

**80C00 Series
Optical Sampling Modules
User Manual**



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Tektronix

**80C00 Series
Optical Sampling Modules
User Manual**

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- Worldwide, visit www.tektronix.com to find contacts in your area.

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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 a larger system. Read the safety sections of the other component manuals for warnings and cautions related to operating the system.

To Avoid Fire or Personal Injury

Ground the product. This product is indirectly grounded through the grounding conductor of the mainframe 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.

The inputs are not rated for connection to mains or Category II, III, or IV circuits.

Do not apply a potential to any terminal, including the common terminal, that exceeds the maximum rating of that terminal.

Do not operate without covers. Do not operate this product with covers or panels removed.

Do not operate with suspected failures. If you suspect that there is damage to this product, have it inspected by qualified service personnel.

Avoid exposed circuitry. Do not touch exposed connections and components when power is present.

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

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.

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.*

Symbols and 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.

The following symbol(s) may appear on the product:



CAUTION
Refer to Manual



Protective Ground
(Earth) Terminal

Environmental Considerations

This section provides information about the environmental impact of the product.

Product End-of-Life Handling

Observe the following guidelines when recycling an instrument or component:

Equipment Recycling. Production of this equipment required the extraction and use of natural resources. The equipment may contain substances that could be harmful to the environment or human health if improperly handled at the product's end of life. In order to avoid release of such substances into the environment and to reduce the use of natural resources, we encourage you to recycle this product in an appropriate system that will ensure that most of the materials are reused or recycled appropriately.



This symbol indicates that this product complies with the applicable European Union requirements according to Directives 2002/96/EC and 2006/66/EC on waste electrical and electronic equipment (WEEE) and batteries. For information about recycling options, check the Support/Service section of the Tektronix Web site (www.tektronix.com).

Restriction of Hazardous Substances

This product has been classified as Monitoring and Control equipment, and is outside the scope of the 2002/95/EC RoHS Directive.

Preface

This is the user manual for the 80C00 Series Optical Modules and their available options. It includes the following information:

- Describes the capabilities of the modules and how to install them
- Explains how to operate the modules: how to control acquisition, processing, and input/output of information

Go to the Tektronix Web site at <http://www.tek.com> for the latest revision of the user documentation. Enter the part number or product name to locate, and the download type, in the Downloads fields on the home page and click **GO**.

You can also order a printed version of this manual. (See page 8, *Optional Accessories*.)

Specifications

Specifications are located in the *DSA8200 Digital Serial Analyzer Specifications and Performance Verification Technical Reference* (Tektronix part number 071-2048-xx). You can download the manual from the Tektronix Web site (www.tektronix.com).

To meet measurement specifications, the following instrument conditions must be met:

- The instrument must have been calibrated/adjusted at an ambient temperature between +20 °C and +30 °C.
- The instrument must have been operating continuously for 20 minutes within the operating temperature range specified.
- Vertical compensation must have been performed with the module installed in the same compartment used when the compensation was performed. Ambient temperature must be within ± 2 °C of the compensation temperature.
- The instrument must be in an environment with temperature, altitude, humidity, and vibration within the operating limits described in the specifications.

Manual Structure

This manual is composed of the following chapters:

- *Getting Started* shows you how to configure and install your optical module.
- *Operating Basics* describes controlling the module using the front panel and the instrument user interface.
- *Reference* provides information on wavelength selection, clock recovery, and optical bandwidth.

Related Documentation

This document covers installation and usage of the sampling module and its features. For information about the main instrument in which the sampling module is installed, refer to the user documents and online help provided with your main instrument.

Getting Started

The 80C00 Series Optical Modules and their available options are high-performance optical modules that support high bandwidth telecom and datacom standards. The 80C00 Series modules work with the following main instruments (mainframes):

- DSA8200 Digital Serial Analyzer
- CSA8000, CSA8000B, and CSA8200 Communications Signal Analyzers
- TDS8000, TDS8000B, and TDS8200 Digital Sampling Oscilloscopes

Proper operation of the optical sampling modules requires that the appropriate application software is installed on the main instrument. The following table lists the mainframe application software versions and the optical modules supported.

To display the version installed, select *About* from the Help menu of the main instrument.

Table 1: Application software version required

Application software version	Modules supported
1.0 ¹	80C01, 80C01-CR, 80C02, 80C02-CR
1.4 ¹	Added: 80C10
1.5 ¹	Added: 80C07B, 80C07B-CR1 80C08C, 80C08C-CR1, 80C08C-CR2, 80C08C-CR4, 80C11, 80C11-CR1, 80C11-CR2, 80C11-CR3, 80C11-CR4
2.0.1.3 ^{2,3}	Added: 80C12 (limited)
2.0.1.5 ³	Added: 80C12
5.0 or greater ⁴	Added: 80C02 Option 01, 80C08C Option 01, 80C10B, 80C11 Option 01, 80C12 Option 01, 80C25GBE

¹ Product application software version 1.x requires the Windows 98 operating system.

² Product application software version 2.x requires the Windows 2000 operating system.

³ Product application software version 2.0.1.3 should be replaced with the latest version available for download from the Tektronix Web site.

⁴ Product application software version 5.x requires the Windows XP operating system.

Product Description

The optical modules provide the features listed in the following tables: (See Table 3.) (See Table 4.)

A table in the *Reference* section provides wavelength selections, filter and bandwidth specifications for each module. (See Table 10 on page 29.)

A figure in the *Operating Basics* section shows the module controls, connectors, and indicators. (See Figure 5 on page 17.)

Table 2: Optical module features (80C02)

Feature	80C02¹
Number of input channels	1
Effective wavelength range	1100 nm to 1650 nm
Supported standards or data filtering rates	OC-192/STM-64
Clock recovery, option	OC-192/STM-64
Absolute maximum nondestructive optical input ²	5 mW average power; 10 mW peak power at wavelength with highest relative responsivity
Internal Fiber Diameter	9 mm/125 μ m single mode ³
Optical return loss	> 30 dB typical
Minimum optical bandwidth at optical connector	> 30 GHz
Output zero	< 10 μ W immediately after dark calibration
Independent channel deskew	Standard
Offset capability at front of module	Standard
Power meter	Standard

¹ Some values in the table are typical.

² The optical input powers below nondestructive levels may exceed saturation and compression limits of the module.

³ Compatible with single-mode fiber of equal or smaller diameter.

Table 3: Optical module features (80C07B, 80C08C, and 80C12)

Feature	80C07B ¹	80C08C ¹	80C12 ¹
Number of input channels	1	1	1
Effective wavelength range	700 nm to 1650 nm	700 nm to 1650 nm	700 nm to 1650 nm
Supported standards or data filtering rates	<i>Standard</i> OC-48 / STM-16, 2 Gigabit Ethernet (ENET2500/2GBE), Infiniband <i>Optional</i> ² OC-3 / STM-1, OC-12 / STM-4, FibreChannel (FC1063/FC), Gigabit Ethernet (ENET1250/GBE), 2G FibreChannel (FC2125/2FC)	9.95328 Gb/s (10GBASE-W), 9.95328 Gb/s (OC-192/STM64), 10.3125 (10GBASE-R), 10.51875 (10GFC), 10.66423 Gb/s (G.975 FEC), 10.709225 Gb/s (G.709 FEC), 11.10 Gb/s (10GbE FEC), 11.317 Gb/s (10GFC FEC)	<i>Multi Gigabit Options</i> ³ 1.0625 Gb/s (FC1063) 2.125 Gb/s (FC2125) 3.125 Gb/s (10GBase-X4) 3.188 Gb/s (10GFC-X4) 3.318 Gb/s (VSR-5) 4.250 Gb/s (FC4250) <i>10 Gigabit Option (Option 10G)</i> 9.95328 Gb/s (10GBase-W), 9.95328 Gb/s (OC-192/STM64), 10.3125 Gb/s (10GBase-R), 10.51875 Gb/s (10GFC), 10.66423 Gb/s (G.975 FEC), 10.709225 Gb/s (G.709 FEC), 11.10 Gb/s (10GbE FEC), 11.317 Gb/s (10GFC FEC)
Clock recovery option	155.52 Mb/s (OC-3/STM-1), 622.08 Mb/s (OC-12/STM-4), 1062.5 Mb/s (FC1063/FC), 1250 Mb/s (ENET1250/GBE), 2125 Mb/s (FC2125/2FC), 2488.32 Mb/s (OC-48/STM-16), 2500 Mb/s (ENET2500/2GBE), 2500 Mb/s (Infiniband), 2666.06 Mb/s (OC-48-FEC)	9.95328 Gb/s (10GBASE-W/OC-192/STM-64) (CR-1) 10.3125 Gb/s (10GBASE-R) (CR-1 & CR-2) 10.51875 Gb/s (10GFC) (CR-2 only) Continuous-rate from 9.8 Gb/s to 12.6 Gb/s (CR-4) ⁴	Clock recovery supported with the use of the 80A05 or 80A07 Electrical Clock Recovery module (purchased separately)
Absolute maximum nondestructive optical input ⁵	5 mW average power; 10 mW peak power at wavelength with highest relative responsivity	1 mW average power; 10 mW peak power for 60 ms.	1 mW average power; 10 mW peak power for 60 ms.
Internal fiber diameter	62.5 mm/125 µm multimode mode ⁶	62.5 mm/125 µm multimode mode ⁶	62.5 mm/125 µm multimode mode ⁶
Optical return loss	> 14 dB for multimode fiber > 24 dB for single-mode fiber	> 14 dB for multimode fiber > 24 dB for single-mode fiber	> 14 dB for multimode fiber > 24 dB for single-mode fiber
Minimum optical bandwidth at optical connector	> 2.3 GHz	> 9.5 GHz	> 8.5 GHz > 9.5 GHz with Option 10G

Feature	80C07B ¹	80C08C ¹	80C12 ¹
Output zero	< 500 nW immediately after dark calibration $\pm 2\%$ (vertical offset)	< 1 μ W immediately after dark calibration $\pm 2\%$ (vertical offset)	< 1 μ W immediately after dark calibration $\pm 2\%$ (vertical offset)
Independent channel deskew	Standard	Standard	Standard
Offset capability at front of module	Standard	Standard	Standard
Power meter	Standard	Standard	Standard

¹ Some values in the table are typical.

² The 80C07B is shipped with five reference receiver filters. Three are standard, with the two remaining configured at the time of purchase. (See Table 5 on page 6.)

³ The 80C12 is available with a variety of options that support 2 to 4 filters. (See Table 5 on page 6.)

⁴ Continuous-rate clock recovery supporting any standard or user-definable rate in the range from 9.8 Gb/s to 12.6 Gb/s.

⁵ The optical input powers below nondestructive levels may exceed saturation and compression limits of the module.

⁶ Compatible with single-mode fiber of equal or smaller diameter.

Table 4: Optical module features (80C10, 80C10B, 80C11, and 80C25GBE)

Feature	80C10, 80C10B, 80C25GBE ¹	80C11 ¹
Number of input channels	1 ²	1
Effective wavelength range	1310 nm \pm 20 nm 1520 nm to 1620 nm	1100 nm to 1650 nm
Supported standards or data filtering rates	80C10: 30 GHz 65 GHz 39.813 Gb/s OC768/STM256 43.018 Gb/s G.709 FEC 80C10B: 30 GHz 65 GHz 80 GHz 39.813 Gb/s OC768/STM256 43.018 Gb/s G.709 FEC 41.25 Gb/s 40GBase-FR 80C10B-F1: 65 GHz 39.813 Gb/s OC768/STM256 43.018 Gb/s G.709 FEC 41.25 Gb/s 40GBase-FR 25.781 Gb/s 100GBase-xR4 27.739 Gb/s 100GBase-xR4 FEC 80C25GBE: 65 GHz 25.781 Gb/s 100GBase-xR4 27.739 Gb/s 100GBase-xR4 FEC	OC-192/STM-64 (9.953 Gb/s), 10GBASE-W (9.953 Gb/s), 10GBASE-R (10.31 Gb/s), 10GFC (10.518 Gb/s), G.975 FEC (10.66 Gb/s), G.709 FEC (10.71 Gb/s), 10GbE FEC (11.10 Gb/s), 10GFC FEC (11.317 Gb/s) 16GFC (14.025 Gb/s)

Table 4: Optical module features (80C10, 80C10B, 80C11, and 80C25GBE) (cont.)

Feature	80C10, 80C10B, 80C25GBE ¹	80C11 ¹
Clock recovery option	Option CRTP (80C10B, 80C25GBE only) Adds clock recovery data pick-off. Clock recovery provided by the Tektronix CR286A Option HS or other compatible external clock recovery device. Electrical signal output characteristics: 50 Ω, AC coupled, differential 2.92 mm female connectors, maximum 1 ps differential skew	9.95328 Gb/s (10GBASE-W/OC-192/STM-64) (CR-1, CR2, & CR-3) 10.66423 Gb/s (CR-2) 10.70922 Gb/s (CR-3) Continuous-rate from 9.8 Gb/s to 12.6 Gb/s (CR-4) ³
Absolute maximum nondestructive optical input ⁴	20 mW average power; 60 mW peak power at wavelength with highest relative responsivity	5 mW average power; 10 mW peak power at wavelength with highest relative responsivity
Internal fiber diameter	9 mm/125 μm single mode ⁵	
Optical return loss	> 30 dB	
Minimum optical bandwidth	80C10 > 60 GHz, minimum > 65 GHz, typical 80C10B > 75 GHz, minimum > 80 GHz, typical 80C10B-F1 and 80C25GBE > 60 GHz, minimum > 65 GHz, typical	> 30 GHz
Output zero	1550 nm: ± [25 μW + 4% Vertical Offset] 1310 nm: ± [35 μW + 4% Vertical Offset]	Up to 14.025 Gb/s settings: < 10 μW ± 2% (vertical offset) 20 GHz, 30 GHz settings: < 10 μW ± 4% (vertical offset)
Independent channel deskew	Standard	
Offset capability at front of module	Standard	
Power meter	Standard	

¹ Some values in the table are typical.

² The 80C10, 80C10B, and 80C25GBE have two separate optical inputs, one for 1310 nm and one for 1550 nm.

³ Continuous-rate clock recovery supporting any standard or user-definable rate in the range from 9.8 Gb/s to 12.6 Gb/s.

⁴ The optical input powers below nondestructive levels may exceed saturation and compression limits of the module.

⁵ Compatible with single-mode fiber of equal or smaller diameter.

Options and Accessories

This section lists the standard and optional accessories available for the sampling modules.

Options The following table lists available sampling module options:

Table 5: Available options

Module	Option	Description
80C02	Option CR	Adds 9.95328 Gb/s clock recovery
	Option 01	Adds Extinction Ratio calibration
80C07B	Option CR1	Adds 155/622/1063/1250/2125/2488/2500/2666 Mb/s clock recovery
	Option F1	Adds reference receiver filters OC-3 (155 Mb/s) and OC-12 (622 Mb/s)
	Option F2	Adds reference receiver filters OC-3 (155 Mb/s) and FibreChannel (1063 Mb/s)
	Option F3	Adds reference receiver filters OC-3 (155 Mb/s) and Gigabit Ethernet (1250 Mb/s)
	Option F4	Adds reference receiver filters OC-3 (155 Mb/s) and 2G FibreChannel (2125 Mb/s)
	Option F5	Adds reference receiver filters OC-12 (622 Mb/s) and FibreChannel (1063 Mb/s)
	Option F6	Adds reference receiver filters OC-12 (622 Mb/s) and Gigabit Ethernet (1250 Mb/s)
	Option F7	Adds reference receiver filters OC-12 (622 Mb/s) and 2G FibreChannel (2125 Mb/s)
	Option F8	Adds reference receiver filters FibreChannel (1063 Mb/s) and Gigabit Ethernet (1250 Mb/s)
	Option F9	Adds reference receiver filters FibreChannel (1063 Mb/s) and 2G FibreChannel (2125 Mb/s)
Option F10	Adds reference receiver filters Gigabit Ethernet (1250 Mb/s) and 2G FibreChannel (2125 Mb/s)	
80C08C	Option CR1	Adds 9.95328 Gb/s and 10.3125 Gb/s clock recovery
	Option CR2	Adds 10.3125 Gb/s and 10.51875 Gb/s clock recovery
	Option CR4	Adds continuous clock recovery from 9.8 Gb/s to 12.6 Gb/s
	Option 01	Adds Extinction Ratio calibration
80C10B	Option F1	Adds reference receiver filters OC768/STM256 (39.813 Gb/s), OTU3 G.709 FEC (43.0184 Gb/s), 40GBase-FR (41.25 Gb/s), 100GBase-xR4 (25.781 Gb/s), 100GBase-xR4 w/ FEC (27.739 Gb/s) (removes 80 GHz and 30 GHz bandwidths)
	Option CRTP	Adds electrical signal outputs to 44.5 Gb/s for use with Tektronix CR286A Option HS or other compatible external clock recovery module
80C11	Option CR1	Adds 9.95328 Gb/s clock recovery
	Option CR2	Adds 9.95328 Gb/s and 10.66423 Gb/s clock recovery
	Option CR3	Adds 9.95328 Gb/s and 10.70922 Gb/s clock recovery
	Option CR4	Adds continuous clock recovery from 9.8 Gb/s to 12.6 Gb/s
	Option 01	Adds Extinction Ratio calibration

Module	Option	Description
80C12	Option F1	Adds reference receiver filters 1G FibreChannel (1.063 Gb/s), 2G FibreChannel (2.125 Gb/s), 4G FibreChannel (4.250 Gb/s)
	Option F2	Adds reference receiver filters 2G FibreChannel (2.125 Gb/s), 4G FibreChannel (4.250 Gb/s), 9 GHz optical bandwidth
	Option F3	Adds reference receiver filters 1G FibreChannel (1.0623 Gb/s), 2G FibreChannel (2.125 Gb/s), 9 GHz optical bandwidth
	Option F4	Adds reference receiver filters 2G FibreChannel (2.125 Gb/s), 10GBase-X4 (3.125 Gb/s), 4G FibreChannel (4.250 Gb/s), 10GFC-X4 (3.188 Gb/s)
	Option F5	Adds reference receiver filters 10GBase-X4 (3.125 Gb/s), 4G FibreChannel (4.250 Gb/s), 10GFC-X4 (3.188 Gb/s), 9 GHz optical bandwidth
	Option F6	Adds reference receiver filters 2G FibreChannel (2.125 Gb/s), 10GBase-X4 (3.125 Gb/s), 10GFC-X4 (3.188 Gb/s), 9 GHz optical bandwidth
	Option FC	Adds reference receiver filters 10GBase-X4 (3.125 Gb/s), VSR-5 (3.318Gb/s), 10GFC-X4 (3.188 Gb/s), 9 GHz optical bandwidth
	Option 10G	Adds reference receiver filters OC192/STM-64 (9.953 Gb/s), 10GFC (10.518 Gb/s), 10GBase-W (9.953 Gb/s), 10GBase-R (10.31 Gb/s), G.975 FEC (10.66 Gb/s), G.709 FEC (10.709 Gb/s), 10GBE FEC (11.10 Gb/s), 10GFC FEC (11.317 Gb/s), 10 GHz optical bandwidth
	Option 01	Adds Extinction Ratio calibration
80C25GBE	Option F1	Adds reference receiver filters OC768/STM256 (39.813 Gb/s), OTU3 G.709 FEC (43.0184 Gb/s), 40GBase-FR (41.25 Gb/s), 100GBase-xR4 (25.781 Gb/s), 100GBase-xR4 w/ FEC (27.739 Gb/s) (removes 80 GHz and 30 GHz bandwidths)
	Option CRTP	Adds electrical signal outputs to 44.5 Gb/s for use with Tektronix CR286A Option HS or other compatible external clock recovery module
All modules	Option C3	Three years of calibration service
All modules	Option C5	Five years of calibration service
All modules	Option D1	Calibration data report
All modules	Option D3	Three years of calibration data reports (requires Opt. C3)
All modules	Option D5	Five years of calibration data reports (requires Opt. C5)
All modules	Option R3	Extended repair warranty to three years
All modules	Option R5	Extended repair warranty to five years

Standard Accessories

The following accessories are shipped with the module:

Table 6: Standard accessories

Item	Part number
Certificate of Traceable Calibration for product at first shipment	Not orderable
Fiber cleaning kit	020-2494-xx
SMA male 50 Ω termination (installed, one per clock recovery output connector)	015-1022-xx

Optional Accessories

You can order the following accessories for use with the sampling modules. See the Tektronix Web site for the current list of optional accessories:

Table 7: Optional accessories

Item	Part number
D4/PC Universal Optical Input (UCI) adapter	119-4514-xx
Biconic UCI adapter	119-4515-xx
FC/PC UCI adapter, APC-108	119-5115-xx
SMA 2.5 UCI adapter	119-4517-xx
SC/PC UCI adapter	119-5116-xx
DIN/PC UCI adapter	119-4546-xx
DIAMOND 2.5 UCI adapter	119-4556-xx
SMA UCI adapter	119-4557-xx
DIAMOND 3.5 UCI adapter	119-4558-xx
ST/PC UCI adapter	119-4513-xx
3.5 male to 3.5 female SMA	015-0552-xx
Slip-on SMA connector	015-0553-xx
CSA8000 & TDS8000 Series Service Manual	071-0438-xx
DSA8200 Service Manual	071-2049-xx
80C00 Series Optical Sampling Modules User Manual (this document)	071-0435-xx

Installation

The optical modules fit in the large slot in the front panel of a compatible instrument, such as the DSA8200. The following figure shows the front panel of a DSA8200 instrument and the locations of the module compartments.

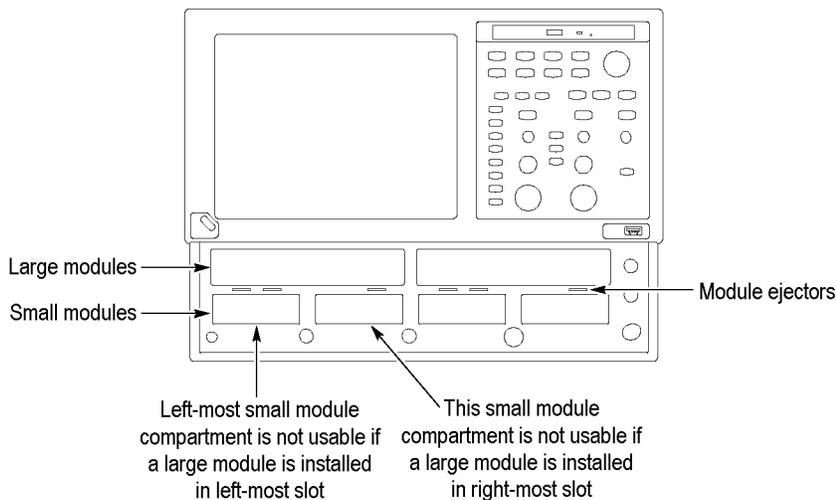


Figure 1: Module compartments

At least one module must be installed in the main instrument to acquire signals.

NOTE. *Installing a large module in either large compartment disables some of the small compartment channels. Refer to the instrument Online Help about compartment interaction.*

The large compartments support single channel modules, while the small compartments support single or dual channel modules. Eight of the 10 inputs are usable at one time.

Electrostatic Discharge

To prevent electrostatic damage to the main instrument and optical modules, follow the precautions described in this manual and the manuals accompanying your main instrument.

Circuitry in the optical module is very susceptible to damage from electrostatic discharge and from over drive signals. Be sure to only operate the optical module in a static-controlled environment (grounded conductive table top, wrist strap, floor mat, and ionized air blower). Be sure to discharge to ground any electrostatic charge that may be present on electrical cables before attaching the cable to the optical module recovered clock and data outputs.



CAUTION. *The recovered clock and data outputs of the optical module are subject to damage from electrostatic discharge (ESD). To prevent damage from electrostatic discharge, store the optical module with the supplied SMA terminations installed. Store the module in a static-free container, such as the shipping container. Whenever you move the optical module from one instrument to another, use a static-free container to carry the optical module.*

Always use a wrist strap (provided with your instrument) when handling an optical module or making connections. Discharge to ground any electrostatic charge that may be present on cables before attaching the cable to the optical-module.

Module Installation

To install a large module, first power off the instrument using the front-panel On/Standby power switch. Then place the module into a compartment and slowly push it in with firm pressure. Once the module is seated, turn the hold-down screws clockwise to lock the module in place. (See Figure 2.)

NOTE. *To install, turn the hold-down screws so that they are completely out (all the way counterclockwise), and then be sure to seat the module completely into its compartment. Doing so will help make sure the retaining ear on each screw rotates into position as you tighten the screws.*



CAUTION. *To prevent damage to the optical module or instrument, never install or remove a module when the front-panel On/Standby power switch is ON (powered-on).*

Once you have installed the module, turn on the instrument.

NOTE. *When removing a module, after turning the hold-down screws counterclockwise, use the module ejectors on the main instrument to eject the module.*

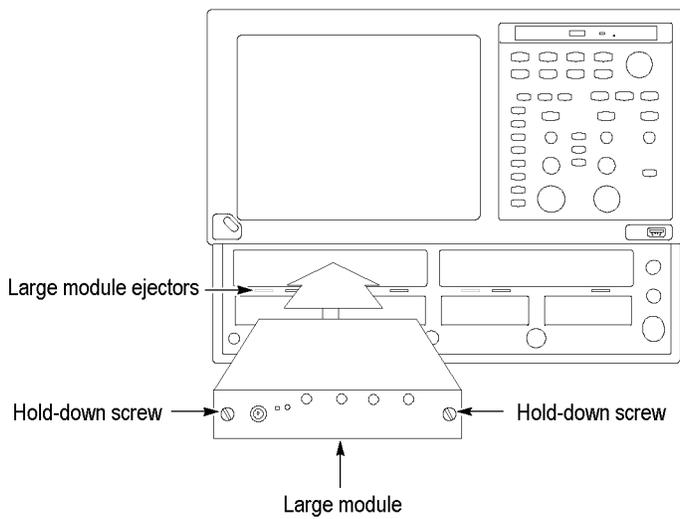


Figure 2: Installing a large module

NOTE. After first installing a sampling module(s) or after moving a sampling module from one compartment to another, you should run Compensation from the Utilities menu to verify that the instrument meets its specifications. You must run a compensation if an extender is installed, changed, or removed from a module. For instructions on running a compensation, see *Optimizing Measurement Accuracy*. (See page 21.)

After running Compensation, you must save the new values to retain them; otherwise they are lost when powering off the instrument.

Operating Basics

This section describes the front panel, connecting to the circuit under test, system interaction with the main instrument, and the programmer interface.

Usage

Handle your optical module carefully at all times.



CAUTION. To avoid damaging your optical module, take the following precautions:

Do not drop the module since damage and misalignment of the photodiode optical assembly can result. Store the module in a secure location when not in use.

Place the protective cap on the input connector when the module is not in use.

*To prevent loss of optical power or damage to the optical connectors, keep the connectors clean at all times. Check that all connectors, jumpers, and protective caps are clean before connecting them to the module. (See page 22, *Cleaning Optical Connectors*.)*

Connecting Optical Signals

Take care to preserve the integrity of the connectors by keeping them free of contamination. For cleaning information, see *Cleaning Optical Connectors*. (See page 22.)

The input of the 80C02, 80C10B, 80C11, and 80C25GBE modules (see note) can couple to single-mode optical fibers with a core diameter/cladding diameter of 9/125 μm . The 80C07B, 80C08C, and 80C12 modules can couple to any single-mode dimension or multimode dimension not exceeding a core diameter/cladding diameter of 62.5/125 μm . You can couple alternate types by using UCI (universal connector interface) series adapters. Refer to the Tektronix Web site for details.

NOTE. *The 80C10B and 80C25GBE have two separate optical inputs. Use the correct input for taking 1310 nm or 1550 nm measurements.*

Attach the fiber optic cable with a suitable connector or a UCI Interface adapter to the optical input receptacle as follows. Figure 3 shows the proper use of a UCI adapter.

1. Firmly press the cable connector or adapter into the interface ferrule until it reaches the stop.
2. Line up the key with the slot in the UCI adapter before inserting.

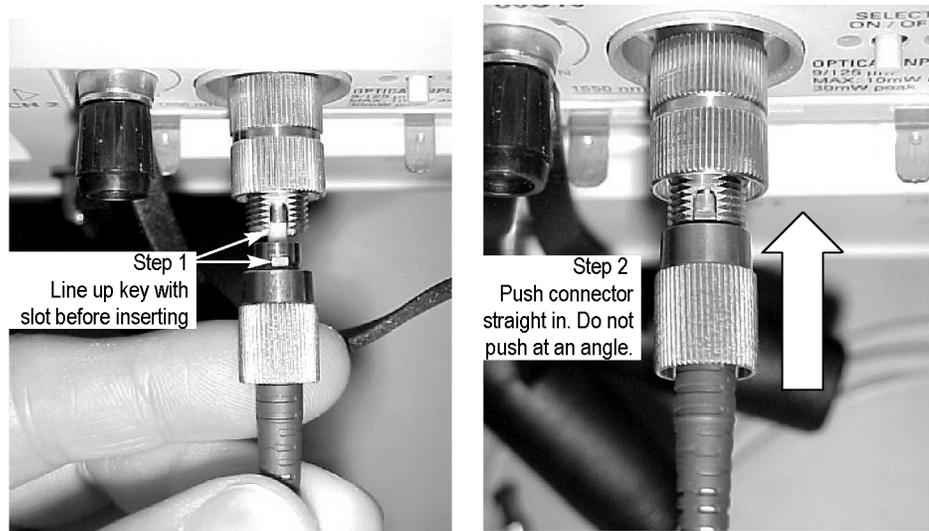


Figure 3: Connecting optical cables correctly



CAUTION. Do not insert the connector into the UCI adapter at an angle. Do not insert the connector and then rotate to line up the key with the slot. Either action may damage the UCI adapter.

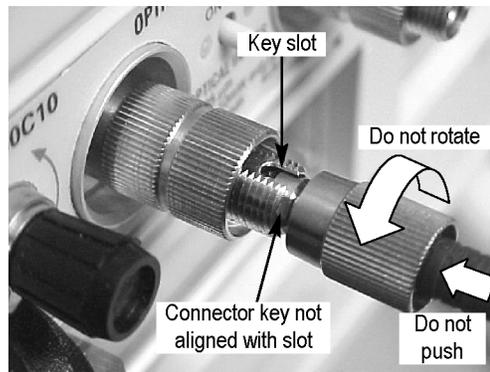


Figure 4: Incorrectly connecting optical cables

3. Firmly tighten the cable connector or the adapter shell. Tighten with finger pressure only.
4. To remove, loosen the cable connector or adapter shell.

Attenuating Optical Signals

To keep the optical input power to an appropriate level, it may be necessary to attenuate the optical signal.



CAUTION. To avoid damaging the optical input of the module, attenuate the input optical signal to the Absolute Maximum Nondestructive Optical Input (peak) specifications. To maintain the levels within performance range and to avoid clipping, use the following table to set the maximum optical input signal levels:

Table 8: Maximum optical signal levels

Module	Average	Peak
80C02	5 mW	10 mW
80C07B	5 mW	10 mW
80C08C	1 mW	10 mW
80C10B	20 mW	60 mW
80C11	5 mW	10 mW
80C12	1 mW	10 mW
80C25GBE	20 mW	60 mW

NOTE. The 80C07B module can have a somewhat deteriorated response for signals greater than $200 \mu W_{p-p}$ (1310 nm and 1550 nm) and $400 mW_{p-p}$ (780 nm and 850 nm). The 80C08C and 80C12 modules also can have a somewhat deteriorated response for signals larger than $500 \mu W_{p-p}$ (1310 nm and 1550 nm) and $800 mW_{p-p}$ (850 nm).

NOTE. Optical sampling modules may have dynamic ranges exceeded without obvious visual indication onscreen because the overloaded signal output of the photodetector may still be within the dynamic range of the internal electrical sampler.

System Interaction

Your optical module is a part of a larger instrument system. Most optical module functions are controlled automatically by the main instrument. These include such things as vertical scaling and horizontal sampling rate. You do not directly control these parameters; they are controlled for you as you perform tasks on the main instrument. The parameters that you control from the optical module front panel are explained in the *Front Panel Controls* section.

An additional optical module function that you control from the main instrument is external channel attenuation. External Attenuation lets you enter a number representing any external attenuation you have added to a channel.

Front Panel Controls

Typical optical module front panels are shown in the following figure. (See Figure 5.)

Channel Selection

Each channel has a SELECT channel button and an amber channel light. The button operates as follows:

- If the amber channel light is on, the channel is acquiring a waveform.
- If you push the channel button and the channel is not being acquired (for any channel or math waveform), then the instrument activates (turns on) the channel.
- If you push the button and the channel is active as a channel waveform, then the instrument selects the channel waveform.
- If the channel waveform is already selected when you push the channel button, the instrument turns the channel off.

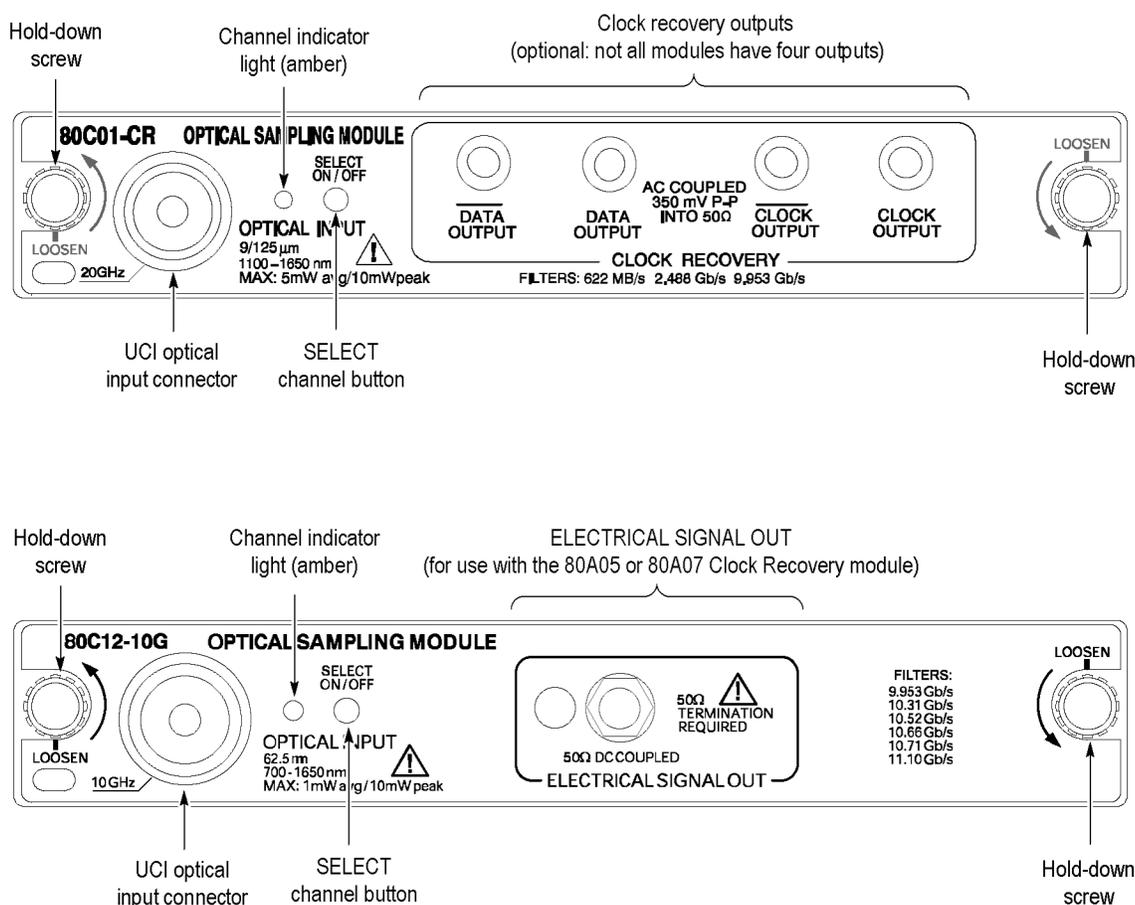


Figure 5: Typical Optical module front panels, 80C01-CR and 80C12-10G shown

Optical Input Connector

The optical input connector uses a universal connector interface (UCI) that allows use of many standard fiber-optic female connector styles. Some of the standard UCI interfaces supported are FC, ST, SC, and DIN. (Refer to a current Tektronix catalog for details.)

Outputs

Most optical modules provide optional clock and data-recovery circuitry, providing clock and data outputs; the recovered clock is internally routed to the main-instrument trigger circuit. The circuitry also provides front-panel output of normal and complemented clock, and on some modules, normal and complemented data.

The 80C12 module provides an electrical signal output. For clock recovery purposes, this signal must be routed to the input of an 80A05 or 80A07 Electrical Clock Recovery module within the same mainframe.

80C10B and 80C25GBE modules with Option CRTP provide differential electrical signal outputs. For clock recovery purposes, route the signals to the input of a compatible, external clock recovery unit, such as the Tektronix CR286A Option HS, using high-quality coaxial cables. Use the outputs as single-ended or differential sources. Always terminate any unused output(s) into 50 Ω . The output connector type is 2.92 mm, which is compatible with Wiltron K, 3.5 mm and SMA formats.



CAUTION. *Electrostatic discharge (ESD) will cause permanent damage to the DATA outputs. Adhere to standard ESD handling precautions when using the outputs. In particular, make sure to discharge to ground any cables or connectors before attaching them to the DATA outputs. To discharge a cable, touch the center pin of the coaxial cable to a grounded conductor (such as the outside ground conductor of the coaxial data output connector) just before connecting the cable to the module.*

The following table lists the modules and available clock recovery outputs:

NOTE. *Use 50 Ω terminations, provided with your optical module, on all unused outputs.*

Table 9: Clock recovery outputs

Modules	Front panel outputs
80C02-CR	DATA, CLOCK, 1/16 CLOCK
80C07B-CR1	DATA, $\overline{\text{DATA}}$, CLOCK, $\overline{\text{CLOCK}}$
80C08C-CR1	CLOCK, 1/16 CLOCK
80C08C-CR2	CLOCK, 1/16 CLOCK
80C08C-CR4	CLOCK, 1/16 CLOCK
80C10B-CRTP	DATA, $\overline{\text{DATA}}$ electrical signal out (for use with the Tektronix CR286A Option HS or other compatible external clock recovery device) ¹
80C11-CR1	DATA, CLOCK, 1/16 CLOCK
80C11-CR2	CLOCK, 1/16 CLOCK
80C11-CR3	CLOCK, 1/16 CLOCK
80C11-CR4	CLOCK, 1/16 CLOCK

Table 9: Clock recovery outputs (cont.)

80C12	ELECTRICAL SIGNAL OUT (for use with the 80A05 or 80A07 module)
80C25GBE-CRTP	DATA, $\overline{\text{DATA}}$ electrical signal out (for use with the Tektronix CR286A Option HS or other compatible external clock recovery device) ¹

¹ Contact Tektronix for details.

To disable using the internal recovered clock as the main instrument trigger, select external or internal triggering. Then select the recovered clock rate without actually selecting recovered clock as the trigger condition to activate the front-panel clock recovery signals.

Hold-Down Screws

Hold-down screws attach the module to the main instrument. Once the hold-down screws are loosened, use the eject levers to remove the module from a powered-down main instrument. Indicators on the hold-down screws point in the direction that the latch is pointing.

NOTE. *Do not pull on module connectors to remove a module; always use the hold-down screws to pull the module out far enough for you to hold the module and remove it from the instrument.*

Commands From the Main Instrument Front Panel

The Vertical Setup dialog box lets you toggle between the basic and optical module controls. The optical and basic controls are shown in the following figure.

You first select the channel you want to set in the Waveform section of the dialog box. Then you select the Setup Wavelength, Filter, Bandwidth, or Compensate controls in the dialog box to change those settings or to initiate a compensation. Optical modules with the clock recovery option also have source and rate controls in the Trigger dialog box.

Detailed information on these dialog boxes is found in the Online Help for your main instrument.

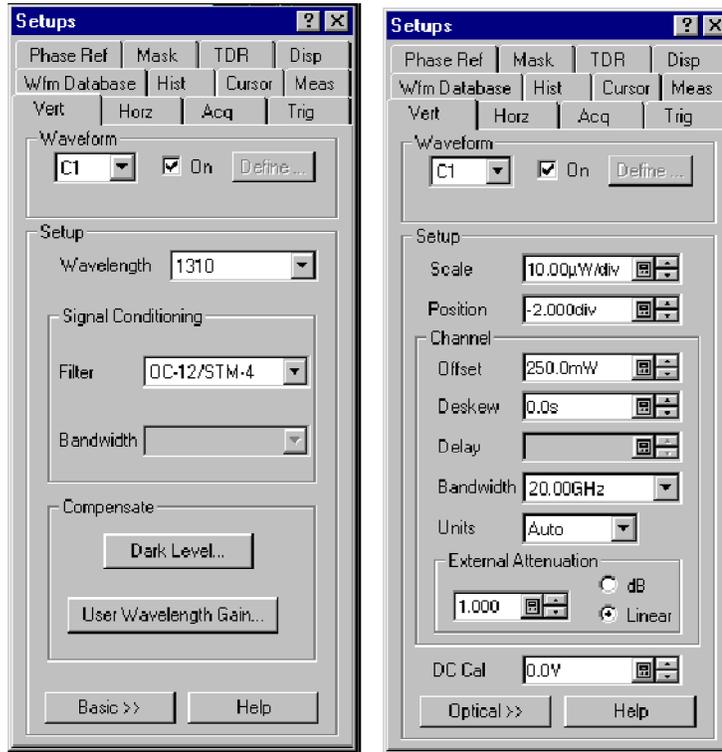


Figure 6: System Vertical menu

Programmer Interface Commands

The remote programming commands for all sampling modules are documented in the *Programmer Guide* accessible from the instrument Help menu.

User Adjustments

All optical module setups, parameters, and adjustments are controlled by the main instrument. To save, recall, or change any module settings, use the main-instrument menus or front-panel controls. Consult the *Online Help* for your main instrument.

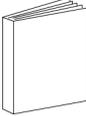
Optimizing Measurement Accuracy

Measurement accuracy of optical modules is increased (or maintained) by performing the following procedures:

- Vertical Compensation
- Cleaning the Optical Connectors
- Dark-Level and User Wavelength Gain Compensations

Perform Vertical Compensation

Performing a vertical compensation will maximize the accuracy of the automatic measurements you take. This procedure uses internal routines to optimize the vertical offset, gain, and linearity.

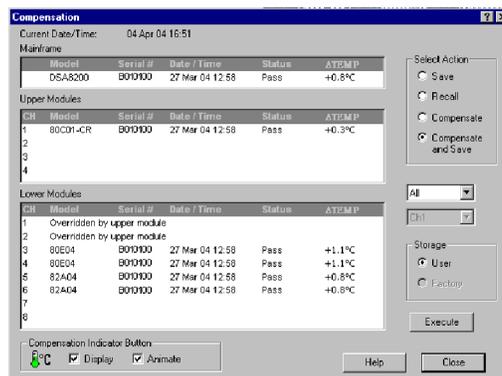
Overview	To perform optical compensations	Control elements and resources
Prerequisites	<ol style="list-style-type: none"> 1. The instrument must have the optical sampling module(s) to be compensated in place. The acquisition system should be set to run continuously. 2. Dust covers must be in place on all optical module channels (or otherwise eliminate the optical input). 3. Power on the instrument and allow a 20 minute warm-up before doing this procedure. 	 <p>See the instrument user documentation and online help for details on operating the instrument controls.</p>
Access the compensation routines	<ol style="list-style-type: none"> 4. From the application menu bar, click Utilities, and then click Compensation. 	

Overview

To perform optical compensations

5. In the Compensation dialog box, the main instrument (mainframe) and sampling modules are listed. The temperature change from the last compensation is also listed.
6. Wait until the Status for all items you wish to compensate changes from **Warm Up** to **Pass**, **Fail**, or **Comp Req'd**.
7. Under Select Action, click the **Compensate** option button.
8. From the top pulldown list, choose **All** (default selection) to select the main instrument and all its modules as targets to compensate.
9. Click the **Execute** button to begin the compensation.
10. Follow the instructions to disconnect inputs and install terminations that will appear on screen; be sure to follow static precautions when following these instructions.

Control elements and resources



Verify that the compensation routines pass

11. The compensation may take several minutes to complete. Verify that **Pass** appears as **Status** for the main instrument and for all sampling modules listed in the Compensation dialog box when compensation completes.
12. If instead **Fail** appears as **Status**, rerun the compensation. If **Fail** status continues after rerunning compensation and you have allowed warm up to occur, the module or main instrument may need service.
13. Click the **Save** option button under Select Action. Click the **Execute** button to save the compensation values.
 - Make sure to save the compensation values. In-memory compensation values are lost when you power off the instrument.

Cleaning Optical Connectors

Small dust particles and oils can easily contaminate optical connectors and reduce or block the signal. Take care to preserve the integrity of the 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, immediately replace protective caps on the optical connectors when not in use.

Use the following items to clean optical connectors:

- Dry, clean, and dust-free compressed air
- Fiber cleaning cassette and/or tape dispenser cleaner
- Pipe cleaner



CAUTION. Clean both ferrule endfaces with a dry cloth tape cleaner (casseted or in a dispenser).

For safe and effective cleaning of the optical male fiber end-face exposed after removing the UCI adapter, Tektronix recommends the following method and tools.

Overview	To clean the optical connectors	Related information
Supplies required	<ol style="list-style-type: none"> 1. One compressed air can, such as Tektronix part number 118-1068-01. One FIS cassette cleaner, (such as FI-6270) or one FIS tape dispenser cleaner (such as FI-7111). 	<p>Cleaning kits for optical connectors (such as the Tektronix Optical Connector Cleaner part number 020-2494-xx) are available from several suppliers.</p>
Remove UCI adapter	<ol style="list-style-type: none"> 2. Loosen the UCI adapter and remove it. This exposes the male fiber end-face behind the UCI connector. 	
Clean UCI adapter	<ol style="list-style-type: none"> 3. Clean contaminates from the inside wall of the hollow female-to-female ferrule alignment tube inside the UCI adapter. <ul style="list-style-type: none"> ■ Use the compressed air can to clean the female input of the UCI adapter end-to-end. ■ Pull the pipe cleaner through the UCI adapter. 	



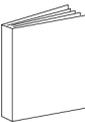
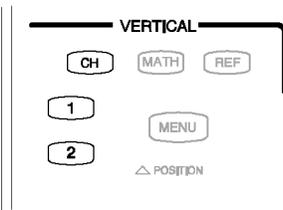
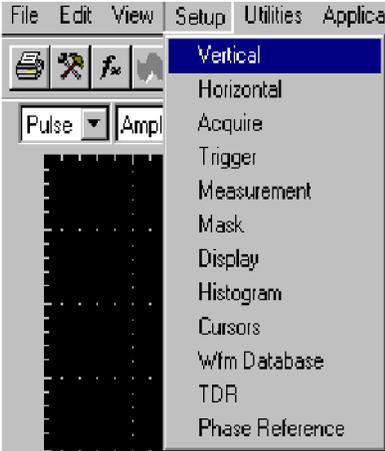
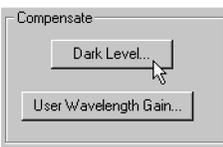
CAUTION. Do not blow compressed air into the female input of the UCI adapter when it is installed on the module.

Overview	To clean the optical connectors	Related information
Clean fiber input	<ol style="list-style-type: none"> 4. Advance the fiber cleaning cassette or tape-dispenser cleaner to expose an unused clean section of the lint-free, dry, cleaning surface. 5. Lightly drag the clean, dry, surface of the cleaning tool cloth against the male end-face of the fiber input for a short distance (a centimeter or two). 6. Place the UCI adapter back on the cleaned fiber end-face. 	
Dust cap	<ol style="list-style-type: none"> 7. When the module does not have a fiber attached to its input(s), attach the black dust-cap to prevent airborne contaminants from lodging in the female optical input. 	
Clean attaching devices	<ol style="list-style-type: none"> 8. Clean any male fiber end-face input fiber or device that you attach to the UCI input. 	<p>Use a similar cleaning method to clean the fiber end-face input fiber or device.</p>

Perform Dark-Level and User Wavelength Gain Compensations

Performing a dark-level calibration will maximize the accuracy of the extinction ratio and other optical automatic measurements you take. Performing a User Wavelength Gain compensation will optimize an optical channel for your custom input signal. Use the following procedure to perform either compensation; this procedure applies only to optical modules.

NOTE. *These procedures compensate the selected module and the its current bandwidth and filter selection. The compensation values are not saved when powering off the instrument.*

Overview	To perform optical compensations	Control elements and resources
Prerequisites	<ol style="list-style-type: none"> The instrument must have the optical sampling module(s) to be dark-level calibrated in place. The acquisition system should be set to run continuously. 	 <p>See the instrument user documentation and online help for details on operating the instrument controls.</p>
Select the waveform	<ol style="list-style-type: none"> Use the Vertical buttons to select the channel to be compensated. 	
Access the dark-level compensation	<ol style="list-style-type: none"> From the application menu bar, click Setup, and then click Vertical. 	
Run the dark-level compensation	<ol style="list-style-type: none"> In Vert Setup dialog box, click the Dark Level button under Compensation. Follow the instructions on screen. Repeat steps 2 and 4 for any additional optical channels that you want to compensate. <p>If any of the following settings or conditions change after performing a dark level compensation, perform another compensation to maintain the specified accuracy.</p> <ul style="list-style-type: none"> ■ Trigger rate setting ■ Vertical offset setting ■ Filter or bandwidth setting ■ Ambient temperature change of more than 1 °C ■ ELECTRICAL SIGNAL OUT front panel connection change (80C12) 	

Overview

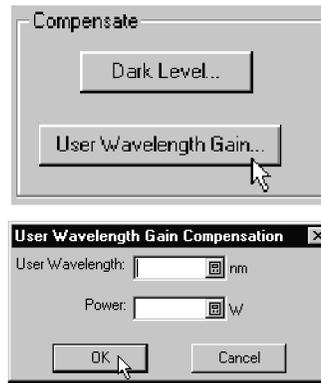
Run the user wavelength gain compensation

To perform optical compensations

You can optionally compensate an optical channel for a custom input signal:

6. In the Vert Setup dialog box, click the **User Wavelength Gain** button under Compensation. Follow the instructions on screen.
 - In the User Wavelength Gain Compensation dialog box, set the wavelength and power of the signal to be applied to the channel.
7. You must connect an optical signal to the module input with a precisely known amount of optical power. Use an independently-calibrated average optical power meter to precisely measure this power. Then connect the signal to the 80C00 using the same fiber cables.
8. Click the **OK** button to execute the compensation.
9. Repeat steps 2, 6, and 7 for any additional optical channels that you want to compensate.

Control elements and resources



NOTE. The 80C10 has two separate optical inputs each optimized for different wavelength regions (1310 nm or 1550 nm). Therefore, it supports two different user wavelength gain compensation calibrations, one for each input.

Cleaning

Exterior The case of the module keeps dust out and should not be opened. Cleaning the exterior of the module is usually confined to the front panel. To clean the case, remove the module from the main instrument but first read the entire *Installation* procedure for proper handling of the module. (See page 9.)



WARNING. *To prevent injury, power off the instrument and disconnect it from line voltage before performing any cleaning.*

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



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

Do not open the case of the module. There are no user serviceable components and cleaning the interior is not required.

Optical Connectors The procedure for cleaning the optical connectors is given in the *Optimizing Measurement Accuracy* section. (See page 22, *Cleaning Optical Connectors*.)

Reference

This section describes how to select the optical module wavelength, how to enable clock recovery, and explains optical bandwidth.

Wavelength, Filter, and Bandwidth Selection

To select the optical wavelength, use the Vertical Setups menu. (See Figure 6 on page 20.)

First select the channel in the Waveform section of the menu. Then select the Wavelength that matches your system from the Setup Wavelength drop down box.

Use the Signal Conditioning boxes to select the filter and bandwidth appropriate for your optical standard.

For more information, consult the *Online Help* for your main instrument.

Table 10: Wavelength, Filter, and Bandwidth selections

Module	Wavelength selections	Filter	Bandwidth
80C02	1310 nm	None (select a bandwidth)	30 GHz
	1550 nm	OC-192/STM-64 (9.953 Gb/s)	20 GHz
	User		12.5 GHz
80C07B	780 nm	None	2.5 GHz
	850 nm	Standard:	
	1310 nm	OC-48 / STM-16	
	1550 nm	2 Gigabit Ethernet (ENET2500 / 2GBE)	
	User	Infiniband	
	Optional:		
		OC-3 / STM-1	
		OC-12 / STM-4	
		FibreChannel (FC1063 / FC)	
		Gigabit Ethernet (ENET1250 / GBE)	
		2G FibreChannel (FC2125 / 2FC)	
80C08C	780 nm	None (select a bandwidth)	10 GHz
	850 nm	OC-192/STM-64 (9.953 Gb/s)	
	1310 nm	10GBASE-W (9.953 Gb/s)	
	1550 nm	10GBASE-R (10.31 Gb/s)	
	User	10GFC (10.518 Gb/s)	
		G.975 FEC (10.66 Gb/s)	
	G.709 FEC (10.709 Gb/s)		
	10GbE FEC (11.10 Gb/s)		
	11.317 Gb/s (10GFC FEC)		
80C10	1310 nm	None (select a bandwidth)	30 GHz
	1550 nm	OC-768/STM-256 (39.813 Gb/s)	65 GHz
	User	G.709 FEC (43.018 Gb/s)	

Table 10: Wavelength, Filter, and Bandwidth selections (cont.)

Module	Wavelength selections	Filter	Bandwidth
80C10B	1310 nm	None (select a bandwidth)	30 GHz
	1550 nm	Standard:	65 GHz
	User	OC-768/STM-256 (39.813 Gb/s)	80 GHz
		G.709 FEC (43.018 Gb/s)	
	40GBase-FR (41.25 Gb/s)		
	Optional:		
	100GBase-xR4 (25.781 Gb/s)		
	100Gbase-xR4 FEC (27.739 Gb/s)		
80C11	1310 nm	None (select a bandwidth)	20 GHz
	1550 nm	OC-192/STM-64 (9.953 Gb/s)	30 GHz
	User	10GBASE-W (9.953 Gb/s)	
		10GBASE-R (10.31 Gb/s)	
		10GFC (10.518 Gb/s)	
		G.975 FEC (10.66 Gb/s)	
		G.709 FEC (10.709 Gb/s)	
		10GbE FEC (11.10 Gb/s)	
		10GFC FEC (11.317 Gb/s)	
		16GFC (14.025 Gb/s)	
80C12	850 nm	None (select a bandwidth)	9 GHz
1310 nm	1G FibreChannel (1.0623 Gb/s)	10 GHz with option 10G	
1550 nm	2G FibreChannel (2.125 Gb/s)		
	10GBase-X4 (3.125 Gb/s)		
	10GFC-X4 (3.188 Gb/s)		
	VSR-5 (3.318Gb/s)		
	4G FibreChannel (4.250 Gb/s)		
	OC192/STM-64 (9.953 Gb/s)		
	10GFC (10.518 Gb/s)		
	10GBase-W (9.953 Gb/s)		
	10GBase-R (10.31 Gb/s)		
	10GBE FEC (11.10 Gb/s)		
	G.975 FEC (10.66 Gb/s)		
	G.709 FEC (10.709 Gb/s)		
	10GFC FEC (11.317 Gb/s)		
	80C25GBE	1310 nm	None (select a bandwidth)
1550 nm	100GBase-xR4 (25.781 Gb/s)		
User	100GBase-xR4 FEC (27.739 Gb/s)		

Clock and Data Recovery

Clock and data recovery are available on most modules as Options CR, CR1, CR2, CR3, or CR4. The 80C12 module comes standard with an electrical signal output that, when routed to an 80A05 or 80A07 Electrical Clock Recovery module, provides clock recovery. The 80A05 must be installed in the same mainframe.

Clock recovery is available on the 80C10B and 80C25GBE modules as Option CRTP, which provides electrical signal outputs that you connect to compatible external clock recovery devices, such as the Tektronix CR286A Option HS, to provide clock recovery. A list of all available optical modules and the clock recovery available for each module is provided in this document. (See Table 9 on page 18.)

- **DATA and $\overline{\text{DATA}}$ (recovered data).** These outputs provide a 50 Ω , AC-coupled, \sim ECL/2 level signal from the optical module data signal. These signals are digitally buffered and retimed to be synchronous with the serial recovered clock.
- **CLOCK and $\overline{\text{CLOCK}}$ (recovered clock).** These outputs are clock signals synchronous with the incoming data signal.
- **1/16 CLOCK (recovered clock).** This output provides the clock signal at 1/16th the rate.

Clock recovery options CR, CR1, CR2, and CR3 provide various predefined output rates (depending on the optical module model and the CR option). Clock recovery option CR4 provides both predefined selections and a continuous-rate selection. The continuous rate depends on the user entering the bit rate into the Trigger Setup dialog box of the main instrument with an accuracy better than 1000 ppm.

NOTE. *If clock and data recovery are enabled, and you do not connect a signal (or not the appropriate signal) to the front panel, the recovered clock and data signal may free run.*

NOTE. *The recovered clock is simultaneously made available internally to the main instrument for use as the trigger; it is not necessary to attach a cable from the clock or 1/16 clock to the external trigger input. Simply select the recovered clock for triggering from the trigger menu.*

The 80C12 module uses the 80A05 or 80A07 Electrical Clock Recovery module for Clock and Data recovery. Refer to the 80A05 or 80A07 module user documentation for triggering information.

The 80C10B and 80C25GBE modules with Option CRTP do not provide an internal recovered clock trigger signal to the main instrument. These modules require a compatible external clock recovery device, such as the Tektronix CR286A Option HS.

Optical Bandwidth

Traditionally bandwidth is defined as the frequency at which the power out is one half the power out at a frequency near DC. In the voltage domain the power dissipated into a resistive load (such as a 50 Ω termination of a sampler) is the V_{RMS}^2/R where V_{RMS} is the RMS of the voltage swing seen at the resistive load, and R is the resistance value. The frequency dependent response of a system is typically described using a logarithmic decibel scale. A value expressed in terms of a decibel relative to a reference is defined as:

$$dB = 10 \log \left(\frac{\text{value}}{\text{reference}} \right)$$

For electrical bandwidths the reference of a system is commonly the response of the system to a sinusoidal frequency at or near DC. The point at which the system response (power is the common parameter that is referred to in many systems) is one half would therefore be:

$$dB = 10 \log \left(\frac{0.5}{\text{response at DC}} \right) = -3 \text{ dB}$$

In terms of frequency, voltage, and resistance the bandwidth is expressed as:

$$-3 \text{ dB} = 10 \log \left(\frac{V(f)^2}{R} \div \frac{V(DC)^2}{R} \right)$$

where $V(f)$ is the RMS of the voltage swing response at the bandwidth frequency and $V(DC)$ is the RMS voltage swing response at a frequency approaching DC. Further math yields $V(f) = 0.707 V(DC)$.

The expression is simplified by canceling the R and moving the squared term inside the log expression to a multiple outside the log expression:

$$10 \log \left(\frac{V(f)^2}{R} \div \frac{V(DC)^2}{R} \right) = 2 \times 10 \log \left(\frac{V(f)}{V(DC)} \right) = 20 \log \left(\frac{V(f)}{V(DC)} \right)$$

In the DSA8200, CSA8000 and TDS8000 Series instruments, the vertical units displayed for an optical module are not in volts, but in watts, which are units of power. The optical-to-electrical converter inside the module outputs a voltage whose amplitude is linearly dependent on the incoming optical power; in this condition the voltage applied at the electrical sampler already represents optical power in its linear form (as opposed to having to square the voltage and divide by R). For the optical sampling modules then, the bandwidth where the displayed optical power is one half that approaching DC is:

$$dB = 10 \log \left(\frac{.05}{\text{response at DC}} \right) = -3 \text{ dB}$$

The $V(f)$ is the frequency at which the vertical swing is one half (0.5) the $V(DC)$ not 0.707. The optical bandwidth therefore corresponds to the traditional electrical bandwidth of -6 dB. During testing of optical modules by impulse testing, the resulting impulse waveform is converted to frequency by Fourier transform and the bandwidth is defined as $-3 \text{ dB} = 10 \log(\text{vertical swing at frequency} / \text{vertical swing at DC})$. During reference receiver curve calculation, however, the definition is changed to match the industry standard definition which assumes electrical bandwidths are $-3 \text{ dB} = 20 \log(\text{vertical swing at frequency} / \text{vertical swing at DC})$.

Bandwidth for Unfiltered Frequency Settings

The curve calculation of frequency response for the unfiltered frequency settings (2 GHz, 2.5 GHz, 12.5 GHz, 20 GHz, 30 GHz, 40 GHz, 50 GHz, 65 GHz, and 80 GHz) uses the definition for dB and bandwidth where $-3 \text{ dB} = 10 \log(\text{vertical swing at frequency} / \text{vertical swing at DC})$; that is, the optical bandwidth.

Bandwidth for Reference Receiver Settings

The curve calculation of frequency response for reference receiver settings (FC, GbE, and OC/STM standards) uses the definition of dB and bandwidth that matches the industry standard which assumes electrical bandwidths where $-3 \text{ dB} = 20 \log(\text{vertical swing at frequency} / \text{vertical swing at DC})$.

Extinction Ratio Calibration

Option 01 (Extinction Ratio Calibration) is available for modules 80C02, 80C08C, 80C11, and 80C12. Modules with option 01 have been specially calibrated to a laboratory standard, providing improved NRZ (non-return-to-zero) extinction ratio measurements (in dB).

The Tektronix DSA8200, CSA8000, and TDS8000 Series instruments provide both an NRZ Extinction Ratio (dB) measurement and an NRZ Extinction Ratio Calibrated (dB) measurement.

When performing extinction ratio measurements, you should use the calibrated measurement, instead of the standard ER, for improved accuracy and module-to-module repeatability. This improvement only applies to balanced NRZ eye diagrams.

To obtain accurate results, perform an NRZ Eye Autoset, followed by a Dark Level Compensation, before taking an Extinction Ratio measurement. Please note the conditions under which Dark Level Compensation remains valid. (See page 24.)

Glossary

Accuracy

The closeness of the indicated value to the true value.

Analog-to-Digital Converter

A device that converts an analog signal to a digital signal.

Attenuation

A decrease in magnitude (for optical systems this is usually optical power) of a signal.

Autoset

A means of letting the instrument set itself to provide a stable and meaningful display of a given waveform.

Average Optical Power (AOP)

The time averaged measurement of the optical power over a much longer time period than the bit rate of the signal.

Bandwidth

The difference between the limiting frequencies of a continuous frequency spectrum. Bandwidth is the frequency at which the power out is one half the power out at a frequency near DC. The range of frequencies handled by a device or system. Bandwidth is a measure of network capacity. Analog bandwidth is measured in cycles per second. Digital bandwidth is measured in bits of information per second. (See page 32, *Optical Bandwidth*.)

Channel

A place to connect a signal or attach a network or transmission line to sampling heads. Also, the smallest component of a math expression. A transmission path between two or more stations.

Channel Number

The number assigned to a specific signal input connector. The top channel of the left-most sampling head compartment of the main instrument is always channel 1, regardless of any repositioning or omission of sampling heads.

Clock

A signal that provides a timing reference.

Common Mode

A circumstance where a signal is induced in phase on both sides of a differential network.

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 of optical power is usually the optical reference for 0 dBm. The formula for decibels is:

$$dB = 20 \log \left(\frac{V_i}{V_l} \right) \text{ for optical, } db = \left(\frac{P_o}{P_i} \right)$$

where V_i is the voltage of the incident pulse, V_l is the voltage reflected back by the load, P_o is the power out, and P_i is the power in. (See page 32, *Optical Bandwidth*.)

dBm

A logarithmic measure of power referenced to 1 milliwatt (1 mW optical power = 0.0 dBm):

Degradation

A deterioration in a signal or system.

Differential Mode

A method of signal transmission where the true signal and its logical complement are transmitted over a pair of conductors.

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.

Extinction Ratio

The ratio of two optical power levels of a digital signal generated by an optical source. P_1 is the optical power level generated when the light source is high, and P_2 is the power level generated when the light source is low.

$$r_e = \frac{P_1}{P_2}$$

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 nonFEC data stream to accommodate the extra information added by the FEC.

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.

Impedance

The opposition to an AC signal in the wire. Impedance is very much like resistance to a DC signal in a DC circuit. Impedance is made up of resistance, inductive, and capacitive reactance.

Initialize

Setting the instrument main instrument to a completely known, default condition.

Internal Clock

An internally generated trigger source that is synchronized with the Internal Clock Output signal.

Mode

A stable condition of oscillation in a laser. A laser can operate in one mode (single mode) or in many modes (multimode).

Modulation

A process whereby a signal is transformed from its original form into a signal that is more suitable for transmission over the medium between the transmitter and the receiver.

Multimode Cable

A thick cored optical fiber (compared to single mode cable) that can propagate light of multiple modes.

OMA (Optical Modulation Amplitude)

The difference between the average power levels of the logic 1 level, High, and the logic 0 level, Low, of the optical pulse signal. The levels are the Means of the logical levels sampled within an Aperture of the logical 1 and 0 regions of the pulse. The logical 1 and 0 time intervals are marked by the crossings of a reference level determined as the Average Optical Power (AOP) of the signal.

Protocol

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

Recovered Clock

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

Setting

The state of the front panel and system at a given time.

Single-Mode Cable

An optical cable with a very small core diameter (usually in the range of 2-10 microns). Such cables are normally used only with laser sources due to their very small acceptance cone. Since the cone diameter approaches the wavelength of the source, only a single mode is propagated.

Trigger

An electrical event that initiates acquisition of a waveform as specified by the time base.

Waveform

The visible representation of an input signal or combination of signals.

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