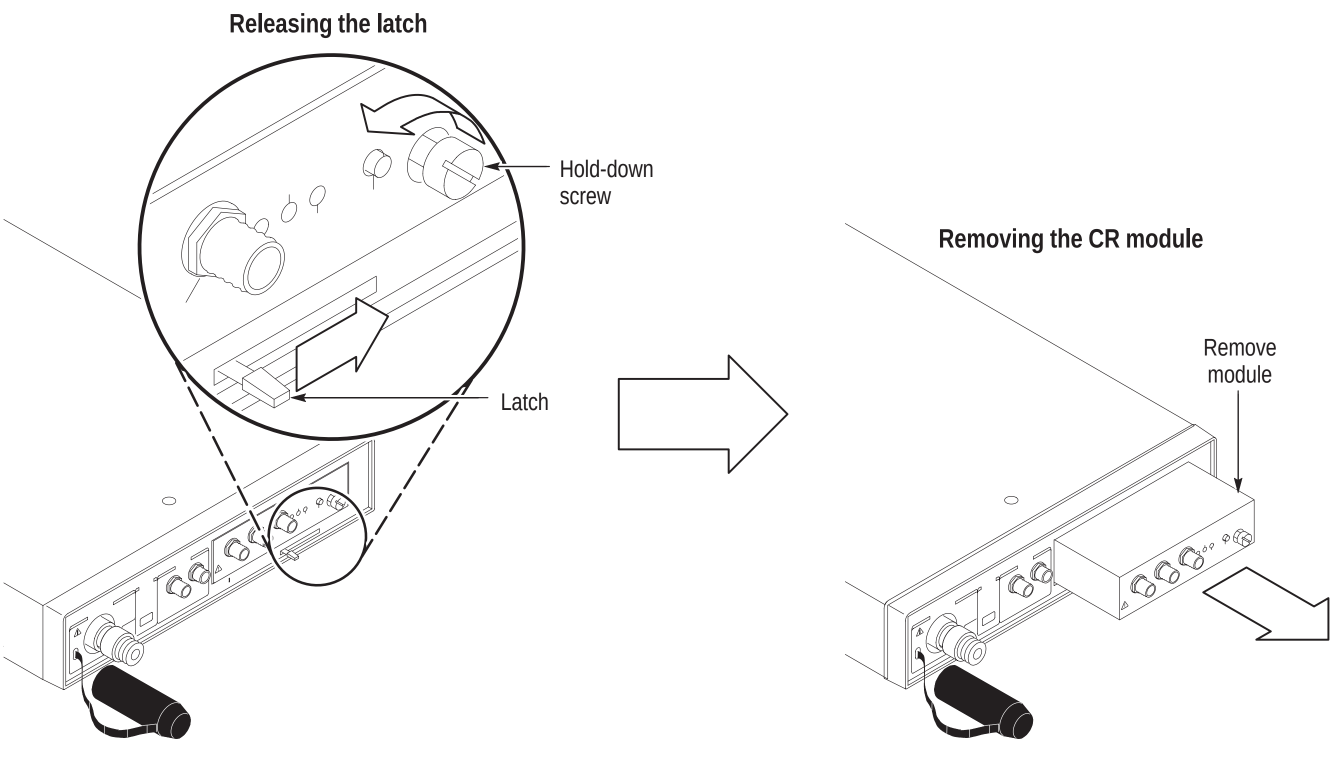

Figure 8: Releasing the module with the latch

Rear Panel Connections and Controls

There are two connectors on the rear panel of the OI2125: Remote Interface and AC Power In. Use Figure 9 and the following descriptions to connect the transmitter to your system.

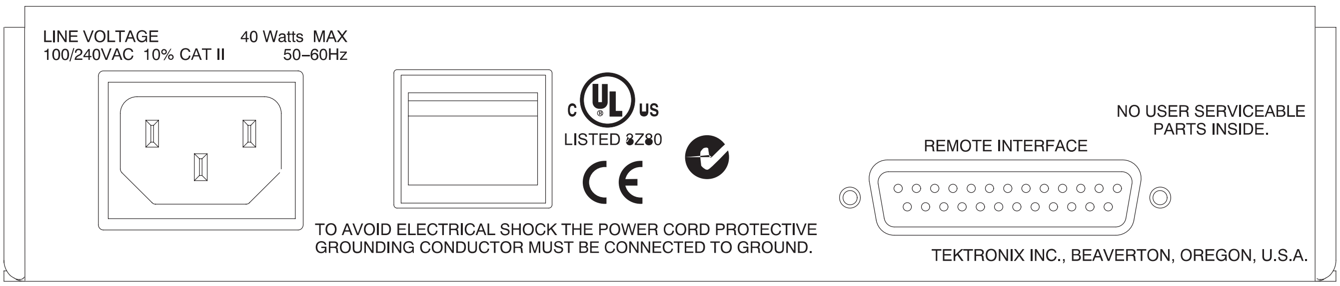

Figure 9: OI1125 rear panel

Remote Interface

The remote interface allows for remote control of the instrument. See *Using the Rear-Panel Remote Interface* on page 19 for details.

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 receiver. The connector contains an integral AC power line filter.

On/Off Switch

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

Using the Rear-Panel Remote Interface

This section describes using the rear-panel remote interface to select the transmitted signal.

Controlling Operation Remotely

When the REMOTE pushbutton switch on the front panel is in the disabled mode, the Enable LED is not illuminated, and you can select the optional clock recovery module data rate from the front-panel controls.

When the REMOTE pushbutton switch on the front panel is in the enabled mode, the Enable LED is illuminated, and you select the optional clock recovery module data rate through the rear-panel remote interface. Refer to Figure 10 and Table 6 on page 20 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 10 illustrates the pinout. The remote interface provides access to all of the front-panel control features using a TTL control interface. The remote interface also allows access to some status indicators and control features not available from the front panel.

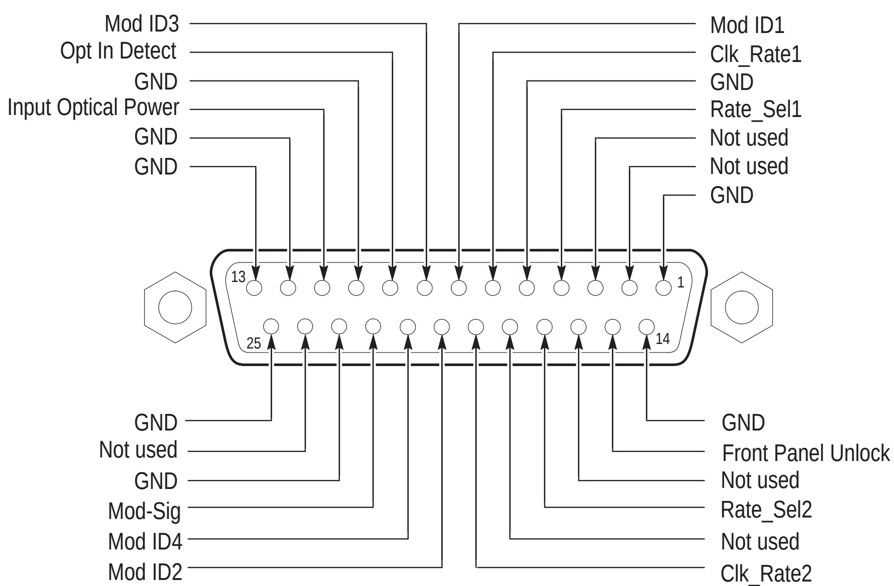

Figure 10: Rear Remote Interface connector pinout

Table 6 lists the signal descriptions for the Remote Interface connector. Unless otherwise noted, the signals are active in both local and remote operating modes.

Table 6: Remote Port signals

Pin number	Signal name	Signal type	Description
4	Rate_Sel1	Digital input	These inputs work together to select up to four different clock recovery rates. See Table 7 for the OM1420 clock rates.
17	Rate_Sel2	Digital input	These inputs are only active in remote mode.
19	Clk_Rate2	Digital output	These status signals work together to communicate up to four different clock recovery rates to the remote port. See Table 7 for the OM1420 clock rates.
6	Clk_Rate1	Digital output	These inputs are active in either local or remote mode.
22	Mod_Sig	Digital output	This output is not used by the OM1420 module.
15	Front Panel Unlock	Digital input	When driven low, this input locks out access to the front-panel local mode control. Default mode is unlocked when the instrument is powered on .
9	Optical Input Detect	Digital output	This output is driven high when the photodetector senses a valid threshold power level.
11	Input Optical Power	Analog output	This pin outputs an analog voltage that corresponds to the optical power incident on the photodetector.
7	Mod ID1	Digital output	Mod_ID1 to ID4 digital outputs form a four-bit binary code used to identify the clock recovery modules. See Table 8 for the identification codes.
20	Mod ID2	Digital output	
8	Mod ID3	Digital output	
21	Mod ID4	Digital output	
Several	Not used		2, 3, 16, 18, 24
Several	Ground	Analog, digital	1, 5, 10, 12, 14, 23, 25

Table 7 shows the data rate select inputs and status outputs for the OM1420 module.

Table 7: OM1420 Module data rate select and status logic

Data Rate	Rate_Sel2	Rate_Sel1	Clk_Rate2	Clk_Rate1
	Data rate select (digital inputs)		Data rate status (digital outputs)	
OC-192	X	0	0	0
OC-192 FEC	X	1	1	1

Table 8 shows the four-bit identification codes on the Mod_ID outputs, used to identify what type of clock recovery module is in the receiver.

Table 8: Clock recovery module type select logic

Data Rate	Mod ID1	Mod ID2	Mod ID3	Mod ID4
OC-192/OC-192 FEC (OM 1420)	0	0	0	0

Specifications

This section contains the specifications of the OI2125 O/E Receiver. All specifications are guaranteed unless noted as "typical". Typical specifications are provided for your convenience but are not guaranteed. Specifications marked with the ✓ symbol have corresponding checks in the *Performance Verification* section on page 35.

Table 9: OI2125 Receiver specifications

Specification		Description
Photodetector Optical Input		
✓	Wavelength	1530 nm to 1565 nm (verified range), 1100 nm to 1650 nm (extended range)
✓	Input Power – Operating	–16 dBm to 0 dBm; 0 dBm (1 mW) maximum
✓	Loss of Signal Threshold	–25 dBm to ±2 dBm
	Input Return Loss	> 28 dB
	Input Connector	Single mode fiber (9/125 μm) Universal/PC with protective boot
Data Output		
✓	Data Rate	2.488 Gb/s to 12.50 Gb/s (verified range), 622 Mb/s (extended range)
✓	Jitter Transfer	< 1.5 ps_{RMS}, 2.488 Gb/s to 12.50 Gb/s
✓	Eye Crossing %	50% ±5%
✓	Mask Testing	No mask hits with 5% mask margin for OC-48, OC-192, and scaled 12.50 Gb/s SONET masks, with 0 dBm to –8 dBm input power
	BER Testing	BER $< 10^{-12}$ for data rates up to OC-192 BER $< 10^{-10}$ for data rates above OC-192
✓	Data Output Voltage	0.5 V_{p-p} - 1.5 V_{p-p}, input power –8 dBm to 0 dBm 0.2 V_{p-p} - 1.5 V_{p-p}, input power –16 dBm to –8 dBm (See Figure 11 on page 25.)
	Attenuated Data Output Voltage	6 dB attenuation of the Data Output Voltage
	Optical Power Bandwidth	50 MHz to 7.5 GHz
	Output Impedance	50 Ω AC coupled
	Output Return Loss	(Data Out) > 12 dB, 50 MHz to 5 GHz; > 5 dB, 5 GHz to 12 GHz (Attenuated Data Out) > 14 dB, 50 MHz to 2.5 GHz; > 10 dB, 2.5 GHz to 20 GHz
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 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
	Optical input power monitor output voltage level (analog)	Optical conversion gain is 1 V/mW ±20%

Table 9: OI2125 Receiver specifications (Cont.)

Specification		Description
	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 10: OM1420 Clock Recovery Module specifications

Specification		Description
✓	Clock Recovery Rate	9.953280 Gb/s in OC-192 mode 10.66423 Gb/s in OC-192-FEC mode
✓	Input Voltage – Operating	0.15 V_{p-p} to 0.75 V_{p-p}
✓	Output Voltage	1.0 V to 2.5 V_{p-p}, AC coupled
✓	Jitter Generation – Clock	< 2.0 ps_{RMS}
	Input Voltage – Maximum	0.75 V_{p-p}
	Input Return Loss	> 10 dB, 100 MHz to 10 GHz
	Output Return Loss	> 8 dB @ OC-192 and OC-192 FEC clock frequencies
	Clock Recovery Data Rate Range	Clock Out voltage > 0.5 V_{p-p} from 9.943 Gb/s to 9.963 Gb/s (OC-192) Clock Out voltage > 0.5 V_{p-p} from 10.654 Gb/s to 10.674 Gb/s (OC-192-FEC)
	Input Connector	SMA connector, 50 Ω, AC coupled
	Output Connector	SMA connector, 50 Ω, AC coupled

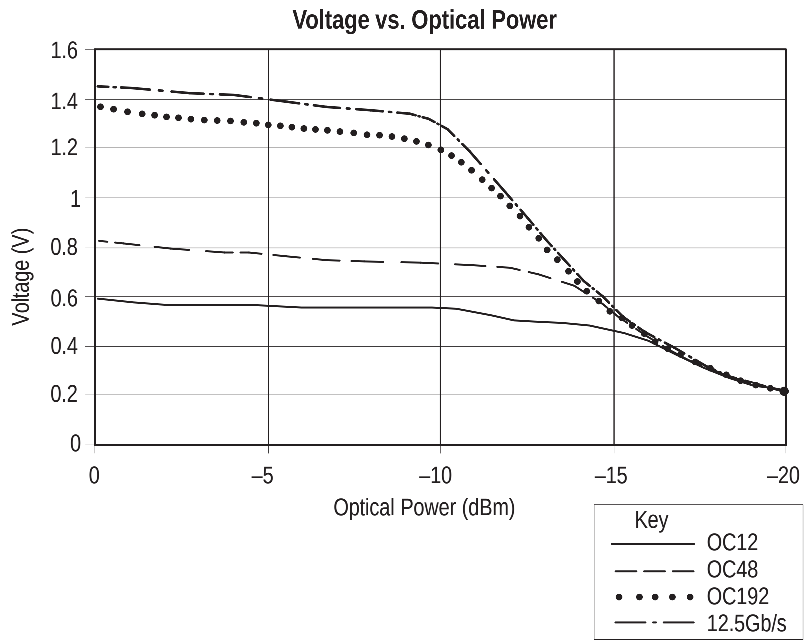

Figure 11: OI2125 Output Voltage versus Input Optical Power

Table 11: 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 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 (10,000 ft) Nonoperating: 12200 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)
	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 12: Certifications and compliances

Category	Standards or description	
EC Declaration of Conformity—EMC	Meets intent of Directive 89/336/EEC for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:	
	EN 61326	EMC requirements for Class A electrical equipment for measurement, control and laboratory use.[1]
	IEC 61000–4–2	Electrostatic discharge immunity (Performance criterion B)
	IEC 61000–4–3	RF electromagnetic field immunity (Performance criterion A)
	IEC 61000–4–4	Electrical fast transient / burst immunity (Performance criterion B)
	IEC 61000–4–5	Power line surge immunity (Performance criterion B)
	IEC 61000–4–6	Conducted RF immunity (Performance criterion A)
	IEC 61000–4–11	Voltage dips and interruptions immunity (Performance criterion B)
	EN 61000–3–2	AC power line harmonic emissions
Australia / New Zealand Declaration of Conformity—EMC	Complies with EMC provision of Radiocommunications Act per the following standard(s):	
	AS/NZS 2064.1/2	Industrial, Scientific, and Medical Equipment: 1992
FCC Compliance	Emissions comply with FCC Code of Federal Regulations 47, Part 15, Subpart B, Class A Limits.	

1 **Emissions which exceed the levels required by this standard may occur when this equipment is connected to a test object.**

Table 13: Safety characteristics

Specification	Description
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.

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 receiver at the block diagram level. Refer to Figure 12 as you read the circuit description.

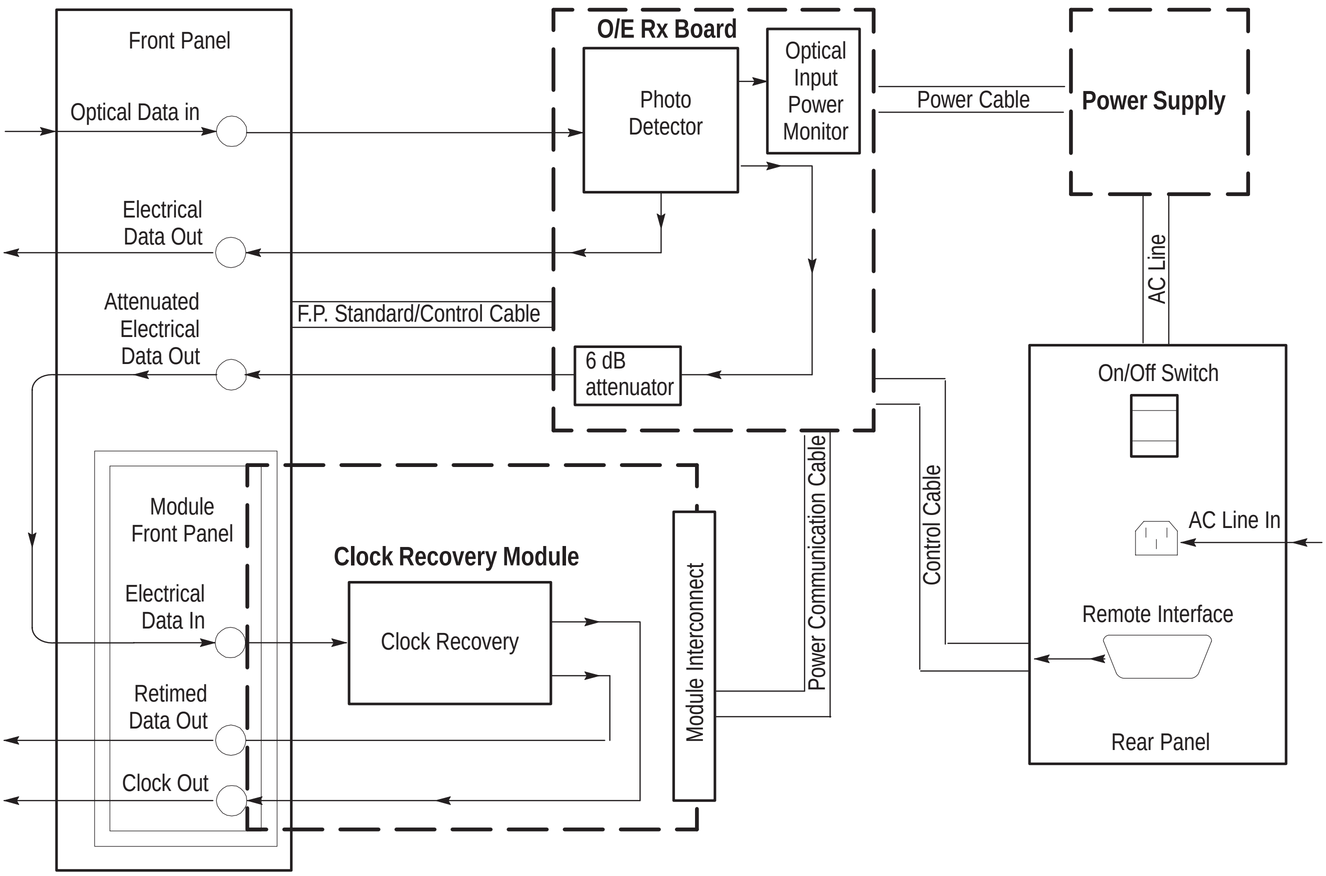

Figure 12: O/E Receiver interconnect diagram

O/E Receiver

The OI2125 O/E Receiver is made up of four interconnected assemblies: the front and rear panels, the receiver board, and the DC power supply.

Front Panel

The front panel of the receiver is divided into two sections: the receiver and the clock recovery module slot.

Receiver. The receiver uses a single-mode fiber, universal FC/PC optical input connector to couple external optical signals to the receiver board. An Input Threshold Detected LED is driven by the internal optical power monitor. The converted electrical data is output from the receiver board to the front panel via two SMA connectors.

The SMA connector (Attenuated Data Out) closest to the clock recovery module slot is intended for coupling the signal to one of the optional clock recovery modules available for the OI2125 O/E Receiver. The output from the other SMA connector (Data Out) can be used to monitor the quality of the converted electrical data.

Clock Recovery Module Slot. The clock recovery module slot accepts optional clock modules and provides DC power through a 32-pin connector at the rear of the slot. A short SMA cable (standard module accessory) couples the converted electrical data from the receiver to the module. SMA connectors on the clock module provide a data input, a recovered clock output, and for some modules, a retimed data output.

Rear Panel

The rear panel of the receiver has three components—the AC line cord connector, the power on/off switch, and the remote interface connector. When any of the international power cords available for the receiver 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 remote interface is a 25-pin D-connector that provides direct control of the receiver board and the clock recovery module. Remote mode can be enabled from either a front panel toggle switch or by pulling the front-panel unlock pin (pin #15) low, which enables the other pins of the connector to pass through TTL-level logic signals to control the receiver.

Receiver Board

External optical signals that are applied to the front panel are directly coupled to a high-speed, InGaAs photodiode module on the receiver board. The photodiode converts the optical energy into electrical current, which is then converted into a voltage by a fixed-gain transimpedance amplifier (TIA). The photodiode is biased by a current source on the receiver circuit board. Monitoring the photodetector bias current allows the average optical power to be detected and output as an analog signal to the remote port connector.

The output of the TIA is fed into an automatic gain control (AGC) amplifier, which is part of the photodiode module. Gain control for the amplifier is provided by feedback from a peak detector that monitors the optical signal in the photodiode module. The AGC amplifier adjusts the gain of the photodetector module to provide a uniform output swing over some range of input optical power. See Figure 11 on page 25 for the typical AGC amplifier response to varying data rate and input optical power.

The photodetector module output is AC-coupled to two 50 Ω connectors. One output is brought directly out to the front-panel SMA connector (data output). The other output (attenuated data output) passes through a 6 dB attenuator. This is the data output that is used for the optional clock modules. The data output is attenuated to ensure that the input limit on the modules is not exceeded.

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 (90 – 240 VAC) to +15 V, –15 V, and +5 V. A six-conductor cable connects the power supply output to the receiver board.

Clock Recovery Modules

The clock recovery modules for the receiver are described below:

OM1420

The clock recovery of the dual-rate OM1420 module is done with a resonant filter technique, which provides both low jitter and narrow bandwidth. The two data rates selectable with the OM1420 are OC-192 (9.953280 Gb/s) and OC-192 FEC (10.66423 Gb/s). The output amplifier of the clock recovery module provides a large output voltage signal.

Performance Verification

Use the following procedures to verify the warranted specifications of the OI2125 O/E Receiver. Before starting these procedures, photocopy the test record beginning on page 55 to record the performance test results.
The recommended calibration interval is one year.

If you are doing a Performance Verification on a Clock Recovery Module, photocopy the appropriate test record to record the performance test results. Clock Recovery Module test records begin on page 57.

These procedures test the following specifications:

Table 14: OI2125 Receiver PV checks

Circuit	Specification
Photodetector Optical Input	Loss of Signal Threshold
Data Output	Bandwidth
Eye Pattern Test Matrix	
Photodetector Optical Input	Input Wavelength
	Input Power
	Data Rate
Data Output	Data Output Voltage
	% Crossing
	Mask Hits

Table 15: Clock Recovery Module PV checks

Circuit	Specification
Input	Clock Recovery Rates
	Input Voltage
Output	Output Voltage
	Jitter Generation

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/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 26.
- All test equipment listed in Table 16 must be operating for a warm-up period of at least 30 minutes.

Equipment Required

Table 16 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 16 below. If you use alternative equipment, verify the connection style of the equipment, and use the appropriate cable or adapter.*

Table 16: Test equipment

Description	Minimum requirements	Example product
Controller	PC/Macintosh/Workstation w/FFT software and GPIB interface	PC w/Labview
GPIB cable	2 m length	Tektronix part number 012-0991-00
Sampling oscilloscope	Bandwidth: 20 GHz Jitter: < 1 ps at minimum sampling delay	Tektronix TDS8000
Optical sampling module	Bandwidth: 20 GHz	Tektronix 80C01
Electrical sampling head	Bandwidth: 20 GHz	Tektronix 80E01
Pattern Generator	< 2.4 Gb/s to > 12.5 Gb/s	Advantest D3186
Wavemeter	1530 nm to 1565 nm	Burleigh WA-1100
Optical Power Meter and Power Head	1550 nm, +15 dBm to –40 dBm, 0.01 dBm resolution, ±5% accuracy	Advantest Q8221 with Q82227 power head
Optical Transmitter	1530 nm to 1565 nm	Tektronix OI 1125

Table 16: Test equipment (cont.)

Description	Minimum requirements	Example product
Tunable Laser	10 dBm output power over 1530 nm to 1565 nm range, PMF-style output connector	NetTest Tunics BT-1560 w/high power option
Optical pulse generator	1550 nm impulse w/trigger out	Calmar FPL-01
Variable optical attenuator	1530 nm to 1565 nm range	Tektronix OA5002
Optical attenuator	30mm, 10 dB, single-mode, FC to FC, female to male	Tektronix part number 119-5118-00
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
Optical cable, PM	FC-APC Single mode, 18 cm	Tektronix part number 174-4664-00
Optical cable (2)	FC/PC to FC/PC, Single mode, 2 m	Tektronix part number 174-3922-00
Cable, low-loss coax	50 Ω, SMA male each end, ~1m	Tektronix part number 015-0561-00
Cable, coax	50 Ω, SMA male each end, 1m	Tektronix part number 174-1341-00
Cable, coax[1]	50 Ω, SMA male each end, 10 cm	Tektronix part number 174-4699-00
Attenuator, electrical[1]	2 X, 50 Ω, SMA	Tektronix part number 015-1001-00
Attenuator, electrical[1]	5 X, 50 Ω, SMA	Tektronix part number 015-1002-00
Torque wrench	5/16-in, 7-10 in-lb. (8 mm, 79 to 112 N-cm)	Pasternack Enterprises PE 5011-1

1 **Only required for Clock Recovery Module tests**

Photodetector Optical Input

This section includes one optical input check: the Loss of Signal Threshold test.

***NOTE**. To optimize performance, make sure that all optical connections are clean and secure and that all components of the system are in good condition.*

LOS Threshold

The loss of signal threshold test checks the minimum level of the incoming optical signal that the receiver will recognize.

Test Overview.

1. Connect the test circuit.
2. Set the BERT parameters (store the bit rates for other tests).
3. Set the optical attenuator parameters.
4. Set the power meter parameters.
5. Take measurements.

Test Setup.

1. Connect the equipment as shown in Figure 13. Use a torque wrench to secure the SMA connections to 7 to 10 lb-in (79 to 112 N-cm).

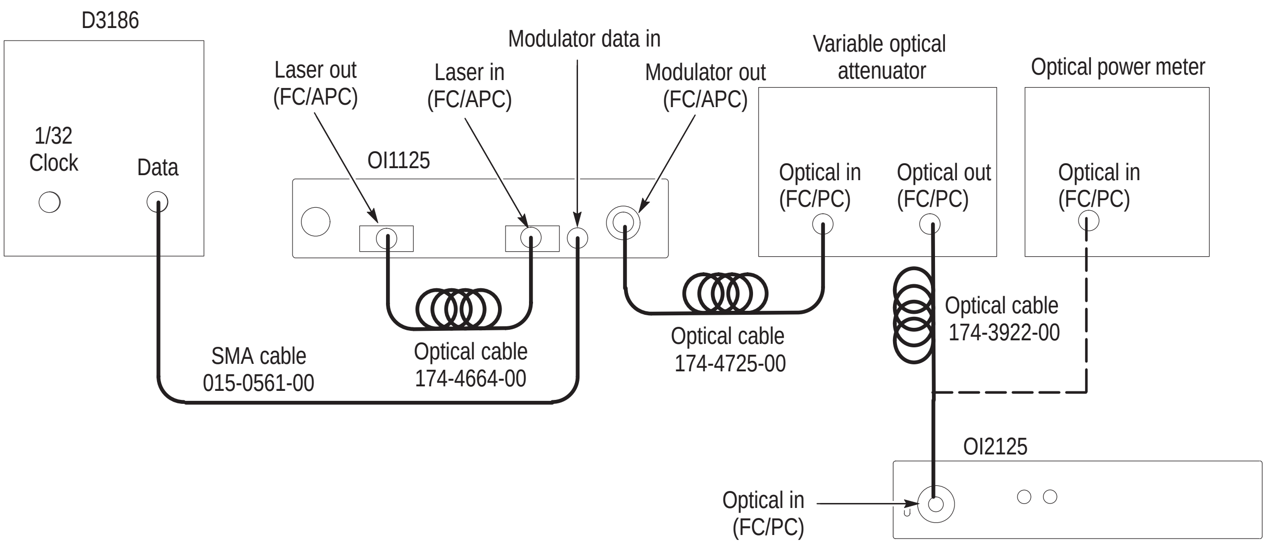

Figure 13: Setup for the LOS threshold test

BERT. Set the BERT settings as follows:

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

---

1. Set the BERT bit rate to 2.488320 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 you will use to recall this bit rate. Suggestion: Use 1 for 2.488320, 2 for 9.953280, and 3 for 12.500000 Gb/s.
   - **b.** Press Edit, and 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.
   - **c.** 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 you selected in step **a**.
2. Repeat steps 1a through 1d for 9.953280 Gb/s and 12.500000 Gb/s bit rates.
3. Recall the 2.488320 Gb/s bit rate.
4. Set the trigger output to 1/32 clock.
5. Set the output mode to AC.
6. Turn the data output on and set the data amplitude to 1.5 $V_{p\text{–}p}$.

Optical Attenuator. Set the optical attenuator settings:

1. Set the wavelength to 1550 nm.
2. Set the mode control to attenuation.
3. Set the attenuation to –20 dB.

Optical Power Meter. Set the optical power meter settings:

1. Set the wavelength to 1550 nm.
2. Set the units of measure to dBm.
3. Set the range to Auto.
4. If necessary, select the channel you will use.

Take Measurements.

1. Enable the transmitter laser by turning the keyswitch clockwise (to the unlocked position). The Laser On and Output Active LEDs both light.
2. Using the fine adjust on the optical attenuator, gradually decrease the output power from the transmitter until the Input Detected LED on the front panel of the receiver extinguishes. Note: The internal power monitor filter in the receiver slows the optical power threshold detector response.
3. Disconnect the cable from the optical input of the receiver, and connect it to the optical power meter.
4. Check the displayed power level on the optical power meter against the limits in Table 17 of the test record. Record the results in Table 17.
5. Disable the transmitter laser by turning the keyswitch counterclockwise (to the locked position). The Laser On and Output Active LEDs both extinguish.

Data Output

This section checks specifications of the data output signal.

Bandwidth

Check the bandwidth of the data output signal by doing the following:

Test Overview.

1. Connect the test circuit.
2. Set the optical attenuator parameters.
3. Set the oscilloscope scale factors.
4. Compensate the oscilloscope.
5. Preview the waveform.
6. Capture and process the impulse response waveform.

Connect the Test Circuit.

1. Connect the equipment as shown in Figure 14. Use a torque wrench to secure the SMA connections to 7 to 10 lb-in (79 to 112 N-cm).

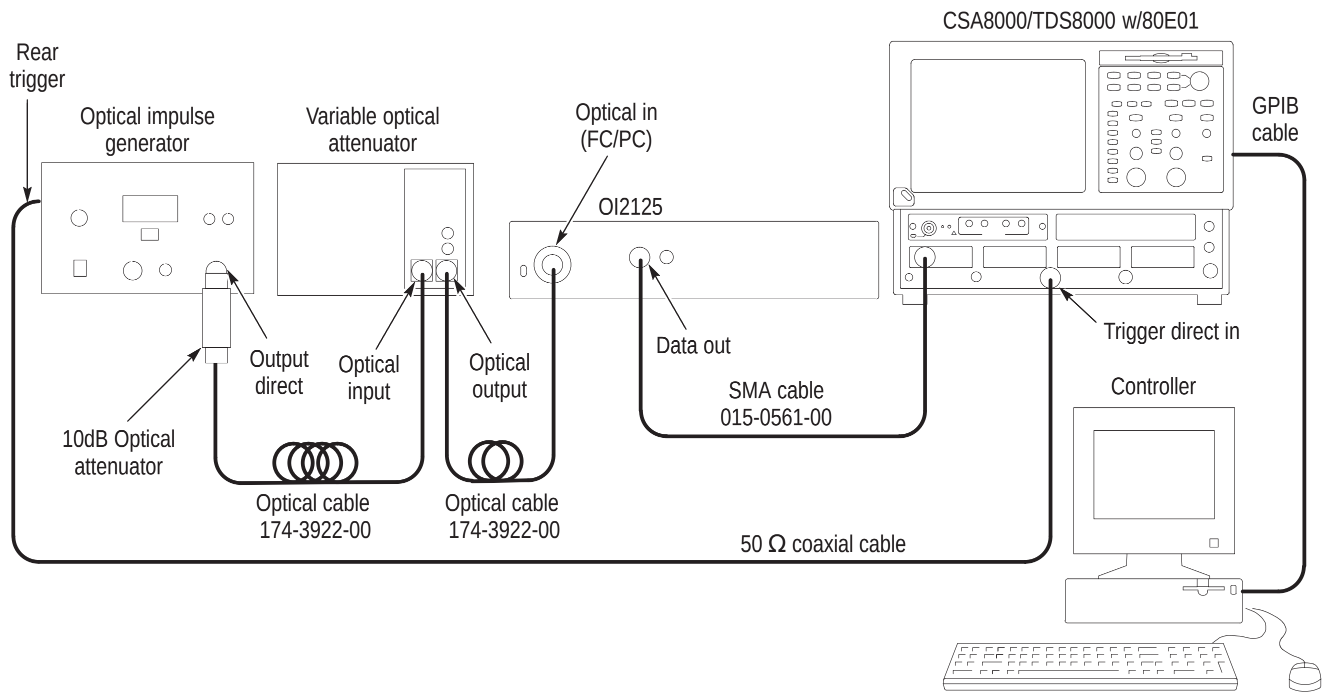

Figure 14: Setup for the bandwidth test

Optical Attenuator. Set the optical attenuator settings as follows:

1. Set the wavelength to 1550 nm.
2. Set the mode control to attenuation.
3. Set the attenuation to about 30 dB.

Oscilloscope. Set the TDS8000 settings as follows:

1. Press the SELECT ON/OFF button on the 80E01 so that the adjacent indicator lights.
2. From the toolbar, select Setup→Acquire.
   a. Select Average as the acquisition mode.
   b. Set the number of samples to 64 Samples.
3. Select the Trig tab to set the trigger parameters.
   a. Select External Direct for the trigger source.
   b. Select Auto for Mode.
   c. Select the rising edge for Slope.
   d. Click the Set to 50% button to set the trigger point midway on the rising signal.
4. Select the Horiz tab to set the horizontal parameters.
   a. Set the Scale to 1.000 ns/div. (This setting will make it easier to initially locate the optical pulse later in the procedure.)
   b. Set the Position to 18.000 ns. (This setting will make it easier to locate the first optical pulse later in the procedure.)
   c. Set the Record Length to 2000.
5. Select the Disp tab to set the display parameters.
   a. In the Style section, select Normal.
   b. Check Show Vectors.

***NOTE**. If the Scale, Position, and Channel Offset control boxes are not displayed in the following step, click the Basic>> button in the lower left part of the Vert Setup dialog box.*

---

6. Select the Vert tab to set the vertical parameters.

a. Set the Scale to 1 mV/div.

b. Set Position to 0.0 div.

c. Set Channel Offset to 0.0 V.

7. Close the Setup box.

Compensate the Oscilloscope.

1. Run a Signal Path Compensation from the Utilities menu.

Preview the Waveform. Refer to Figure 15 on page 44 as you do the following:

1. Adjust the attenuation of the variable optical attenuator until it produces an impulse pulse amplitude of 2 mV_{p-p} to 3 mV_{p-p} .

2. Use the Horizontal Position control to position the impulse at the first horizontal division. (This ensures that postimpulse aberrations are included in the record.)

You may experience signal jitter if you try to display a signal that is not the first impulse and is late in relation to time zero.

3. Adjust the Horizontal Scale control so that the width of the impulse at its base is approximately 1/4 to 3/4 of a horizontal division on the display.

***NOTE**. If the width of the impulse is much greater than 3/4 of a horizontal division, the resulting Fourier transform will not have enough frequency resolution; if the width is much smaller than 1/4 of a horizontal division, the amount of samples that fall on the impulse may be too coarse, resulting in quantum errors in the resulting Fourier transform.*

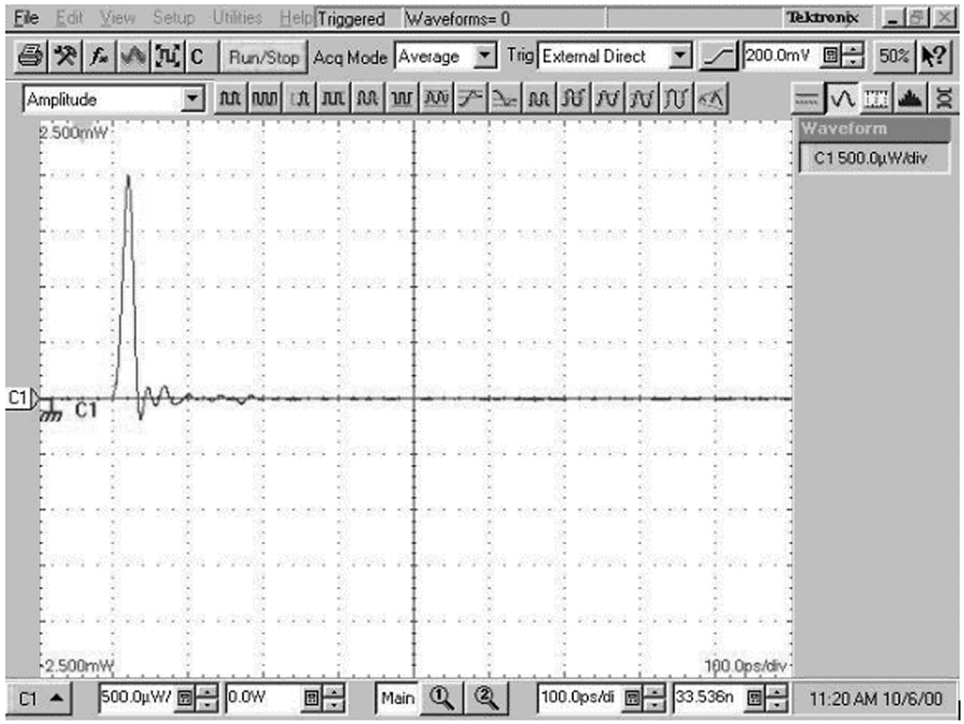

Figure 15: Proper positioning of the impulse for optimum curve download

Capture and Process the Impulse Response Waveform.

1. Using a controller (such as a PC, Macintosh, or workstation) attached to the TDS8000 or CSA8000 instrument via GPIB, download the waveform.

NOTE. *Alternatively, you can use the Save Waveform, Copy Waveform, or a network connection to transfer a waveform curve to a spreadsheet, ASCII file, or other application. Refer to the* CSA8000 Communications Signal Analyzer & TDS8000 Digital Sampling Oscilloscope User Manual *for more information about these methods of transferring waveform data.*

2. Using the available controller software, such as Labview, perform a Fourier Transform on the waveform; this transforms the time-domain impulse response to a scalar frequency response.
3. Normalize the Fourier Transform result such that DC or low frequency is 0 dB.
4. Plot the frequency response.
5. Check that the OI2125 O/E Receiver meets the performance requirement bandwidth. Record the result on the test record.

Eye Pattern Test Matrix

These procedures direct you to set up the equipment to display an eye pattern. Use the eye pattern to measure the parameters listed in Tables 18 through 20 in the test record.

Test Overview

To prepare the test matrix, do the following setups:

1. Connect the test circuit.
2. Set the BERT parameters.
3. Set the tunable laser parameters.
4. Set up the optical attenuator.
5. Set up the optical power meter.
6. Preview the eye pattern.
7. Set the oscilloscope measurement parameters.
8. Calibrate the oscilloscope.
9. 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 tables, you must change the bit rate of the BERT, the laser wavelength, the attenuator settings, and the signal conditioning mode in the oscilloscope, according to the table and row you are completing.

Test Circuit

Connect the equipment as shown in Figure 16 on page 46. A torque wrench is recommended for securing the SMA connections to 7 to 10 lb-in (79 to 112 N-cm).

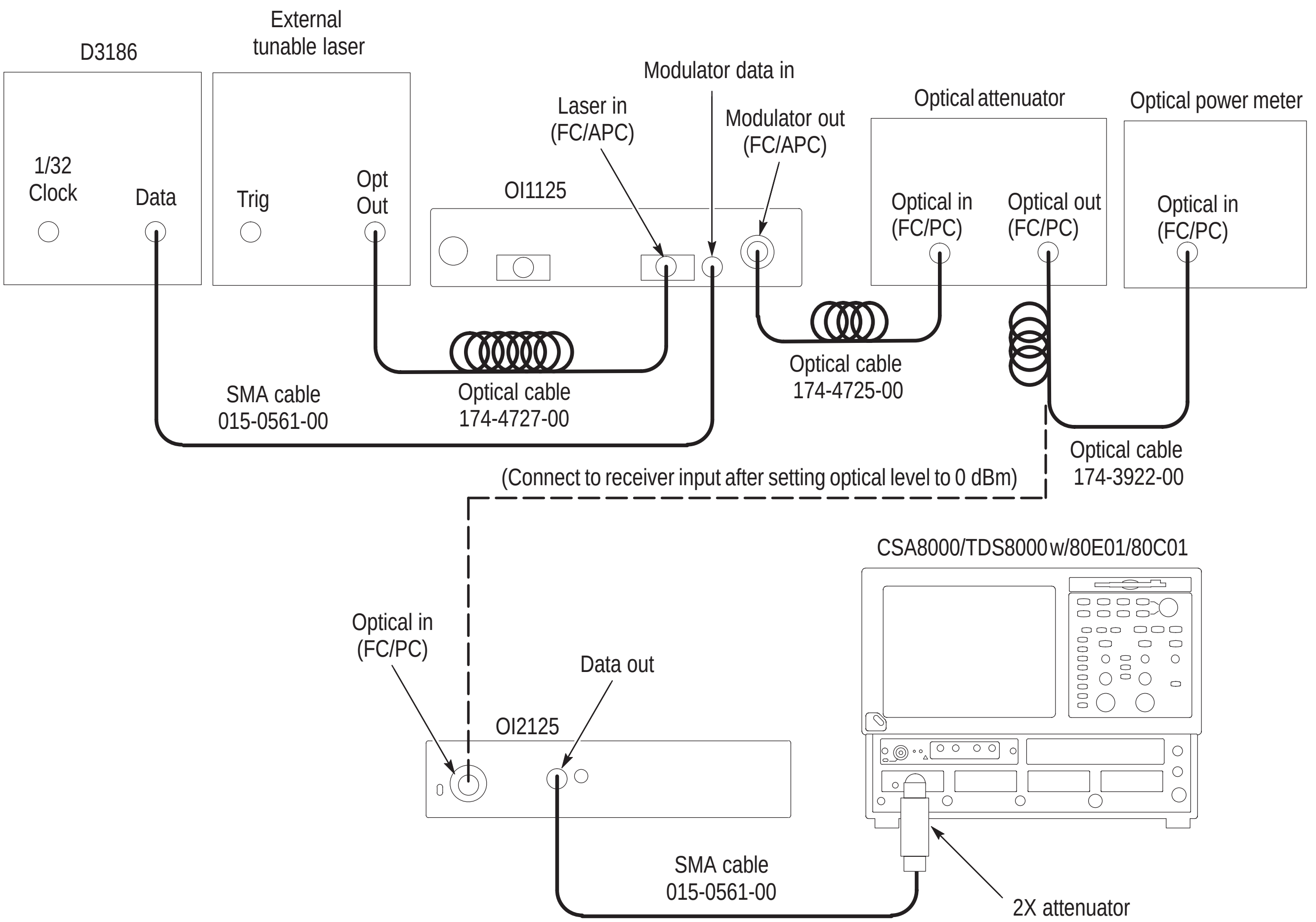

Figure 16: Setup for the eye pattern test matrix

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 output mode to AC.
7. Turn the data output on and set the data amplitude to 1.0 V_{p-p}.

Tunable Laser

Set the tunable laser parameters:

1. Enable the tunable laser.
2. Set the wavelength to 1530 nm.
3. Set the amplitude to 10 dBm.

Optical Attenuator

Set the optical attenuator settings:

1. Set the wavelength to 1530 nm.
2. Set the mode control to attenuation.
3. Set the attenuation to 0 dB.

Optical Power Meter

Set the optical power meter settings:

1. Set the wavelength to 1530 nm.
2. Set the units of measure to dBm.
3. Set the range to Auto.
4. If necessary, select the channel you are using.

Preview the Eye Pattern

Scale the optical signal to 0 dBm on the power meter, and then connect the optical signal to the receiver to preview the electrical eye pattern:

1. Enable the transmitter laser by turning the keyswitch clockwise (to the unlocked position). The Laser On LED and Laser Output Active LED light.
2. Adjust the attenuator to get a 0 dBm reading on the optical power meter.
3. Disable the transmitter laser by turning the keyswitch counterclockwise.
4. Disconnect the optical cable from the power meter, and connect it to the receiver. (See dashed line in Figure 16 on page 46).
5. Enable the transmitter laser by turning the keyswitch clockwise.
6. On the oscilloscope, press Autoset.
7. Press the Clear Data button, and then the Run/Stop button.

The oscilloscope displays an eye pattern similar to Figure 17 on page 49. The oscilloscope setup in the next section sets up the mask parameters.

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→Horz.

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

2. Select the Vert tab to set the vertical parameters:

   In the External Attenuation box, enter 2.00 and select Linear.

3. Select the Trig tab to set the trigger parameters:

   In the Trigger Source box, select External Direct.

4. Select the Mask tab to set the mask parameters:

   a. Set Source to the oscilloscope 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.

5. Select the Meas tab to set the measurement parameters:

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

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

   c. In the source tab, set CH x to the measurement channel you are using.

   d. Click Select Meas.

   e. From the drop-down menus, select NRZ Amplitude→Amplitude.

   f. Repeat steps **a** through **e** for Meas 2. When doing step **e**, select NRZ Amplitude→Crossing %.

6. Close the Setup window.

Compensate the Oscilloscope.

1. Run a Signal Path Compensation from the Utilities menu.

Take Measurements

The equipment is now set up for recording measurements in Table 18:

1. From the toolbar, select Setup→Acq 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.
2. Close the Setup window.
3. Press the Autoset button.
4. Press the Clear Data button, and then the Run/Stop button on the oscilloscope to begin a measurement.

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

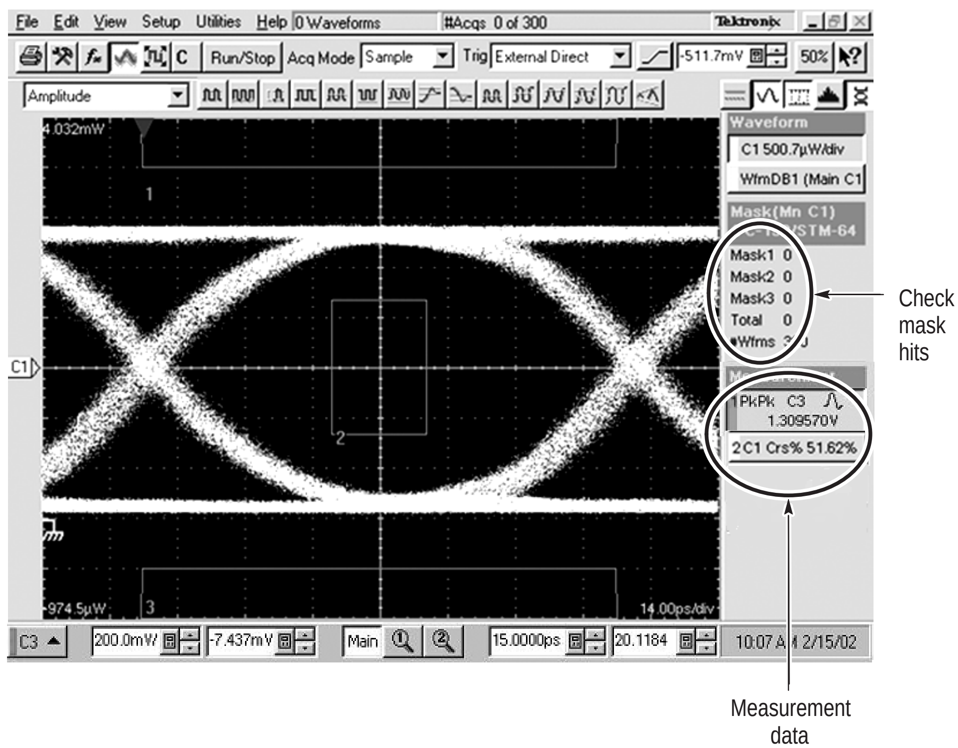

Figure 17: Measurements taken from the eye pattern

5. Verify that the eye pattern does not violate the mask boundaries.
6. Record the measurement data (see Figure 17) in the first row of Table 18.

7. Disable the transmitter laser, disconnect the optical cable from the input of the receiver, and connect the cable to the optical power meter.

8. Set the wavelength on the attenuator and power meter, and adjust the laser power and wavelength to record the measurements for the remaining rows in Table 18.

***NOTE**. Disregard mask hits when you take measurements at the –16 dBm power levels.*

---

9. Recall the 9.95328 Gb/s bit rate.

10. From the Mask tab on the oscilloscope setup menu, set the Communication Standard to SONET→OC-192.

11. Repeat steps 4 through 8 for Table 19, beginning with the optical settings from the last row you completed in the previous table. (This saves a few steps and connect/disconnect cycles for the optical connectors.)

12. Recall the 12.50000 Gb/s bit rate.

13. Press Autoset.

14. Using the keypad in the horizontal menu, adjust the horizontal scale to 12 ps/div. This scales the OC-192 mask to the 12.50000 Gb/s data rate.

15. If necessary, adjust the horizontal position to center the crossing points of the eye around the center mask boundary.

16. Repeat steps 4 through 8 and step 15, if necessary, for Table 20, beginning with the optical settings from the last row you completed in the previous table.

This concludes the performance verification for the receiver. If you need to perform the *Clock Recovery Module Tests*, see page 51.

Clock Recovery Module Tests

This section contains procedures for checking the output voltage and RMS jitter specifications on the OM1420 clock recovery module. To take these measurements, you set up a histogram display of the clock output signal to extract a jitter measurement, and use the Measurement feature of the oscilloscope to automatically measure and display the peak to peak voltage of the clock output signal.

OM1420

Check the RMS jitter and output voltage of the OM1420 clock output signal:

Test Overview.

1. Connect the test circuit.
2. Set the BERT parameters.
3. Preview the waveform to scale the waveform in amplitude and time.
4. Set up and adjust the histogram measurement on the oscilloscope.
5. Take measurements.

Connect the Test Circuit.

1. Connect the equipment as shown in Figure 18.

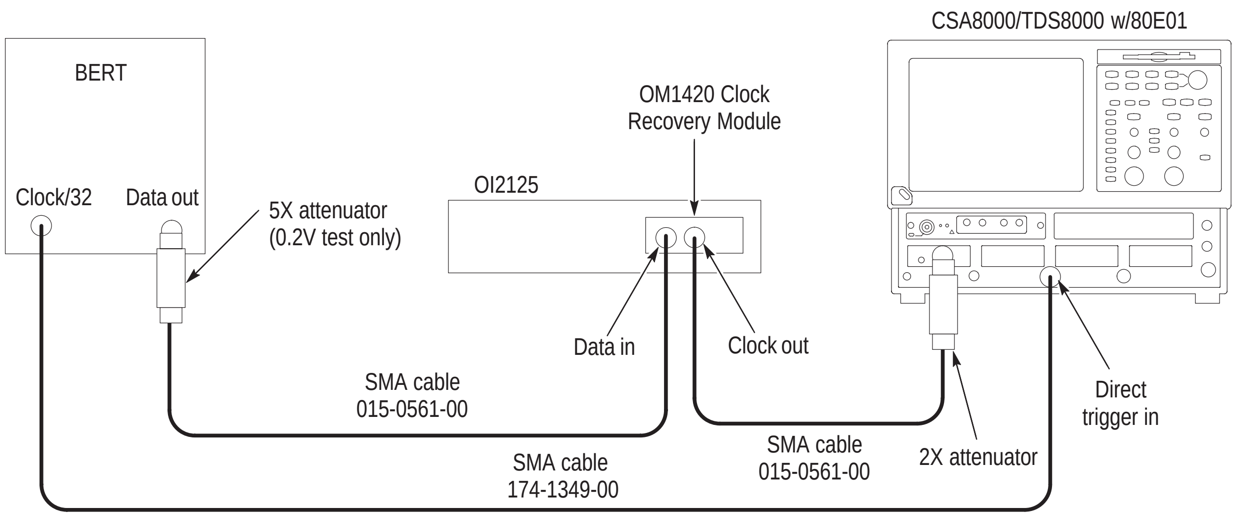

Figure 18: OM1420 Clock Recovery Module test setup

BERT. Set the BERT parameters as follows:

1. Recall the 9.953 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 output mode to AC.
7. Turn the data output on and set the data amplitude to 0.75 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→Horizontal.
   a. In the All Timebases box, set the Mode field to Short Term Jitter from the drop-down menu.
   b. Set Units to seconds.
2. Select the Vert tab to set the vertical parameters:

   In the External Attenuation box, enter 2.00 and select Linear.
3. Select the Trig tab to set the trigger parameters.
   a. In the Trigger Source box, select External Direct.
4. Select the Hist tab to set the histogram parameters.
   a. In the source box, set Source to the channel that 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 Mode.
5. Select the Meas tab to set the measurement parameters:
   a. In the Meas x field, select Meas 1.

b. In the source tab, set CH x to the measurement channel that you are using.

c. In the Signal Type box, click Pulse.

d. Click Select Meas.

e. From the drop-down menus, select Pulse Amplitude→Pk-Pk.

6. Close the Setup window.

Preview the Waveform.

1. Turn on the receiver and select OC-192 on the OM1420 module.
2. Press Autoset.
3. Press the Clear Data button and then the Run/Stop button on the oscilloscope to display a waveform as shown in Figure 19 on page 53.

Set up the Measurements. Refer to Figure 19 as you align the waveform.

1. Align the rising edge of the waveform with the center of the oscilloscope graticules.
2. Reduce the vertical size of the histogram box as small as possible.

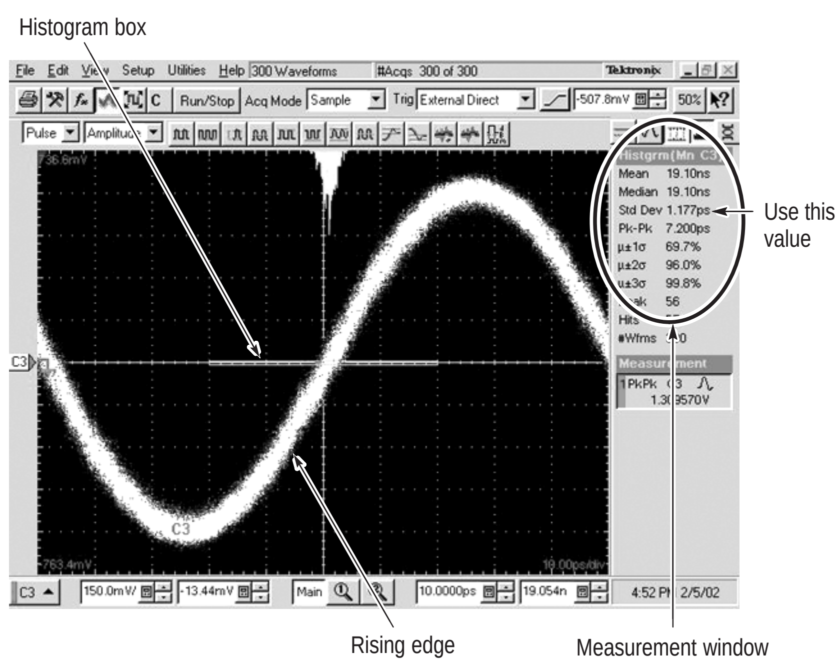

Figure 19: RMS Jitter measurement

3. From the toolbar, select Setup→Acq 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.

4. Close the Setup window.

Take Measurements.

1. Press the Autoset button.

2. Press the Clear Data button, and then the Run/Stop button on the oscilloscope to begin a measurement.

3. Check that the voltage and jitter measurements from the measurement window on the oscilloscope meet the limits in the test record.

4. Record the measurements in the 9.953 Gb/s, 0.75 V row in Table 22.

5. Set the bit rate on the BERT to 10.66423 Gb/s.

6. Select the OC-192 FEC rate on the OM 1420 module.

7. Repeat steps 1 to 4 for the 10.66423 Gb/s, 0.75 V row in Table 22.

8. Disconnect the SMA cable from the BERT and connect the 5X attenuator to the BERT. Connect the SMA cable to the 5X attenuator.

9. Repeat steps 1 to 4 for the 10.66423 Gb/s, 0.15 V row in Table 22.

10. Recall the 9.953 Gb/s bit rate on the BERT.

11. Select the OC-192 rate on the OM 1420 module.

12. Repeat steps 1 to 4 for the 9.953 Gb/s, 0.15 V row in Table 22.

This completes the performance verification for the OM1420 module.

OI2125 O/E Receiver Test Record

Photocopy this form and use it to record the performance test results.

Table 17: OI2125 O/E Receiver test record

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

Performance Test			Minimum	Measured	Maximum
<Circuit>	<Test name>				
Optical Input	Loss of Signal Threshold		–27 dBm		–23 dBm
	Bandwidth	Lower Limit	————		50 MHz
		Upper Limit	7.5 GHz		————
Data Output	Voltage	–8 dBm to 0 dBm	0.5 V_{p-p}	Use the Min/Max values as limits for the test results in Tables 18 through 20.	1.5 V_{p-p}
		–16 dBm to –8 dBm	0.2 V_{p-p}		1.5 V_{p-p}
	% Crossing		45%		55%

Table 18: BERT input @2.48832 Gb/s bit rate

Wavelength	Optical Input Power	Data Output Voltage	% Crossing	Mask Hit
1530 nm	0 dBm			
	-8 dBm			
	-16 dBm			Not measured
1565 nm	0 dBm			
	-8 dBm			
	-16 dBm			Not measured

Table 19: BERT input @9.95328 Gb/s bit rate

Wavelength	Optical Input Power	Data Output Voltage	% Crossing	Mask Hit
1530 nm	0 dBm			
	-8 dBm			
	-16 dBm			Not measured

Table 19: BERT input @9.95328 Gb/s bit rate (Cont.)

Wavelength	Optical Input Power	Data Output Voltage	% Crossing	Mask Hit
1565 nm	0 dBm			
	-8 dBm			
	-16 dBm			Not measured

Table 20: BERT input @12.50000 Gb/s bit rate

Wavelength	Optical Input Power	Data Output Voltage	% Crossing	Mask Hit
1530 nm	0 dBm			
	-8 dBm			
	-16 dBm			Not measured
1565 nm	0 dBm			
	-8 dBm			
	-16 dBm			Not measured

Clock Recovery Module Test Records

The following pages contain test records for the optional clock recovery modules. Photocopy the appropriate test record and use it to record the performance test results.

Table 21: OM1420 test record

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

Performance Test		Minimum	Measured	Maximum
<Circuit>	<Test name>			
Clock Output	Output Voltage	1.0 $V_{p\text{-}p}$	Use the Min/Max values as limits for the test results in Table 22.	2.5 $V_{p\text{-}p}$
	Jitter Generation	————		2 ps rms

Table 22: OM1420 clock output data

BERT Data Rate (Gb/s)	Input Voltage, $V_{p–p}$	Jitter, $V_{p–p}$	Clock Output Voltage, $V_{p–p}$
9.95328	0.15		
	0.75		
10.66423	0.15		
	0.75		

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 23 as a guide. Immediately repair defects that could cause personal injury or lead to further damage to the instrument.

Table 23: 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.*

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.

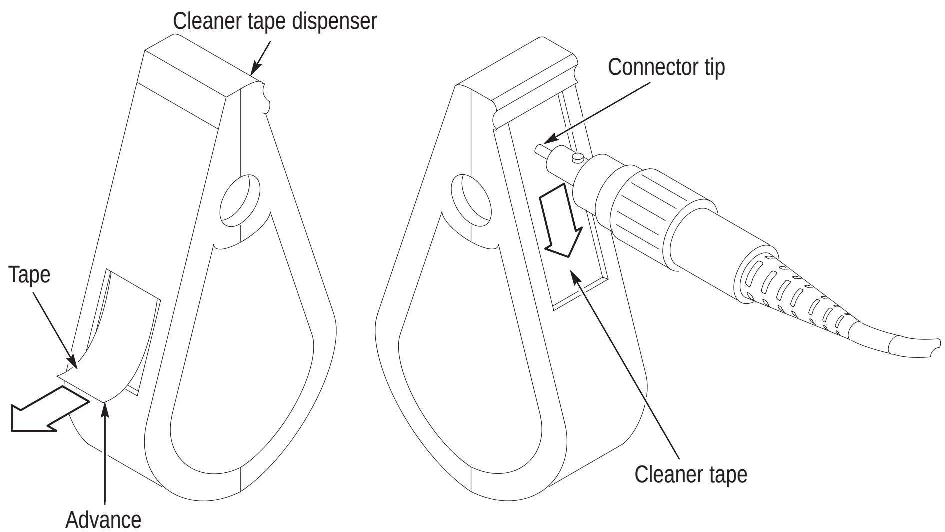

Figure 20: Cleaning an optical connector

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

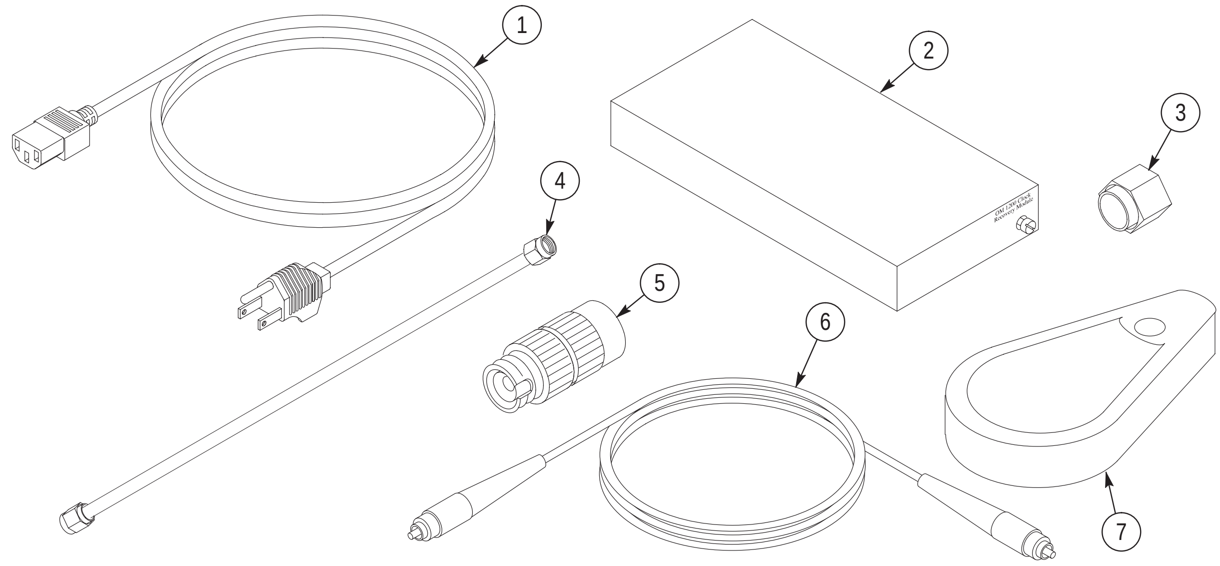

Figure 21: Standard accessories

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	119–6690–00			1	MODULE ASSY:CLOCK RECOVERY,SLOT COVER,OI2125	80009	119–6690–00
–3	015–1022–00			1	TERMINATOR,COAX:50 OHM, 0.5W,SMA	26805	2001–4401–00
–4	015–0561–00			1	CABLE,DLY,COAX:50 OHM,4NS,W/CONN,SMA,MALE,EACH END	0GZV8	SF104PE,920MM,2X1 1SMA–451
–5	119–4516–00			1	CONNECTOR,OPTO:ADAPTER,FC–PC,ATTEN 0.6DB,RTN LOSS 35DB,RPTB+/–0.2DB,TFS3030	TK2491	APC–10
–6	174–3922–00			1	CA ASSY,FBR OPT:SINGLE MODE,3 METER LONG,FC–PC TO FC–PC	0R0U6	8814–3M–SB
–7	006–8217–00			1	CONN CLEANER:FIS CONNECTOR CLEANER	0CKD9	F1–7111
	071–1053–XX			1	MANUAL,TECH:INS,O/E RECEIVER, OI2125	TK2548	071–1053–XX

Optional accessories (not pictured)

Tektronix part number	Serial no. effective	Serial no. discont'd	Qty	Name & description	Mfr. code	Mfr. part number
119–4517–00			1	ADAPTER,SMA:TFS3030,2.5MM,AMT–10	TK2491	AMT–10
119–4556–00			1	ADAPTER,HP–PC:OPTICAL CONNECTOR,UNIVERSAL CONNECTOR INTERFACE,AHP–10(HMS–10/HP)	TK2491	AHP–10 PROPRIETARY INFO
119–4557–00			1	ADAPTER,UNIV:SMA 905/906,ASM–90	TK2491	ASM–90 PROPRIETARY INFO
119–4558–00			1	ADAPTER,UNIV:DIAMOND 3.5MM,AMS–00(DIAMOND–PC,HMS–0)	TK2491	AMS–00 PROPRIETARY INFO
119–5115–00			1	ADAPTER,FC/APC:OPTICAL CONNECTOR,APC–108	TK2491	APC–108
119–5116–00			1	ADAPTER,SC/APC:OPTICAL CONNECTOR,ASC–108	TK2491	ASC–108
119–5887–00			1	ADAPTER,UCI:OPTICAL CONNECTOR,UNIVERSAL CONNECTOR INTERFACE, ADT–UNI.S8/DIN.2,TOP160	TK2491	AD–108, DIN/APC
119–5888–00			1	ADAPTER,UCI:OPTICAL CONNECTOR,UNIVERSAL CONNECTOR INTERFACE,ADT–UNI/ST,TOP160	80009	119–5880–00
131–7368–00			1	CONN,FIBER OPT:ATTENUATOR,OAF FC–PC,SINGLE MODE,5 DB,2.14 MM OD	80009	131–7368–00
TVGF13				SIDE BY SIDE INSTRUMENT RACK ADAPTER	80009	TVGF13

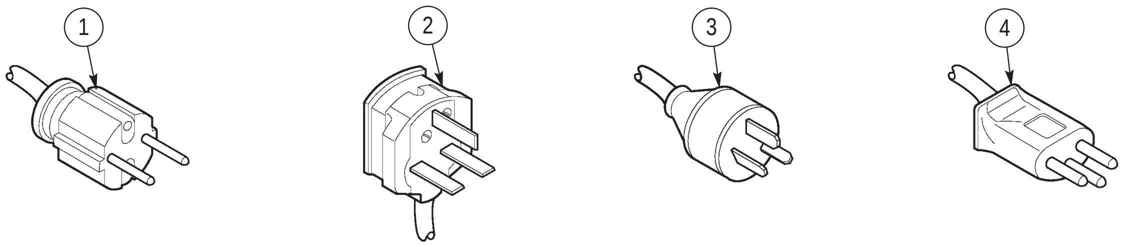

Figure 22: Optional power cords

Optional power cords

Fig. & index number	Tektronix part number	Serial no. effective	Serial no. discont'd	Qty	Name & description	Mfr. code	Mfr. part number
22–1	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
0R0U6	FICO INC	2 BRIDGEVIEW CIRCLE	TYNGSBORO, MA 01879
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

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