User Manual

Tektronix

80C00 Series
Optical Sampling Modules

071-0435-04

This document applies to firmware version 1.00
and above.

www.tektronix.com

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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.

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

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.

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.

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 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.*

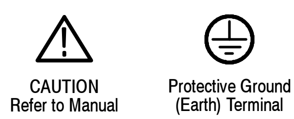
Terms on the Product. These terms may appear on the product:

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 user manual for the 80C01, 80C02, 80C03, 80C04, 80C05, 80C06, 80C07, 80C08, 80C08B, 80C09, and 80C10 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
- Lists specifications of the modules

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.
- *Specifications* contains specifications for the 80C01, 80C02, 80C03, 80C04, 80C05, 80C06, 80C07, 80C08, 80C08B, 80C09, and 80C10 Optical Modules.

Related Manuals

This manual is part of a document set of standard-accessory manuals and online documentation; this manual mainly focuses on installation and background needed to use the module features. See the following list for other documents supporting 8000-series and 8000B-series products. Manual part numbers are listed in the *Accessories* section of your *CSA8000B & TDS8000B User Manual*.

Manual name	Description
CSA8000 and TDS8000 Online Help	An online help system, integrated with the User Interface application that ships with the CSA8000, TDS8000, CSA8000B, and TDS8000B instruments.
CSA8000B & TDS8000B Reference	A quick reference to major features of the instrument and how they operate.
CSA8000B & TDS8000B User Manual	The user manual for the CSA8000B and TDS8000B instruments.
80E01, 80E02, 80E03, 80E04, and 80E06 Electrical Sampling Modules User Manual[1]	The user manual for the electrical modules, included as a standard accessory if you ordered electrical modules with your instrument. Shipped in the sampling module package, not the main instrument package.
CSA8000 & TDS8000 Programmer Guide	An online help document that provides an alphabetical listing of the programming commands and other information related to controlling the instrument over the General Purpose Interface Bus (GPIB).
CSA8000 & TDS8000 Service Manual	An optional manual describes how to service the instrument to the module level. Manual must be ordered separately.

1 **You can insert the sampling module user manuals in Appendix C of the *CSA8000B & TDS8000B User Manual*.**

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 80C01, 80C02, 80C03, 80C04, 80C05, 80C06, 80C07, 80C08, 80C08B, 80C09, and 80C10 Optical Modules and their available options are high-performance optical modules that support high bandwidth telecom and datacom standards. These modules can be installed in the CSA8000, CSA8000B, TDS8000, and TDS8000B instruments.

Proper operation of the sampling modules requires that the appropriate TDS8000 and CSA8000 application software is installed on the main instrument. The versions according to the specific module are shown in the following table. To display the version installed, select *About TDS/CSA8000* from the Help menu of the main instrument.

Table 1: Application software version required

Modules	TDS/CSA8000 application software version
80C01, 80C01-CR, 80C02, 80C02-CR, 80C03, 80C03-CR	1.0.0 or greater
80C04, 80C04-CR1	1.1.0 or greater
80C04-CR2, 80C05, 80C06	1.2.0 or greater
80C07, 80C07-CR1, 80C08, 80C08-CR1, 80C09, 80C09-CR1	1.3.0 or greater
80C08B, 80C08B-CR1, 80C08B-CR2, 80C10	1.4.0 or greater

Product Description

The optical modules provide the features shown in Tables 2, 3, and 4. Table 8 on page 19 also provides wavelength selections, filter, and bandwidth specifications for each module. Figure 1 shows the optical module controls, connectors, and indicators.

Table 2: Optical module features (80C01 - 80C04 and 80C09) [1]

Feature	80C01	80C02, 80C04 & 80C09	80C03
Number of input channels	1	1	1
Effective wavelength range	1100 nm to 1650 nm	1100 nm to 1650 nm	700 nm to 1650 nm

Table 2: Optical module features (80C01 - 80C04 and 80C09) (Cont.)[1]

Feature	80C01	80C02, 80C04 & 80C09	80C03
Reference receiver filters	OC-12/STM-4, OC-48/STM-16, OC-192/STM-64	OC-192/STM-64, FEC10.6646Gb/s (80C04 only)[2] FEC10.70922Gb/s (80C09 only)[5]	FC1063, GBE, 2.50 Gb/s, OC-48/STM-16
Clock recovery, option	OC-12/STM-4, OC-48/STM-16	OC-192/STM-64, FEC10.6646Gb/s (80C04 only) FEC10.709225Gb/s (80C09 only)	FC1063, GBE, 2.50 Gb/s, OC48/STM-16
Absolute maximum nondestructive optical input[3]	5 mW average power; 10 mW peak power at wavelength with highest relative responsivity.		
Internal Fiber Diameter	9 µm/125 µm single mode	9 µm/125 µm single mode	62.5 µm/125 µm multimode[4]
Optical return loss	> 30 dB	> 30 dB typical (or better 80C09)	> 14 dB for multimode fiber > 28dB for single-mode fiber
Minimum optical bandwidth at optical connector	> 20 GHz	> 30 GHz	> 2.3 GHz
Output zero	< 10 µW immediately after dark calibration		< 500 nW immediately after dark calibration
Independent channel deskew	Standard	Standard	Standard
Offset capability at front of module	Standard	Standard	Standard
Power meter	Standard	Standard	Standard

Table 3: Optical module features (80C05 - 80C06)

Feature	80C05	80C06
Number of input channels	1	1
Effective wavelength range	1520 nm to 1580 nm	1520 nm to 1580 nm
Reference receiver filters	OC-192/STM64	None
Clock recovery option	None	None
Absolute maximum nondestructive optical input[3]	10 mW average power; 30 mW peak power at wavelength with highest relative responsivity.	20 mW average power; 60 mW peak power at wavelength with highest relative responsivity.
Internal fiber diameter	9 µm/125 µm single mode[4]	9 µm/125 µm single mode[4]
Optical return loss	> 30 dB	> 30 dB
Minimum optical bandwidth at optical connector	> 40 GHz	> 55 GHz, typical
Output zero	< 30 µW immediately after dark calibration	< 30 µW immediately after dark calibration

Table 3: Optical module features (80C05 - 80C06) (Cont.)

Feature	80C05	80C06
Independent channel deskew	Standard	Standard
Offset capability at front of module	Standard	Standard
Power meter	Standard	Standard

Table 4: Optical module features (80C07 and 80C08)

Feature	80C07	80C08
Number of input channels	1	1
Effective wavelength range	700 nm to 1650 nm	700 nm to 1650 nm
Reference receiver filters	OC-3/STM-1, OC-12/STM-4, OC-48/STM-16	9.95328 Gb/s (10GBASE-W) 10.3125 Gb/s (10GBASE-R)[6]
Clock recovery option	OC-3/STM-1, OC-12/STM-4, OC-48/STM-16	9.95328 Gb/s (10GBASE-W) 10.3125 Gb/s (10GBASE-R)
Absolute maximum nondestructive optical input[3]	5 mW average power; 10 mW peak power at wavelength with highest relative responsivity.	1 mW average power; 10 mW peak power for 60ms.
Internal fiber diameter	62.5 μm/125 μm single mode[4]	62.5 μm/125 μm multimode[4]
Optical return loss	$>$14 dB for multimode fiber $>$24dB for single-mode fiber	$>$14 dB for multimode fiber $>$24 dB for single-mode fiber
Minimum optical bandwidth at optical connector	$>$2.3 GHz	$>$10 GHz
Output zero	$<$500 nW immediately after dark calibration +/- 2% (Vertical offset)	$<$1 uW immediately after dark calibration +/- 2% (Vertical offset)
Independent channel deskew	Standard	Standard
Offset capability at front of module	Standard	Standard
Power meter	Standard	Standard

Table 5: Optical module features (80C08B and 80C10)

Feature	80C08B	80C10
Number of input channels	1	1[8]
Effective wavelength range	700 nm to 1650 nm	1310 nm +/- 30 nm 1550 nm +/- 30 nm

Table 5: Optical module features (80C08B and 80C10) (Cont.)

<table>
<tr><th>Feature</th><th>80C08B</th><th>80C10</th></tr>
<tr><td>Reference receiver filters</td><td>9.95328 Gb/s (10GBASE-W/
OC-192/STM64)
10.3125 (10GBASE-R)
10.51875 (10GFC)</td><td>OC-768/STM256
43.018 Gb/s G.709 FEC</td></tr>
<tr><td>Clock recovery option</td><td>9.95328 Gb/s (10GBASE-W/
OC-192/STM-64) (CR-1)[7]
10.3125 Gb/s (10GBASE-R) (CR-1 &
CR-2)[7]
10.51875 Gb/s (10GFC) (CR-2 only)[7]</td><td>None</td></tr>
<tr><td>Absolute maximum
nondestructive
optical input[3]</td><td>1 mW average power; 10 mW peak power for 60ms.</td><td>20 mW average power; 60 mW peak power at wavelength with highest relative responsivity.</td></tr>
<tr><td>Internal fiber diameter</td><td>62.5 μm/125 μm
multimode[4]</td><td>9 μm/125 μm
single mode[4]</td></tr>
<tr><td>Optical return loss</td><td>> 14 dB for multimode fiber
> 24 dB for single-mode fiber</td><td>> 30 dB</td></tr>
<tr><td>Minimum optical bandwidth</td><td>> 10 GHz</td><td>> 60 GHz, minimum
> 65 GHz, typical</td></tr>
<tr><td>Output zero</td><td>< 1 uW immediately after dark calibration +/- 2% (Vertical offset)</td><td>1550 nm:
± [25 μW +0.04*|Vertical Offset |]
1310 nm:
± [35 μW +0.04*|Vertical Offset |]</td></tr>
<tr><td>Independent channel deskew</td><td>Standard</td><td>Standard</td></tr>
<tr><td>Offset capability at front of module</td><td>Standard</td><td>Standard</td></tr>
<tr><td>Power meter</td><td>Standard</td><td>Standard</td></tr>
</table>

1 Some values in the table are typical.

2 The 80C04 supports selection of two Reference Receiver filters: the OC-192 for 9.95328 Gb/s SONET/SDH standard and the 10.66Gb/s for the Forward Error Correction (FEC) rate of 10.664Gb/s. Option 80C04-CR1 adds OC-192 clock recovery only; option CR2 adds OC-192 and 10.664Gb/s clock recovery.

3 The 80C01, 80C02, 80C04, 80C05, 80C06, and 80C09 will remain functional at these levels, but the 80C03, 80C07, and 80C08 will saturate well below (<1 mW) due to their internal amplifiers.

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

5 The 80C09 supports selection of two Reference Receiver filters: the OC-192 for 9.95328 Gb/s SONET/SDH standard and the 10.71Gb for the Forward Error Correction (FEC) rate of 10.709Gb/s. Option 80C09-CR1 adds OC-192 clock recovery and 10.709Gb/s forward error correction clock recovery (data recovery at OC-192 and 10.709Gb/s FEC rates is not supported by the CR1 option.

6 The 80C08 supports selection of two clock recovery options: Option 80C08-CR1 adds 10GBASE-W (9.95328Gb/s) and 10GBASE-R (10.3125Gb/s) clock recovery only (no data recovery).

7 The 80C08B supports selection of two clock recovery options: Option 80C08B-CR1 adds OC-192 (9.95328Gb/s) and 10GBASE-R (10.3125Gb/s) clock recovery only (no data recovery); Option 80C08B-CR2 adds 10GFC (10.51875Gb/s) and 10GBASE-R (10.3125Gb/s) clock recovery only (no data recovery)

8 There are two separate optical inputs, one for 1310 nm and one for 1550 nm.

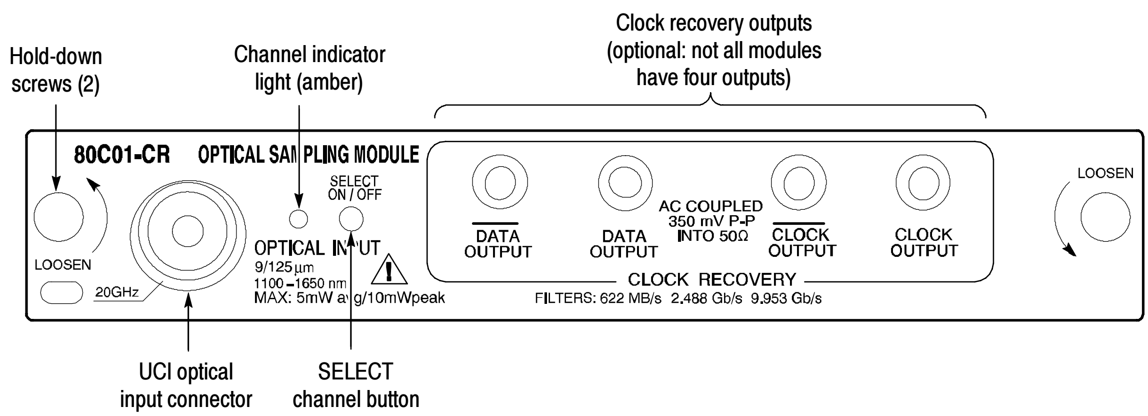


Figure 1: Optical module, 80C01-CR shown

Options and Accessories

This section lists the standard and optional accessories available for the sampling modules, as well as the product options.

Options

The following options can be ordered for the instrument:

Table 6: Available options

Option	Module	Description
Option CR	80C01-CR	Adds 622.08 Mb/s and 2.48832 Gb/s clock recovery
	80C02-CR	Adds 9.95328 Gb/s clock recovery
	80C03-CR	Adds 1.0625 Gb/s, 1.2500 Gb/s, 2.48832 Gb/s, and 2.500 Gb/s clock recovery
Option CR1	80C04-CR1	Adds 9.95328 Gb/s clock recovery
	80C07-CR1	Adds 155/622/2488 Mb/s clock recovery
	80C08-CR1	Adds 9.95328 Gb/s and 10.3125 Gb/s clock recovery
	80C08B-CR1	Adds 9.95328 Gb/s and 10.3125 Gb/s clock recovery
	80C09-CR1	Adds 9.95328 Gb/s and 10.709 Gb/s clock recovery
Option CR2	80C04-CR2	Adds 9.995328 Gb/s and 10.664 Gb/s clock recovery
	80C08B-CR2	Adds 10.3125 Gb/s and 10.51875 Gb/s clock recovery
Option C3		Three years of calibration services
Option C5		Five years of calibration services (80C08B only)
Option D1		Calibration data report
Option D3		Test data for calibration services in Option D1 (with C3 only)
Option D5		Calibration data report (with C5 only)
Option R3		Repair warranty extended to cover three years
Option R5		Repair warranty extended to cover five years (80C08B only)

Standard Accessories

The following accessories are shipped with the instrument:

Table 7: Standard accessories

Item	Part number
80C00 Series Optical Sampling Modules User Manual	071-0435-xx
Certificate of Traceable Calibration for product at initial shipment	Not Orderable
Frequency response data[1]	Not Orderable
Software Upgrade	020-2372–xx
FC/PC UCI adapter, installed	119-4516-xx
Fiber cleaning kit	020-2357-xx
SMA male 50 Ω termination (installed, one per clock recovery output connector)	015-1022-xx

[1] **Frequency response data is not provided for the 80C05 and 80C06 modules; however impulse and step response showing risetime is provided. Frequency response data is provided for the 80C08B filtered modes (9.953, 10.31, and 10.52 Gb/s) and 80C10 filtered modes (39.813 and 43.108 Gb/s) modules.**

Optional Accessories

The following accessories are orderable for use with the sampling module at the time this manual originally published. Consult a current Tektronix catalog for additions, changes, and details:

Table 8: 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	119-4516-xx
SMA 2.5 UCI adapter	119-4517-xx
SC/PC UCI adapter	119-4518-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
CSA8000B & TDS8000B Service Manual	071-0438-xx

Installation

The optical modules fit in the large slot in the front panel of a compatible instrument, such as a CSA8000B or TDS8000B. Figure 2 shows the front panel of a CSA8000B and the locations of the module compartments.

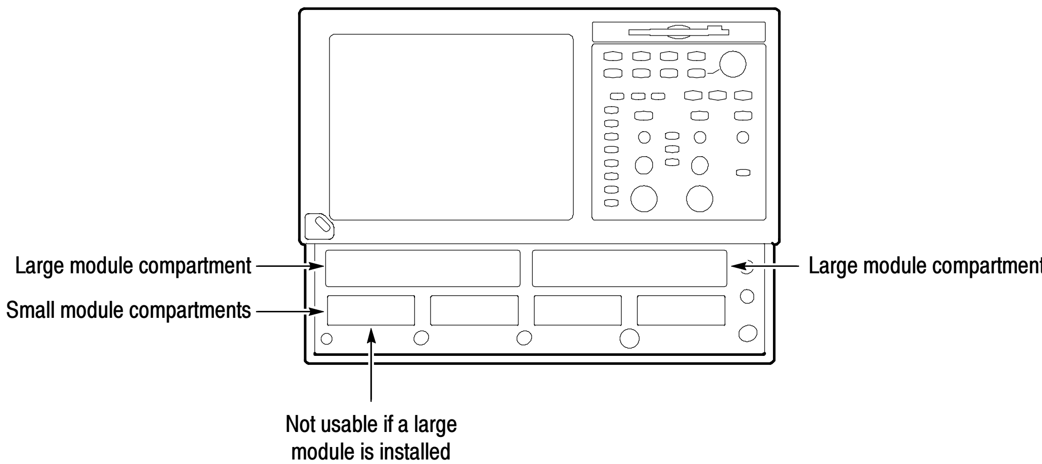


Figure 2: Module compartments

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

NOTE*. Installing a large module, in either large compartment, disables the left-most small compartment (CH 1 and CH 2 for small modules).*

The large compartments support single channel sampling modules, while the small compartments support single or dual channel sampling 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 outputs.

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 into place. See Figure 3.

NOTE. *To facilitate installation, 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 ensure the retaining ear on each screw rotates in to 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 secured the module, you can turn on the instrument. See the main instrument user manual for information on powering on your instrument and checking its function.

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

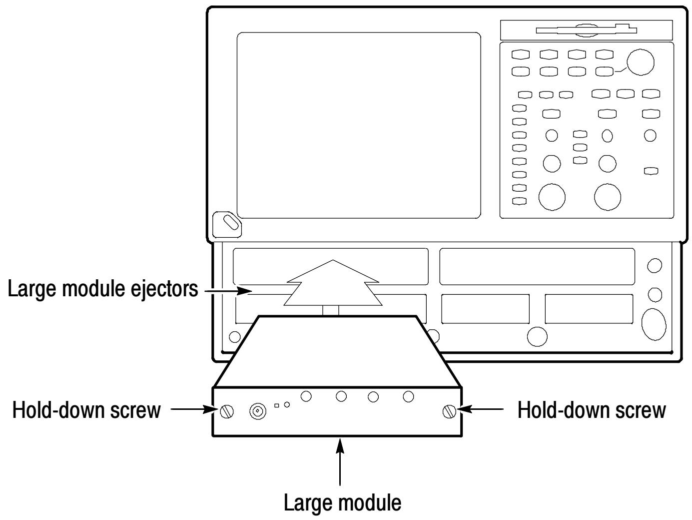


Figure 3: Installing a large module

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

Replace 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. Also insure that all connectors and jumpers attached to the inputs are clean prior to insertion. *See* Cleaning Optical Connectors *on page 17.*

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* on page 17.

The input of the 80C01, 80C02, 80C04, 80C05, 80C06, 80C09, and 80C10 modules (see note) can couple to single-mode optical fibers with a core diameter/cladding diameter of 9/125 μm. The 80C03, 80C07, 80C08, and 80C08B modules can couple to any single-mode dimension or multimode dimension not exceeding a core diameter/cladding diameter of 62.5/125 μm. Alternate types can be coupled by use of UCI (universal connector interface) series adapters. Refer to a current Tektronix catalog for details.

NOTE. *The 80C10 has two separate optical inputs. The user must choose the correct one to use depending on 1310 nm or 1550 nm operation.*

Attach the fiber optic cable with a suitable connector or a UCI Interface adapter to the optical input receptacle as follows:

1. Firmly press the cable connector or adapter into the interface ferrule until it reaches the stop.
2. Rotate the cable connector or the adapter body until the anti-rotation pin engages.
3. Firmly tighten the cable connector or the adapter shell. Tighten with finger pressure only.
4. To remove, unscrew 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 to the Absolute Maximum Nondestructive Optical Input specifications. To maintain the levels within performance range and to avoid clipping, attenuate optical signals as indicated in the table below:*

Module	*Average*	*Peak*
80C01	*5 mW*	*10 mW*
80C02	*5 mW*	*10 mW*
80C03	*5 mW*	*10 mW*
80C04	*5 mW*	*10 mW*
80C05	*20 mW*	*60 mW*
80C06	*20 mW*	*60 mW*
80C07	*5 mW*	*10 mW*
80C08	*1 mW*	*10 mW*
80C08B	*1 mW*	*10 mW*
80C09	*5 mW*	*10 mW*
80C10	*20 mW*	*60 mW*

NOTE. *The 80C03 and 80C07 modules can have a somewhat deteriorated response for signals larger than 200* $\mu W_{p\text{-}p}$. *The 80C08 modules also can have a somewhat deteriorated response for signals larger than 500* $\mu W_{p\text{-}p}$, *and the vertical response will eventually saturate for levels approaching 1* $mW_{p\text{-}p}$.

***NOTE**. Optical sampling modules may have dynamic ranges exceeded without obvious visual indication onscreen because the photodetector and/or filters used may not necessarily pass through overloaded signals to the samplers at the front end.*

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

The optical module front panel is shown in Figure 4.

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

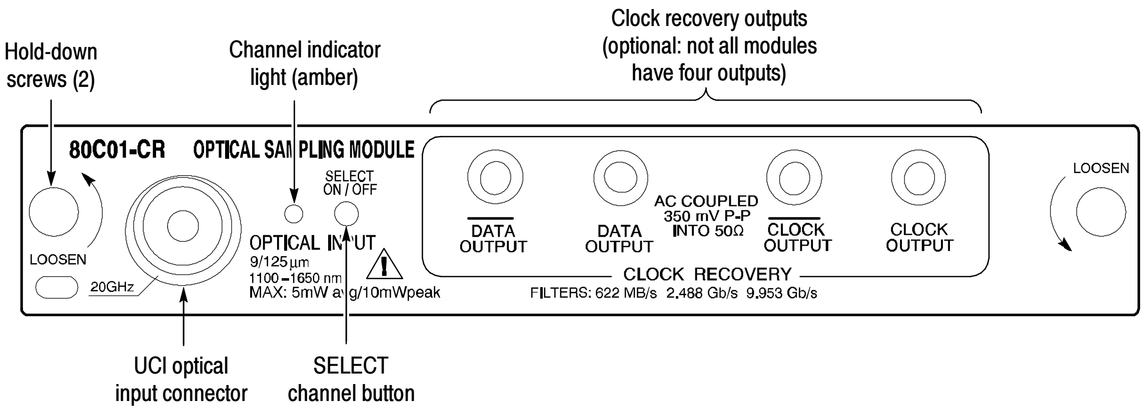


Figure 4: Optical module, 80C01-CR shown

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.)

Clock Recovery Outputs

Optional clock and data-recovery circuitry provides clock and data outputs; the recovered clock is internally routed to the main-instrument trigger circuit. The circuitry also provides front-panel outputs: normal and complemented clock, and on some modules, normal and complemented data. See Table 9. Use 50 Ω terminations, provided with your optical module, on unused outputs.

Table 9: Clock recovery outputs

Modules	Front Panel Outputs
80C01-CR	DATA, $\overline{\text{DATA}}$, CLOCK, $\overline{\text{CLOCK}}$
80C02-CR	DATA, CLOCK, 1/16 CLOCK
80C03-CR	CLOCK, $\overline{\text{CLOCK}}$, DATA, $\overline{\text{DATA}}$
80C04-CR1 80C04-CR2	DATA, CLOCK, 1/16 CLOCK CLOCK, 1/16 CLOCK
80C07-CR1	DATA, $\overline{\text{DATA}}$, CLOCK, $\overline{\text{CLOCK}}$
80C08-CR1 80C08B-CR1 80C08B-CR2	CLOCK, 1/16 CLOCK CLOCK, 1/16 CLOCK CLOCK, 1/16 CLOCK
80C09-CR1	CLOCK, 1/16 CLOCK

You can disable the internal recovered clock from being used as the main instrument trigger by selecting external or internal triggering; select the recovered clock rate without actually selecting recovered clock as the trigger condition in order to activate the front-panel clock recovery signals.

Hold-Down Screws

Hold-down screws secure 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.

Commands From the Main-Instrument Front Panel

The Vertical Setup dialog box lets you toggle between the basic and optical module controls. The basic and optical controls are shown in Figure 5.

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 can be found in the *CSA8000B & TDS8000B User Manual* and the *CSA8000 and TDS8000 Online Help*.

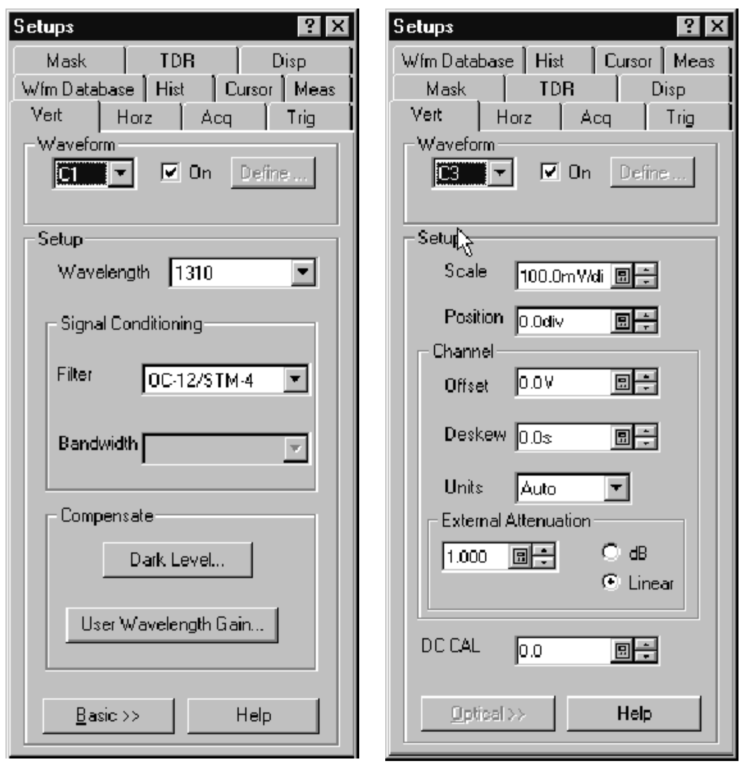


Figure 5: System Vertical menu

Programmer Interface Commands

The remote programming commands for all sampling modules are documented in the *CSA8000 & TDS8000 Programmer Guide* accessed 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 *CSA8000B & TDS8000B User Manual* or the *CSA8000 and TDS8000 Online Help*.

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.*

When cleaning the connectors with a swab, use gentle circular motions. Use only high quality cleaning supplies that are non-abrasive and leave no residue.

When possible, use the dry cleaning method on page 18.

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:

- clean, dust-free compressed
- fiber cleaning cassette and/or tape dispenser cleaner
- pure, electronics-grade isopropyl alcohol (see Caution)

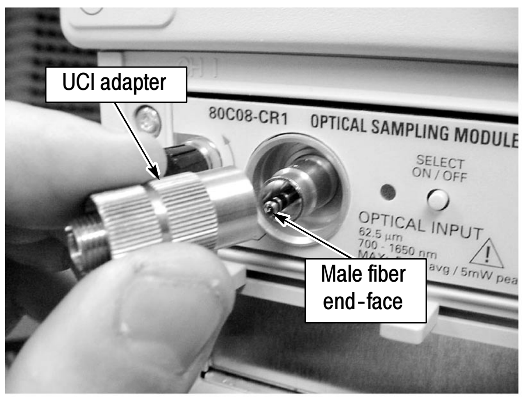
CAUTION. *If possible, clean your connecting fiber (ferrule endface) with a dry cloth tape (cassetted or in a dispenser) cleaner. This is the preferred method, instead of the swabs and alcohol. Both ferrule endfaces can be cleaned in this way. If the alcohol method is used, it is recommended to follow that with the dry cleaning method outlined on page 18.*

NOTE. *Cleaning kits for optical connectors (such as the Tektronix Optical Connector Cleaner part number 006-8134-00) are available from a number of suppliers.*

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

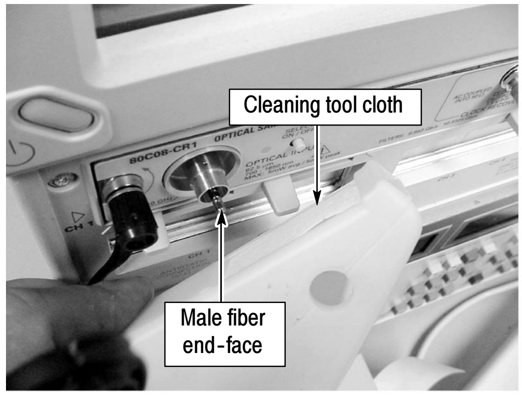
Equipment required	One compressed air can, such as Tektronix part number 118-1068-01. One FIS cassette cleaner, such as FI-6270. One FIS tape dispenser cleaner, such as FI-7111.
Prerequisites	None

1. Remove the UCI adapter. This exposes the male fiber end-face fiber connector behind the UCI connector and allows access to it.



2. Advance the fiber cleaning cassette or tape-dispenser cleaner to expose an unused clean section of the lint free dry cleaning surface.

3. 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).



4. Replace the UCI adapter back onto the cleaned fiber end-face.

5. When the module does not have a fiber attached to its input(s) ensure the black dust-cap is in place to prevent airborne contaminates from lodging in the female optical input.

6. Be sure to repeat a similar cleaning method to any male fiber end-face input fiber or device that will be attached to the input of the 80C0X UCI input.

It is recommended that you use clean, dust-free compressed air to remove contaminates on the inside wall of the hollow female-to-female ferrule alignment tube inside the UCI adapter:

1. Remove the UCI adapter from the front panel of the instrument.
2. Use the compressed air to clean the female input of the adapter end-to-end.

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

Optical Dark Level Compensation

The Vertical menu lets you access the optical module Dark Level and User Wavelength Gain Compensation procedures. This menu is shown in Figure 5 on page 16.

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

User Wavelength Gain Compensation

Execute a Compensation of the module as soon as the module has reached operation equilibrium (that is, after a 20 minute warm-up). Compensation for the entire system or for an individual optical module can be initiated from the Utilities menu Compensation command. For more information, see *Optimizing Measurement Accuracy* in the main instrument user manual. Compensation of the module also performs an optical dark level compensation

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

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. This menu is shown in Figure 5 on page 16.

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:

Table 10: Wavelength, Filter, and Bandwidth selections

Module	Wavelength selections	Filter	Bandwidth
80C01	1310 nm 1550 nm User	None (select a bandwidth) OC-12/STM-4 (622.08 Mb/s) OC-192/STM-64 (9.953 Gb/s) OC-48/STM-16 (2.48832 Gb/s)	20 GHz 12.5 GHz
80C02	1310 nm 1550 nm User	None (select a bandwidth) OC-192/STM-64 (9.953 Gb/s)	30 GHz 20 GHz 12.5 GHz
80C03	780 nm 850 nm 1310 nm 1550 nm User	None 2.50 Gb/s OC-48/STM-16 (2.488 Gb/s) FC1063 (1.0625 Gb/s) GbE (1.25 Gb/s)	2 GHz
80C04	1310 nm 1550 nm User	None (select a bandwidth) OC-192/STM-64 (9.953 Gb/s) FEC10.66 Gb/s	30 GHz 20 GHz
80C05	1550 nm User	None (select a bandwidth) OC-192/STM-64 (9.953 Gb/s)	40 GHz 30 GHz 20 GHz
80C06	1550 nm User	None	50 GHz
80C07	780 nm 850 nm 1310 nm 1550 nm User	None OC-3/STM-1 (155Mb/s) OC-12/STM-4 (622.08 Mb/s) OC-48/STM-16 (2.48832 Gb/s)	2 GHz

Table 10: Wavelength, Filter, and Bandwidth selections

Module	Wavelength selections	Filter	Bandwidth
80C08	780 nm 850 nm 1310 nm 1550 nm User	None 10GBASE-W (9.953 Gb/s) 10GBASE-R (10.31 Gb/s)	10 GHz
80C08B	780 nm 850 nm 1310 nm 1550 nm User	None 10GBASE-W (9.953 Gb/s) 10GBASE-R (10.31 Gb/s) OC-192/STM-64 (9.953 Gb/s) 10GFC (10.518 Gb/s)	10 GHz
80C09	1310 nm 1550 nm User	None (select a bandwidth) OC-192/STM-64 (9.953 Gb/s) FEC10.71 Gb/s	30 GHz 20 GHz
80C10	1310 nm 1550 nm User	None (select a bandwidth) OC-768/STM-256 (39.813 Gb/s) G.709 FEC (43.018 Gb/s)	30 GHz 65 GHz

For more information, consult the *CSA8000 and TDS8000 Online Help*.

Clock Recovery

This section describes the clock recovery option.

DATA and $\overline{\text{DATA}}$ (recovered data). These outputs (DATA only on the 80C02 and 80C04-CR1) provide a 50 Ω, AC-coupled, ~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 (CLOCK and 1/16 CLOCK on the 80C02-CR, 80C04-CR1, 80C04-CR2, 80C08-CR1, 80C08B-CR1, 80C08B-CR2, and 80C09-CR1) are clock signals synchronous with the incoming data signal. These clocks are only available with Option CR, CR1 or CR2. Only CLOCK and 1/16 CLOCK are available at the front panel for the 80C04-CR2, 80C08-CR1, 80C08B-CR1, 80C08B-CR2, and 80C09-CR1 modules.

***NOTE**. If clock and data recovery are enabled and no signal (or not the appropriate signal) is applied to the front panel, the recovered clock and data may free run.*

NOTE. Table 14 *on page 49 summarizes the clock recovery options for all modules.*

NOTE. *The recovered clock is simultaneously made available internally to the mainframe 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.*

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 ohm 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. A logarithmic scale using decibels is typically used to describe a system's frequency dependent response. A value expressed in terms of a decibel relative to a reference is defined as:

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

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:

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

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

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

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 $V(f) = 0.707 \times V(DC)$.

The expression is simplified by cancelling 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 CSA8000B and TDS8000B instruments, the vertical units displayed for an optical module are not in voltage, but watts; this is a unit 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:

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

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 dB = 10 log(vertical swing at frequency / 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 dB = 20 × log(vertical swing at frequency / vertical swing at DC).

Bandwidth for Unfiltered Frequency Settings

The curve calculation of frequency response for the unfiltered frequency settings (2.3 GHz, 12.5 GHz, 20 GHz, 30 GHz, 40 GHz, and 50 GHz) uses the definition for dB and bandwidth where –3 dB = 10 log(vertical swing at frequency / 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 dB = 20 log (vertical swing at frequency / vertical swing at DC).

Specifications

This section contains specifications for the 80C01, 80C02, 80C03, 80C04, 80C05, 80C06, 80C07, 80C08, 80C08B, 80C09, and 80C10 Optical Modules. All specifications are guaranteed unless noted as "typical." Typical specifications are provided for your convenience but are not guaranteed. Except for limits noted "typical," specifications that are marked with the ✓ symbol are checked in the *Performance Verification* section of the service manual.

All specifications apply to the 80C01, 80C02, 80C03, 80C04, 80C05, 80C06, 80C07, 80C08, 80C08B, 80C09, and 80C10 Optical Modules unless noted otherwise. To meet specifications, three conditions must first 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.
- The instrument must be in an environment with temperature, altitude, humidity, and vibration within the operating limits described in these specifications

***NOTE**. "Sampling Interface" refers to both the electrical sampling module interface and the optical module interface, unless otherwise specified.*

Table 11: Optical modules - Descriptions

Name	Characteristics
80C01	Long wavelength 1100 nm - 1650 nm. Unamplified O/E converter with two user selectable optical bandwidths: 12.5 GHz, > 20 GHz, or three user selectable reference receiver responses: OC-12/STM-4 for 622.08 Mb/s SONET/SDH standards, OC-48/STM-16 for 2.488 Gb/s SONET/SDH standards, and OC-192/STM-64 for 9.953 Gb/s SONET/SDH standards.
80C02	Long wavelength 1100 nm - 1650 nm. Unamplified O/E converter with three user selectable optical bandwidths: 12.5 GHz 20 GHz, 30 GHz, or one user selectable reference receiver response: OC-192/STM-64 for 9.953 Gb/s Sonet/SDH standards.

Table 11: Optical modules - Descriptions (Cont.)

Name	Characteristics
80C03	Broad wavelength 700 nm - 1650 nm. Amplified O/E converter with optical bandwidth of 2.5 GHz. The 2.5 Gb/s, OC-48/STM-16, and 2.0 GHz modes all use a physical path that has OC48/STM-16 reference receiver type response. Two other selectable reference receiver responses: FC1063 for the 1.0625 Gb/s fibre channel standard and GBE for the 1.25 Gb/s gigabit ethernet standard.
80C04	Long wavelength 1100 nm - 1650 nm unamplified. Unamplified O/E converter with two user selectable optical bandwidths: 20 GHz, 30 GHz, or two user selectable reference receiver responses: OC-192/STM-64 for 9.953 Gb/s Sonet/SDH standards 10.664 Gb/s ITU-T Recommendation G.975 standard
80C05	Long wavelength 1520 - 1580 nm unamplified. Three user-selectable optical bandwidths: 20 GHz 30 GHz 40 GHz, or one reference receiver response: OC-192/STM-64 for 9.953 Gb/s Sonet/SDH standards
80C06	Long wavelength 1520 - 1580 nm. O/E converter unamplified, 55 GHz optical sampler accepts high power optical signals typical for RZ signaling. Particularly well-suited for 40 Gb/s RZ telecom applications, as well as general purpose optical component testing.
80C07	Broad wavelength 700 nm - 1650 nm. Amplified O/E converter with optical bandwidth of 2.5 GHz. The OC-48/STM-16 and 2.0 GHz modes all use a physical path that has OC48/STM-16 reference receiver type response. Two other selectable reference receiver responses: OC-3/STM-1 OC-12/STM-4
80C08	Broad wavelength 700nm-1650nm. Amplified O/E converter with maximum optical bandwidth (in combination with the internal electrical sampler) of 10 GHz. There are two Data Rate Receiver setups selectable: 10GBASE-W for 9.95328 Gb/s 10GBASE-R for 10.3125 Gb/s
80C08B	Broad wavelength 700nm-1650nm. Amplified O/E converter with maximum optical bandwidth (in combination with the internal electrical sampler) of 9.5 GHz. There are four Data Rate Receiver setups selectable: 10GBASE-W for 9.95328 Gb/s 10Gb/s Ethernet standard 10GBASE-R for 10.3125 Gb/s 10Gb/s Ethernet FEC standard OC-192/STM-64 for 9.953 Gb/s Sonet/SDH standards 10GFC for 10.51875 Gb/s 10Gb/s FibreChannel standard

Table 11: Optical modules - Descriptions (Cont.)

Name	Characteristics
80C09	Long wavelength 1100 nm - 1650 nm. Unamplified O/E converter with two user selectable optical bandwidths: 20 GHz, 30 GHz, or two user selectable reference receiver responses: OC-192/STM-64 for 9.953 Gb/s Sonet/SDH standards 10.709 Gb/s ITU-T Recommendation G.709 standard
80C10	Long wavelength 1310 nm and 1550 nm. Unamplified O/E converter with two user selectable optical bandwidths: 30 GHz, 65 GHz, or two user selectable reference receiver responses: OC-768/STM-256 for 39.813 Gb/s Sonet/SDH standards 43.018 Gb/s ITU-T Recommendation G.709 standard

Table 12: Optical modules - Acquisition

Name	Characteristics	
Number of input channels	1 optical	
Internal fiber diameter[1]	*Module*	*Characteristics*
	80C01	9 µm/125 µm single mode
	80C02	9 µm/125 µm single mode
	80C03, 80C07, 80C08, and 80C08B	62.5 µm (Corning 62.5/125 CPC6 specs) multimode (compatible with single-mode fiber) cladding: 125 µm, buffer: 900 µm
Internal fiber diameter[1]	80C04	9 µm/125 µm single mode
	80C05	9 µm/125 µm single mode
	80C06	9 µm/125 µm single mode
	80C09	9 µm/125 µm single mode
	80C10	9 µm/125 µm single mode
Fiber connector	Rifocs UCI (universal connector interface) male connector	
Optical return loss	*Module*	*Loss*
	80C01, 80C02, 80C04, 80C05, 80C06, 80C09, and 80C10	> 30 dB for single-mode fiber
	80C03, 80C07, 80C08, and 80C08B	> 14 dB for multimode fiber > 24 dB for single-mode fiber

Table 12: Optical modules - Acquisition (Cont.)

Name	Characteristics	
Absolute maximum nondestructive optical input[2]	80C01, 80C02, 80C03, 80C04, 80C07, and 80C09	5 mW average power; 10 mW peak power at wavelength with highest relative responsivity.
	80C05 and 80C10	20 mW average power; 60 mW power at wavelength with highest relative responsivity.
	80C06	20 mW average power; 60 mW power at wavelength with highest relative responsivity.
	80C08 and 80C08B	1 mW average power; 10 mW peak power at wavelength with highest relative responsivity.
Maximum operating ranges[11]	80C01, 80C02, 80C04, and 80C09	0 to10 mW displayed limits, not including offset.
	80C03 and 80C07	0 to1 mW displayed limits, not including offset.
	80C05	0 to 30 mW displayed limits, not including offset. However, signal limit is 10mW average optical power, 20 mW displayed peak power at wavelength with highest relative responsivity.
	80C06	0 to 60 mW displayed limits, inclusive of offset, which may be coerced to above 4mW/div to ensure this is attained, and respecting that the signal limit is 15mW average optical power, 30mW displayed peak power at wavelength with highest relative responsivity.
	80C08 and 80C08B	0 to 2 mW displayed limits, not including offset.
	80C10	0 to 30 mW displayed limits, not including offset.
Effective wavelength range[3], typical	*Module*	*Range*
	80C01, 80C02, 80C04, and 80C09	1100 nm to 1650 nm
	80C03, 80C07, 80C08, and 80C08B	700 nm to 1650 nm
	80C05, 80C06	1520 nm to 1580 nm
	80C10	1550 nm: 1520 nm to 1580 nm 1310 nm: 1290 nm to 1330 nm

Table 12: Optical modules - Acquisition (Cont.)

Name	Characteristics	
Calibrated wavelengths	*Module*	*Range*
	80C01, 80C02, 80C04, 80C09, and 80C010	1550 nm and 1310 nm ±20 nm
	80C03, 80C07, 80C08, and 80C08B	1550 nm, 1310 nm, 850 nm, and 780 nm (all ±20 nm)
	80C05 and 80C06	1550 nm ±20 nm
Dark level	80C01: OC-12/STM-4, OC-48/STM-16, OC192/STM-64, 12.5 GHz settings: < 10 μW ±2% (vertical offset) 20 GHz settings: < 10 μW ±4% (vertical offset) 80C02: OC192/STM-64, 12.5 GHz settings: < 10 μW ±2% (vertical offset) 20 GHz, 30 GHz settings: < 10 μW ±4% (vertical offset) 80C03 and 80C07: All settings: < 500 nW ±2% (vertical offset) 80C04: OC192/STM-64, 10.66 Gb/s settings: < 10 μW ±2% (vertical offset) 20 GHz, 30 GHz settings: < 10 μW ±4% (vertical offset) 80C05: OC192/STM-64 < 10 μW ±2% (vertical offset) 20 GHz, 30 GHz, 40 GHz: < 30 μW ±4% (vertical offset) 80C06: 50 GHz < 25 μW ±4% (vertical offset) 80C08 and 80C08B: All settings: < 1.0 μW ±2% (vertical offset) 80C09: OC192/STM-64, 10.71 Gb/s settings: < 10 μW ±2% (vertical offset) 20 GHz, 30 GHz settings: < 10 μW ±4% (vertical offset) 80C10: 65 GHz 1550 nm ±[25 μW +0.04*|Vertical Offset |] 1310 nm ±[35 μW +0.04*|Vertical Offset |] To achieve these levels, perform a dark level compensation, keep the trigger rate and vertical offset the same as during the compensation, and if the ambient temperature changes more than 1° C, perform another dark level compensation.	

Table 12: Optical modules - Acquisition (Cont.)

Name	Characteristics
Main-instrument display vertical scale factors	Module / Maximum / Minimum 80C01, 80C02, 80C04, and 80C09: 1 mW per division / 10 μW per division 80C03 and 80C07: 100 μW per division / 1 μW per division 80C05: 3 mW per division / 30 μW per division 80C06: 6 mW per division / 60 μW per division 80C08 and 80C08B: 200 μW per division / 2 μW per division 80C10: 3 mW per division / 30 μW per division Full scale vertical on the display of the main instrument is 10 divisions. Maximum full scale and minimum full scale are therefore 10 times the values listed above. Vertical scale is adjustable in a 1-2-5 sequence. Between those settings, the scale can be adjusted in smaller increments.
Vertical offset range	80C01: ±8 mW offset relative to center of waveform display (5 divisions from either top or bottom of waveform display) 80C02: ±6 mW offset relative to center of waveform display (5 divisions from either top or bottom of waveform display) 80C03: ±1 mW offset relative to center of waveform display (5 divisions from either top or bottom of waveform display) 80C04: ±6 mW offset relative to center of waveform display (5 divisions from either top or bottom of waveform display) 80C05, 80C10: ±15 mW offset relative to center of waveform display (5 divisions from either top or bottom of waveform display) 80C06: ±40 mW offset relative to center of waveform display (5 divisions from either top or bottom of waveform display) (typical) 80C07: ±1 mW offset relative to center of waveform display (5 divisions from either top or bottom of waveform display) 80C08, 80C08B: ±4 mW offset relative to center of waveform display (5 divisions from either top or bottom of waveform display) 80C09: ±6 mW offset relative to center of waveform display (5 divisions from either top or bottom of waveform display)

Table 12: Optical modules - Acquisition (Cont.)

Name	Characteristics
DC vertical accuracy[4], typical	80C01: OC-192/STM-64, 10GFC, 10GBASE-W, 10GBASE-R, and 10 GHz: ± 25 μW ± 2% of [(vertical value) - (vertical offset)] 80C02: 12.5 GHz, OC-192/STM-64: ± 25 μW ± 2% of [(vertical value) - (vertical offset)] 20 GHz setting: ± 25 μW ± 4% of [(vertical value) - (vertical offset)] 30 GHz setting: ± 25 μW ± 6% of [(vertical value) - (vertical offset)] 80C03, all settings: ± 25 μW ± 2% of [(vertical value) - (vertical offset)] 80C04: 10.66 Gb/s and OC-192/STM-64: ± 25 μW ± 2% of [(vertical value) - (vertical offset)] 20 GHz setting: ± 25 μW ± 4% of [(vertical value) - (vertical offset)] 30 GHz setting: ± 25 μW ± 6% of [(vertical value) - (vertical offset)] 80C05: OC-192/STM-64: ± 25 μW ± 2% of [(vertical value) - (vertical offset)] 20 GHz setting: ± 25 μW ± 4% of [(vertical value) - (vertical offset)] 30 GHz setting: ± 25 μW ± 6% of [(vertical value) - (vertical offset)] 40 GHz setting: ± 25 μW ± 8% of [(vertical value) - (vertical offset)] 80C06: 50 GHz setting: ± 120 μW ± 6% of [(vertical value) - (vertical offset)] 80C07, 80C08, and 80C08B all settings: ± 25 μW ± 2% of [(vertical value) - (vertical offset)] 80C09: 10.71 Gb/s, OC-192/STM-64: ± 25 μW ± 2% of [(vertical value) - (vertical offset)] 20 GHz setting: ± 25 μW ± 4% of [(vertical value) - (vertical offset)] 30 GHz setting: ± 25 μW ± 6% of [(vertical value) - (vertical offset)] 80C10: 30 GHz setting: ± 25 μW ± 4% of [(vertical value) - (vertical offset)] 39 Gb/s, OC-768/STM-256 and 43 Gb/s (G.709), FEC43.02 Gb/s: ± 25 μW ± 6% of [(vertical value) - (vertical offset)] 65 GHz setting: ± 25 μW ± 8% of [(vertical value) - (vertical offset)]

Table 12: Optical modules - Acquisition (Cont.)

Name	Characteristics
DC vertical difference accuracy[4], typical The accuracy of the difference between two cursors in the vertical scale of the same channel.	80C01: 12.5 GHz, OC-192/STM-64, OC-48/STM-16, OC-12/STM-4 settings: ± 2% of [difference reading] 20 GHz setting: ± 4% of [difference reading] 80C02: 12.5 GHz, OC-192/STM-64: ± 2% of [difference reading] 20 GHz setting: ± 4% of [difference reading] 30 GHz setting: ± 6% of [difference reading] 80C03 and 80C07, all settings: ± 2% of [difference reading] 80C04: 10.66 Gb/s and OC-192/STM-64: ± 2% of [difference reading] 20 GHz setting: ± 4% of [difference reading] 30 GHz setting: ± 6% of [difference reading] 80C05: OC-192/STM-64: ± 2% of [difference reading] 20 GHz setting: ± 4% of [difference reading] 30 GHz setting: ± 6% of [difference reading] 40 GHz setting: ± 8% of [difference reading] 80C06, 80C08, and 80C08B all settings: ± 2% of [difference reading] 80C09: 10.71 Gb/s, OC-192/STM-64, ± 2% of [difference reading] 20 GHz: ± 4% of [difference reading] 30 GHz setting: ± 6% of [difference reading]] 80C10: 30 GHz setting: ± 4% of [difference reading] 39 Gb/s , OC-768/STM-256, 43 Gb/s, FEC43.02 setting: ± 6% of [difference reading] 65 GHz setting: ± 8% of [difference reading]

Table 12: Optical modules - Acquisition (Cont.)

Name	Characteristics	
Offset capabilities	Open loop. User assigned, fixed offset value is applied to channel.	
Minimum optical bandwidth[5]	80C01 module, 20 GHz setting 12.5 GHz setting	> 20 GHz > 12.5 GHz
	80C02 module, 30 GHz setting 80C02-CR, 30 GHz setting 80C02 and 80C02-CR, 30 GHz setting 80C02, 20 GHz setting 80C02 CR, 12.5 GHz setting	> 30 GHz, typical[7] > 29 GHz, typical[7] > 28 GHz[7] > 20 GHz > 12.5 GHz
	80C03 module, 2.5 GHz setting	> 2.3 GHz, typical
	80C04 module, 30 GHz setting 80C04-CR1 & 80C04-CR2 30 GHz setting 80C04, 80C04-CR1 & 80C04-CR2 30 GHz setting 80C04 20 GHz setting	> 30 GHz, typical[7] > 29 GHz, typical[7] > 28 GHz[7] > 20 GHz
	80C05 module 20 GHz 30 GHz 40 GHz	> 20 GHz > 30 GHz > 40 GHz, typical
	80C06 module 55 GHz[6]	> 55 GHz, typical
	80C07 module, 2.5 GHz setting	> 2.3 GHz, typical
	80C08 module, 10 GHz setting	> 10 GHz, typical > 9 GHz
	80C08B module, 10 GHz setting	> 10 GHz, typical > 9.5 GHz
	80C09 module, 30 GHz setting 80C09 CR1, 30 GHz setting 80C09 & 80C09-CR1, 30 GHz setting 80C09 20 GHz setting	> 30 GHz, typical[7] > 29 GHz, typical[7] > 28 GHz[7] > 20 GHz
	80C10 module, 30 GHz setting 65 GHz setting	> 30 GHz > 65 GHz

Table 12: Optical modules - Acquisition (Cont.)

Name	Characteristics	
Rise time, typical For peak optical signal input which creates < 2 mW$_{pp}$ modulation depth.	*80C01 module*	
	OC-12/STM-4 setting:	750 ps ±50 ps
	OC-48/STM-16 setting:	187 ps ±15 ps
	OC-192/STM-64 setting:	47 ps ±10 ps
	12.5 GHz setting:	<40 ps
	20 GHz setting:	<25 ps
	80C02 module	
	30 GHz setting:	<16 ps
	20 GHz setting:	<25 ps
	12.5 GHz setting:	<40 ps
	OC-192/STM-64 setting:	47 ps ±10 ps
	80C04 module	
	30 GHz setting:	<16 ps
	20 GHz setting:	<25 ps
	10.66 Gb/s setting:	44 ps ±10 ps
	OC-192/STM-64 setting:	47 ps ±10 ps
	80C05 module	
	40 GHz setting:	<12 ps
	30 GHz setting:	<16 ps
	20 GHz setting:	<25 ps
	OC-192/STM-64 setting:	47 ps ±10 ps
	80C06 module	
	50 GHz setting:	<9.6 ps
	80C09 module	
	30 GHz setting:	<16 ps
	20 GHz setting:	<25 ps
	10.71 Gb/s setting:	44 ps ±10 ps
	OC-192/STM-64 setting:	47 ps ±10 ps
	80C10 module	
	65 GHz setting:	7.4 ps
	30 GHz setting:	16 ps
	OC-768/STM-256 setting:	12 ps
	G.709 43 Gb/s setting:	11.2 ps

Table 12: Optical modules - Acquisition (Cont.)

Name	Characteristics		
Rise time, typical For peak optical signal input which creates < 200 μW_{pp} modulation depth.	*80C03 module*		
	FC1063 setting:		440 ps ± 35 ps
	GBE setting:		373 ps ± 30 ps
	OC-48/STM-16 setting:		187 ps ± 15 ps
	80C07 module		
	OC-3 setting:		3.0 ns ± 170 ps
	OC-12 setting:		750 ps ± 50 ps
	OC-48 setting:		187 ps ± 15 ps
Rise time, typical For peak optical signal input which creates < 500 μW_{pp} modulation depth.	*80C08 module*		
	10GBASE-W: 10GBASE-R:		53 ps ± 10 ps 53 ps ± 10 ps
	80C08B module		
	OC-192/STM-64 setting: 10GFC: 10GBASE-W: 10GBASE-R: 10 GHz:		47 ps ± 10 ps 46 ps ± 10 ps 47 ps ± 10 ps 46 ps ± 10 ps < 50 ps
Time domain vertical response aberrations, typical For peak optical signal input < 5 mW_{p-p} except for 80C03 and 80C07 which creates 200 μW_{pp} modulation depth.	80C01	OC-12/STM-4 setting: OC-48/STM-16 setting: OC-192/STM-64 setting: 12.5 GHz setting: 20 GHz setting:	< 5% < 5% < 10% < 10% < 15%
	80C02	OC-192/STM-64 setting: 12.5 GHz setting: 20 GHz setting: 30 GHz setting:	< 10% < 15% < 20% < 30%
	80C03	All settings:	< 5% p-to-p
	80C04	OC-192/STM-64 setting: 10.66 Gb/s setting: 20 GHz setting: 30 GHz setting:	< 10% < 10% < 20% < 30%
	80C07	All settings:	< 5% (typical)
	80C09	OC-192/STM-64 setting: 10.71 Gb/s setting: 20 GHz setting: 30 GHz setting:	< 10% < 10% < 20% < 30%

Table 12: Optical modules - Acquisition (Cont.)

Name	Characteristics		
Time domain vertical response aberrations, typical For peak optical signal input $< 10\ mW_{p\text{-}p}$.	80C05	OC-192/STM-64 setting: 20 GHz setting: 30 GHz setting: 40 GHz setting	< 5% < 10% < 10% < 15%
	80C06	50 GHz:	< 5% (typical) < 10% (maximum)
Time domain vertical response aberrations, typical For peak optical signal input $< 500\ \mu W_{p\text{-}p}$.	80C08	All settings:	< 10% (typical)
Time domain vertical response aberrations, typical For peak optical signal input $< 2\ mW_{p\text{-}p}$.	80C08B	All settings:	< 10% (typical)
✔ Time domain vertical response aberrations, typical For peak optical signal input $< 20\ mW_{p\text{-}p}$.	80C10	OC-768/STM-256 setting: FEC43.02 Gb/s setting: 30 GHz setting: 65 GHz setting	< 5% (maximum) < 3% (typical) < 5% (maximum) < 3% (typical) < 5% (maximum) < 3% (typical) < 10% (maximum) < 5% (typical)

Table 12: Optical modules - Acquisition (Cont.)

Name	Characteristics		
Vertical equivalent optical noise (maximum and typical)[8]	*80C01 module*	*Maximum RMS*[9]	*Typical RMS*[9]
	OC-12/STM-4 setting:	$< 12\ \mu W_{rms}$	$< 8\ \mu W_{rms}$
	OC-48/STM-16 setting:	$< 12\ \mu W_{rms}$	$< 8\ \mu W_{rms}$
	OC-192/STM-64 setting:	$< 12\ \mu W_{rms}$	$< 8\ \mu W_{rms}$
	12.5 GHz setting:	$< 12\ \mu W_{rms}$	$< 8\ \mu W_{rms}$
	20 GHz setting:	$< 25\ \mu W_{rms}$	$< 15\ \mu W_{rms}$
	80C01-CR module	*Maximum RMS*[9]	*Typical RMS*[9]
	OC-12/STM-4 setting:	$< 15\ \mu W_{rms}$	$< 10\ \mu W_{rms}$
	OC-48/STM-16 setting:	$< 15\ \mu W_{rms}$	$< 10\ \mu W_{rms}$
	OC-192/STM-64 setting:	$< 15\ \mu W_{rms}$	$< 10\ \mu W_{rms}$
	12.5 GHz setting:	$< 15\ \mu W_{rms}$	$< 10\ \mu W_{rms}$
	20 GHz setting:	$< 25\ \mu W_{rms}$	$< 15\ \mu W_{rms}$
	80C02 module	*Maximum RMS*[9]	*Typical RMS*[9]
	OC-192/STM-64 setting:	$< 10\ \mu W_{rms}$	$< 6\ \mu W_{rms}$
	12.5 GHz setting:	$< 10\ \mu W_{rms}$	$< 6\ \mu W_{rms}$
	20 GHz setting:	$< 15\ \mu W_{rms}$	$< 10\ \mu W_{rms}$
	30 GHz setting:	$< 30\ \mu W_{rms}$[7]	$< 20\ \mu W_{rms}$
	80C02-CR module	*Maximum RMS*[9]	*Typical RMS*[9]
	OC-192/STM-64 setting:	$< 12\ \mu W_{rms}$	$< 7\ \mu W_{rms}$
	12.5 GHz setting:	$< 12\ \mu W_{rms}$	$< 7\ \mu W_{rms}$
	20 GHz setting:	$< 20\ \mu W_{rms}$	$< 15\ \mu W_{rms}$
	30 GHz setting:	$< 40\ \mu W_{rms}$[7]	$< 30\ \mu W_{rms}$
	80C03 & 80C03-CR modules	*Maximum RMS*[9]	*Typical RMS*[9]
	FC1063 setting:	$< 1\ \mu W_{rms}$	$< 0.75\ \mu W_{rms}$
	GBE setting:	$< 1\ \mu W_{rms}$	$< 0.75\ \mu W_{rms}$
	OC-48/STM-16 setting:	$< 1.5\ \mu W_{rms}$	$< 1\ \mu W_{rms}$
	80C04 module	*Maximum RMS*[9]	*Typical RMS*[9]
	OC-192/STM-64 setting:	$< 10\ \mu W_{rms}$	$< 6\ \mu W_{rms}$
	FEC 10.66 Gb/s setting:	$< 10\ \mu W_{rms}$	$< 6\ \mu W_{rms}$
	20 GHz setting:	$< 15\ \mu W_{rms}$	$< 10\ \mu W_{rms}$
	30 GHz setting:	$< 30\ \mu W_{rms}$[7]	$< 20\ \mu W_{rms}$
	80C04-CR1 and 80C04-CR2 modules	*Maximum RMS*[9]	*Typical RMS*[9]
	OC-192/STM-64 setting:	$< 12\ \mu W_{rms}$	$< 7\ \mu W_{rms}$

Table 12: Optical modules - Acquisition (Cont.)

Name	Characteristics		
Vertical equivalent optical noise (maximum and typical)[8]	20 GHz setting:	$< 20\ \mu W_{rms}$	$< 15\ \mu W_{rms}$
	30 GHz setting:	$< 40\ \mu W_{rms}$[7]	$< 30\ \mu W_{rms}$
	80C05 module	*Maximum RMS*	*Typical RMS*
	OC-192/STM-64 setting:	$< 15\ \mu W_{rms}$	$< 10\ \mu W_{rms}$
	20 GHz setting:	$< 25\ \mu W_{rms}$	$< 15\ \mu W_{rms}$
	30 GHz setting:	$< 35\ \mu W_{rms}$	$< 25\ \mu W_{rms}$
	40 GHz setting:	$< 70\ \mu W_{rms}$[7]	$< 50\ \mu W_{rms}$
	80C06 module	*Maximum RMS*	*Typical RMS*
	50 GHz setting (typical):	$< 192\ \mu W_{rms}$	$< 150\ \mu W_{rms}$
	80C07 module	*Maximum RMS*	*Typical RMS*
	OC-3/STM-1 setting:	$< 1\ \mu W_{rms}$	$< .50\ \mu W_{rms}$
	OC-12/STM-4 setting:	$< 1\ \mu W_{rms}$	$< .50\ \mu W_{rms}$
	OC-48/STM-16 setting:	$< 1.5\ \mu W_{rms}$	$< .70\ \mu W_{rms}$
	80C08 and 80C08B modules (no clock recovery)	*Maximum RMS*[9]	*Typical RMS*[9]
	All settings:	$< 5\ \mu W_{rms}$	$< 2.5\ \mu W_{rms}$
	80C08-CR1, 80C08B-CR1 and 80C08B-CR2 modules (clock recovery)	*Maximum RMS*[9]	*Typical RMS*[9]
	All settings:	$< 5.5\ \mu W_{rms}$	$< 3.0\ \mu W_{rms}$

Table 12: Optical modules - Acquisition (Cont.)

Name	Characteristics		
Vertical equivalent optical noise (maximum and typical)[8]	*80C09 module*	*Maximum RMS[9]*	*Typical RMS[9]*
	OC-192/STM-64 setting:	< 10 μW_{rms}	< 6 μW_{rms}
	FEC 10.71 Gb/s setting:	< 10 μW_{rms}	< 6 μW_{rms}
	20 GHz setting:	< 20 μW_{rms}	< 15 μW_{rms}
	30 GHz setting:	< 30 μW_{rms}[7]	< 20 μW_{rms}
	80C06 module	*Maximum RMS*	*Typical RMS*
	50 GHz setting (typical):	< 192 μW_{rms}	< 150 μW_{rms}
	80C09-CR1 and 80C09-CR2 modules	*Maximum RMS[9]*	*Typical RMS[9]*
	OC-192/STM-64 setting:	< 10 μW_{rms}	< 7 μW_{rms}
	FEC 10.71 Gb/s setting:	< 10 μW_{rms}	< 7 μW_{rms}
	20 GHz setting:	< 20 μW_{rms}	< 15 μW_{rms}
	30 GHz setting:	< 30 μW_{rms}[7]	< 30 μW_{rms}
	80C10 module (no clock recovery)	*Typ/Max 1550 nm*	*Typ/Max 1310 nm*
	OC-768/STM-256 setting:	< 60/75 μW_{rms}	< 110/136 μW_{rms}
	43.02 Gb/s FEC setting:	< 60/75 μW_{rms}	< 110/136 μW_{rms}
	30 GHz setting:	< 45/60 μW_{rms}	< 82/110 μW_{rms}
	65 GHz setting:	< 100/150 μW_{rms}	< 182/273 μW_{rms}

Table 12: Optical modules - Acquisition (Cont.)

<table>
<tr><th>Name</th><th>Characteristics</th></tr>
<tr><td>OC-3/STM-1
155 Mb/s Reference Receiver setting frequency response[7]</td><td>In the 155.52 Mb/s NRZ setting, the scalar frequency response is verified to fall within fourth-order Bessel-Thompson reference receiver boundary limits.

The OC-3/STM-1 nominal scalar frequency response matches the ITU 155.52 Reference Receiver Nominal curve with the following tolerance:
<table>
<tr><td>(MHz)</td><td></td><td>(dB)</td><td></td></tr>
<tr><td>Frequency</td><td>Lower</td><td>Nominal</td><td>Upper</td></tr>
<tr><td>0.000</td><td>-0.50</td><td>0.00</td><td>0.50</td></tr>
<tr><td>23.33</td><td>-0.61</td><td>-0.11</td><td>0.39</td></tr>
<tr><td>46.65</td><td>-0.95</td><td>-0.45</td><td>0.05</td></tr>
<tr><td>69.98</td><td>-1.52</td><td>-1.02</td><td>-0.52</td></tr>
<tr><td>93.30</td><td>-2.36</td><td>-1.86</td><td>-1.36</td></tr>
<tr><td>116.7</td><td>-3.50</td><td>-3.00</td><td>-2.50</td></tr>
<tr><td>140.0</td><td>-5.67</td><td>-4.51</td><td>-3.35</td></tr>
<tr><td>155.5</td><td>-7.25</td><td>-5.71</td><td>-4.17</td></tr>
<tr><td>163.3</td><td>-8.08</td><td>-6.37</td><td>-4.66</td></tr>
<tr><td>186.6</td><td>-10.74</td><td>-8.54</td><td>-6.35</td></tr>
<tr><td>209.9</td><td>-13.55</td><td>-10.93</td><td>-8.31</td></tr>
<tr><td>233.3</td><td>-16.41</td><td>-13.41</td><td>-10.41</td></tr>
</table></td></tr>
<tr><td>OC-12/STM-4
622 Mb/s Reference Receiver setting frequency response[7]</td><td>In the 622.08 Mb/s NRZ setting, the scalar frequency response is verified to fall within fourth-order Bessel-Thompson reference receiver boundary limits.

The OC-12/STM-4 nominal scalar frequency response matches the ITU 622.08 Reference Receiver Nominal curve with the following tolerance:
<table>
<tr><td>(MHz)</td><td></td><td>(dB)</td><td></td></tr>
<tr><td>Frequency</td><td>Lower</td><td>Nominal</td><td>Upper</td></tr>
<tr><td>0.000</td><td>-0.50</td><td>0.00</td><td>0.50</td></tr>
<tr><td>93.3</td><td>-0.61</td><td>-0.11</td><td>0.39</td></tr>
<tr><td>186.6</td><td>-0.95</td><td>-0.45</td><td>0.05</td></tr>
<tr><td>279.9</td><td>-1.52</td><td>-1.02</td><td>-0.52</td></tr>
<tr><td>373.2</td><td>-2.36</td><td>-1.86</td><td>-1.36</td></tr>
<tr><td>466.7</td><td>-3.50</td><td>-3.00</td><td>-2.50</td></tr>
<tr><td>559.9</td><td>-5.67</td><td>-4.51</td><td>-3.35</td></tr>
<tr><td>622.1</td><td>-7.25</td><td>-5.71</td><td>-4.17</td></tr>
<tr><td>653.2</td><td>-8.08</td><td>-6.37</td><td>-4.66</td></tr>
<tr><td>746.5</td><td>-10.74</td><td>-8.54</td><td>-6.35</td></tr>
<tr><td>839.8</td><td>-13.55</td><td>-10.93</td><td>-8.31</td></tr>
<tr><td>933.1</td><td>-16.41</td><td>-13.41</td><td>-10.4</td></tr>
</table></td></tr>
</table>

Table 12: Optical modules - Acquisition (Cont.)

Name	Characteristics
✓ OC48/STM-16 2.488 Gb/s Reference Receiver setting frequency response[7]	Scalar frequency response falls within Industry Standard, Bessel-Thompson reference receiver boundary limits. SONET OC-48/STM-16 frequency response boundary limits are described in ITU-T G.957 Tables I.1 and I.2. For convenience, the scalar frequency response of the output amplitude (for sinusoidal swept optical input) has been interpreted from the Bessel-Thompson transfer function and listed below:

(MHz) Frequency	Lower	(dB) Nominal	Upper
0.000	-0.50	0.00	0.50
373.3	-0.61	-0.11	0.39
746.5	-0.95	-0.45	0.05
1119.7	-1.52	-1.02	-0.52
1493.1	-2.36	-1.86	-1.36
1866.3	-3.50	-3.00	-2.50
2239.5	-5.67	-4.51	-3.35
2488.3	-7.25	-5.71	-4.17
2612.8	-8.08	-6.37	-4.66
2986.0	-10.74	-8.54	-6.35
3359.3	-13.55	-10.93	-8.31
3732.6	-16.41	-13.41	-10.41

Table 12: Optical modules - Acquisition (Cont.)

Name	Characteristics
OC192/STM-64 9.953 Gb/s Reference Receiver setting frequency response[7]	Scalar frequency response falls within Industry Standard, Bessel-Thompson reference receiver boundary limits. Tektronix manufactures and tests the 80C01, 80C02, 80C04, 80C05, 80C08[10], and 80C09 optical modules using 10 Gb reference receivers to have a new superior and tighter tolerance OC192/STM-64 Reference Receiver response. ITU experts recently agreed on the minimum performance specifications for 10 Gbit/s (STM-64/OC-192) optical reference receivers (San Antonio ITU Study Group 15 February 2000). These specifications are used to establish system interoperability and test conformance of optical interfaces to draft ITU-T Recommendation G.691 which is scheduled to be completed in April 200 (see ITU table A.1/G.691 from the WD 16-48 document from Study Group 15 dated February 2000). For convenience, the scalar frequency response of the output amplitude (for sinusoidal swept optical input) has been interpreted from the published Bessel-Thompson transfer function and listed below:

(MHz) Frequency	Lower	(dB) Nominal	Upper
0.000	-0.85	0.00	0.85
1493.2	-0.96	-0.11	0.74
2986.0	-1.30	-0.45	0.40
4478.8	-1.87	-1.02	0.17
5972.4	-2.71	-1.86	-1.01
7465.0	-3.86	-3.00	-2.16
8958.0	-6.19	-4.51	-2.83
9953.28	-7.87	-5.71	-3.55
10451.2	-8.75	-6.37	-3.99
11944.0	-11.53	-8.54	-5.56
13437.2	-14.45	-10.93	-7.41
14930.4	-17.41	-13.41	-9.41

Table 12: Optical modules - Acquisition (Cont.)

<table>
<tr><th>Name</th><th>Characteristics</th></tr>
<tr><td>✓ OC768/STM-256 39.813 Gb/s Reference Receiver setting frequency response[7]</td><td>Bessel-Thompson Scalar Frequency Response curve for margin testing and tolerance at various frequencies; based on +/- 1.00 DC to .75x(data rate) and +/-5.0dB at 1.5x(data rate). NOTE: the table below is a discrete list of some specific values that are commonly listed in ITU standards; this curve and tolerances are actually continuous function.

<table>
<tr><td>(GHz)
Frequency</td><td>
Lower</td><td>(dB)
Nominal</td><td>
Upper</td></tr>
<tr><td>0</td><td>-1.00</td><td>0</td><td>1.00</td></tr>
<tr><td>5.97</td><td>-1.10</td><td>-0.10</td><td>0.90</td></tr>
<tr><td>11.94</td><td>-1.45</td><td>-0.45</td><td>0.55</td></tr>
<tr><td>17.92</td><td>-2.02</td><td>-1.02</td><td>-0.02</td></tr>
<tr><td>23.89</td><td>-2.86</td><td>-1.86</td><td>-0.86</td></tr>
<tr><td>29.86</td><td>-4.00</td><td>-3.00</td><td>-2.00</td></tr>
<tr><td>35.83</td><td>-6.56</td><td>-4.51</td><td>-2.46</td></tr>
<tr><td>39.81</td><td>-8.37</td><td>-5.71</td><td>-3.05</td></tr>
<tr><td>41.80</td><td>-9.31</td><td>-6.37</td><td>-3.43</td></tr>
<tr><td>47.78</td><td>-12.26</td><td>-8.54</td><td>-4.83</td></tr>
<tr><td>53.75</td><td>-15.32</td><td>-10.93</td><td>-6.53</td></tr>
<tr><td>59.72</td><td>-18.41</td><td>-13.41</td><td>-8.41</td></tr>
</table></td></tr>
<tr><td>✓ 10GFC Reference Receiver setting frequency response[7]</td><td>For convenience, the scalar frequency response of the output amplitude (for sinusoidal swept optical input) has been interpreted from the published Bessel-Thompson transfer function for 10.51875 Gb/s Reference Receivers and then listed below:

<table>
<tr><td>(MHz)
Frequency</td><td>
Lower</td><td>(dB)
Nominal</td><td>
Upper</td></tr>
<tr><td>0</td><td>-0.85</td><td>0</td><td>0.85</td></tr>
<tr><td>1578.0</td><td>-0.96</td><td>-0.11</td><td>0.74</td></tr>
<tr><td>3155.6</td><td>-1.30</td><td>-0.45</td><td>0.40</td></tr>
<tr><td>4733.3</td><td>-1.87</td><td>-1.02</td><td>-0.17</td></tr>
<tr><td>6311.7</td><td>-2.71</td><td>-1.86</td><td>-1.01</td></tr>
<tr><td>7889.1</td><td>-3.86</td><td>-3.00</td><td>-2.16</td></tr>
<tr><td>9466.9</td><td>-6.71</td><td>-4.51</td><td>-2.83</td></tr>
<tr><td>10518.8</td><td>-8.70</td><td>-5.71</td><td>-3.55</td></tr>
<tr><td>11045.0</td><td>-9.72</td><td>-6.37</td><td>-3.99</td></tr>
<tr><td>12622.6</td><td>-12.88</td><td>-8.54</td><td>-5.56</td></tr>
<tr><td>14200.6</td><td>-16.14</td><td>-10.93</td><td>-7.41</td></tr>
<tr><td>15778.6</td><td>-19.41</td><td>-13.41</td><td>-9.41</td></tr>
</table></td></tr>
</table>

Table 12: Optical modules - Acquisition (Cont.)

<table>
<tr><th>Name</th><th>Characteristics</th></tr>
<tr><td>✓ 10GBASE-W Reference Receiver setting frequency response[7]</td><td>For convenience, the scalar frequency response of the output amplitude (for sinusoidal swept optical input) has been interpreted from the published Bessel-Thompson transfer function for 10.00000 Gb/s reference receivers (as specified for the 9.95328 Gb/s rate of the 10GBASE-W) and listed below:
<table>
<tr><th>(MHz)
Frequency</th><th>Lower</th><th>(dB)
Nominal</th><th>Upper</th></tr>
<tr><td>0</td><td>-0.85</td><td>0.00</td><td>0.85</td></tr>
<tr><td>1500</td><td>-0.96</td><td>-0.11</td><td>0.74</td></tr>
<tr><td>3000</td><td>-1.30</td><td>-0.45</td><td>0.40</td></tr>
<tr><td>4500</td><td>-1.87</td><td>-1.02</td><td>0.17</td></tr>
<tr><td>6000</td><td>-2.71</td><td>-1.86</td><td>-1.01</td></tr>
<tr><td>7500</td><td>-3.86</td><td>-3.00</td><td>-2.16</td></tr>
<tr><td>9000</td><td>-6.19</td><td>-4.51</td><td>-2.83</td></tr>
<tr><td>10000</td><td>-7.87</td><td>-5.71</td><td>-3.55</td></tr>
<tr><td>10500</td><td>-8.75</td><td>-6.37</td><td>-3.99</td></tr>
<tr><td>12000</td><td>-11.53</td><td>-8.54</td><td>-5.56</td></tr>
<tr><td>13500</td><td>-14.45</td><td>-10.93</td><td>-7.41</td></tr>
<tr><td>15000</td><td>-17.41</td><td>-13.41</td><td>-9.41</td></tr>
</table></td></tr>
<tr><td>✓ 10GBASE-R Reference Receiver setting frequency response[7]</td><td>For convenience, the scalar frequency response of the output amplitude (for sinusoidal swept optical input) has been interpreted from the published Bessel-Thompson transfer function for 10.00000 Gb/s reference receivers (as specified for the 10.3125 Gb/s rate of the 10GBASE-R) and listed below:
<table>
<tr><th>(MHz)
Frequency</th><th>Lower</th><th>(dB)
Nominal</th><th>Upper</th></tr>
<tr><td>0</td><td>-0.85</td><td>0.00</td><td>0.85</td></tr>
<tr><td>1500</td><td>-0.96</td><td>-0.11</td><td>0.74</td></tr>
<tr><td>3000</td><td>-1.30</td><td>-0.45</td><td>0.40</td></tr>
<tr><td>4500</td><td>-1.87</td><td>-1.02</td><td>0.17</td></tr>
<tr><td>6000</td><td>-2.71</td><td>-1.86</td><td>-1.01</td></tr>
<tr><td>7500</td><td>-3.86</td><td>-3.00</td><td>-2.16</td></tr>
<tr><td>9000</td><td>-6.19</td><td>-4.51</td><td>-2.83</td></tr>
<tr><td>10000</td><td>-7.87</td><td>-5.71</td><td>-3.55</td></tr>
<tr><td>10500</td><td>-8.75</td><td>-6.37</td><td>-3.99</td></tr>
<tr><td>12000</td><td>-11.53</td><td>-8.54</td><td>-5.56</td></tr>
<tr><td>13500</td><td>-14.45</td><td>-10.93</td><td>-7.41</td></tr>
<tr><td>15000</td><td>-17.41</td><td>-13.41</td><td>-9.41</td></tr>
</table></td></tr>
</table>

Table 12: Optical modules - Acquisition (Cont.)

Name	Characteristics
✓ FEC 10.66 Gb/s Reference Receiver setting frequency response[7]	This Reference Receiver is essentially identical to that for the OC192 9.95328 Gb/s rate with the following changes: the frequency scale for the tolerance curves and nominal -3dB breakpoints are scaled linearly by the ratio of (10.664 Gb/s)/(9.95328 Gb/s); for example: the 9.953 Gb/s reference receiver has a nominal -3dB response at 0.75*9.95328GHz = 7.465GHz. This 10.66Gb reference receiver has a nominal -3dB response at (10.664/9.95328) x 7.465GHz = 7.998GHz. For convenience, the scalar frequency response of the output amplitude (for sinusoidal swept optical input) has been interpreted from the published Bessel-Thompson transfer function, the frequencies scaled as described above, and then listed below:

(MHz) Frequency	Lower	(dB) Nominal	Upper
0	-0.85	0	0.85
1599.8	-0.96	-0.11	0.74
3199.2	-1.30	-0.45	0.40
4798.6	-1.87	-1.02	-0.17
6398.9	-2.71	-1.86	-1.01
7998.0	-3.86	-3.00	-2.16
9597.7	-6.19	-4.51	-2.83
10664.0	-7.87	-5.71	-3.55
11197.5	-8.75	-6.37	-3.99
12796.9	-11.53	-8.54	-5.56
14396.7	-14.45	-10.93	-7.41
15996.5	-17.41	-13.41	-9.41

Table 12: Optical modules - Acquisition (Cont.)

<table>
<tr><th>Name</th><th>Characteristics</th></tr>
<tr><td>✓ FEC 10.71 Gb Reference Receiver setting frequency response[7]</td><td>
This Reference Receiver is essentially identical to that for the OC192 9.95328 Gb/s rate with the following changes: the frequency scale for the tolerance curves and nominal -3dB breakpoints are scaled linearly by the ratio of (10.709 Gb/s)/(9.95328 Gb/s); for example: the 9.953 Gb/s reference receiver has a nominal -3dB response at 0.75*9.95328GHz = 7.465GHz. This 10.71 Gb reference receiver has a nominal -3dB response at (10.709/9.95328) x 7.465GHz = 8.032GHz.
For convenience, the scalar frequency response of the output amplitude (for sinusoidal swept optical input) has been interpreted from the published Bessel-Thompson transfer function, the frequencies scaled as described above, and then listed below:
<table>
<tr><th>(MHz)
Frequency</th><th>Lower</th><th>(dB)
Nominal</th><th>Upper</th></tr>
<tr><td>0</td><td>-0.85</td><td>0</td><td>0.85</td></tr>
<tr><td>1606.6</td><td>-0.96</td><td>-0.11</td><td>0.74</td></tr>
<tr><td>3212.8</td><td>-1.30</td><td>-0.45</td><td>0.40</td></tr>
<tr><td>4819.0</td><td>-1.87</td><td>-1.02</td><td>-0.17</td></tr>
<tr><td>6426.0</td><td>-2.71</td><td>-1.86</td><td>-1.01</td></tr>
<tr><td>8032.0</td><td>-3.86</td><td>-3.00</td><td>-2.16</td></tr>
<tr><td>9638.4</td><td>-6.19</td><td>-4.51</td><td>-2.83</td></tr>
<tr><td>10709.2</td><td>-7.87</td><td>-5.71</td><td>-3.55</td></tr>
<tr><td>11245.0</td><td>-8.75</td><td>-6.37</td><td>-3.99</td></tr>
<tr><td>12851.1</td><td>-11.53</td><td>-8.54</td><td>-5.56</td></tr>
<tr><td>14457.7</td><td>-14.45</td><td>-10.93</td><td>-7.41</td></tr>
<tr><td>16064.4</td><td>-17.41</td><td>-13.41</td><td>-9.41</td></tr>
</table>
</td></tr>
<tr><td>✓ FEC 43.02 Gb/s Reference Receiver setting frequency response[7]</td><td>
The forward error correction method defined in ITU-T standard G.709 creates an additional overhead upon a standard OC768 (STM256) 40 Gb/s data stream in which the data rate is effectively increased by a ratio of 255/236. Table 7-1 in G.709 standard lists this explicit serial data rate on the physical layer.
<table>
<tr><th>(GHz)
Frequency</th><th>Lower</th><th>(dB)
Nominal</th><th>Upper</th></tr>
<tr><td>0</td><td>-1.00</td><td>0</td><td>1.00</td></tr>
<tr><td>6.45</td><td>-1.10</td><td>-0.10</td><td>0.90</td></tr>
<tr><td>12.90</td><td>-1.45</td><td>-0.45</td><td>0.55</td></tr>
<tr><td>19.36</td><td>-2.02</td><td>-1.02</td><td>-0.02</td></tr>
<tr><td>25.81</td><td>-2.86</td><td>-1.86</td><td>-0.86</td></tr>
<tr><td>32.26</td><td>-4.00</td><td>-3.00</td><td>-2.00</td></tr>
<tr><td>38.71</td><td>-6.56</td><td>-4.51</td><td>-2.46</td></tr>
<tr><td>43.02</td><td>-8.37</td><td>-5.71</td><td>-3.05</td></tr>
<tr><td>45.17</td><td>-9.31</td><td>-6.37</td><td>-3.43</td></tr>
<tr><td>51.63</td><td>-12.26</td><td>-8.54</td><td>-4.83</td></tr>
<tr><td>58.08</td><td>-15.32</td><td>-10.93</td><td>-6.53</td></tr>
<tr><td>64.53</td><td>-18.41</td><td>-13.41</td><td>-8.41</td></tr>
</table>
</td></tr>
</table>

Table 12: Optical modules - Acquisition (Cont.)

<table>
<tr><th>Name</th><th>Characteristics</th></tr>
<tr><td>✓ 2.50 Gb/s (2X GBE) Reference Receiver setting frequency response[7]</td><td>Scalar frequency response falls within Industry Standard, Bessel-Thompson reference receiver boundary limits.

2.50 Gb/s frequency response boundary limits are derived by simply scaling all frequency values by 2X as described in IEEE 802.3z section 38.6.5 (this section refers to ITU G.957 for tolerances). For convenience, the scalar frequency response of the output amplitude (for sinusoidal swept optical input) has been interpreted from the Bessel-Thompson transfer function and listed below:

<table>
<tr><td>(MHz)</td><td></td><td>(dB)</td><td></td></tr>
<tr><td>Frequency</td><td>Lower</td><td>Nominal</td><td>upper</td></tr>
<tr><td>0.000</td><td>-0.50</td><td>0.00</td><td>0.50</td></tr>
<tr><td>375</td><td>-0.61</td><td>-0.11</td><td>0.39</td></tr>
<tr><td>750</td><td>-0.95</td><td>-0.45</td><td>0.05</td></tr>
<tr><td>1125</td><td>-1.52</td><td>-1.02</td><td>-0.52</td></tr>
<tr><td>1500</td><td>-2.36</td><td>-1.86</td><td>-1.36</td></tr>
<tr><td>1875</td><td>-3.50</td><td>-3.00</td><td>-2.50</td></tr>
<tr><td>2250</td><td>-5.67</td><td>-4.51</td><td>-3.35</td></tr>
<tr><td>2500</td><td>-7.25</td><td>-5.71</td><td>-4.17</td></tr>
<tr><td>2625</td><td>-8.08</td><td>-6.37</td><td>-4.66</td></tr>
<tr><td>3000</td><td>-10.74</td><td>-8.54</td><td>-6.35</td></tr>
<tr><td>3375</td><td>-13.55</td><td>-10.93</td><td>-8.31</td></tr>
<tr><td>3750</td><td>-16.41</td><td>-13.41</td><td>-10.41</td></tr>
<tr><td>5000</td><td>-26.11</td><td>-21.45</td><td>-16.78</td></tr>
</table></td></tr>
<tr><td>✓ GBE (1.25 Gb/s) Reference Receiver setting frequency response[7]</td><td>Scalar frequency response falls within Industry Standard, Bessel-Thompson reference receiver boundary limits.

1.250 Gb/s frequency response boundary limits are described in IEEE 802.3z section 38.6.5 (this section refers to ITU G.957 for tolerances). For convenience, the scalar frequency response of the output amplitude (for sinusoidal swept optical input) has been interpreted from the Bessel-Thompson transfer function and listed below:

<table>
<tr><td>(MHz)</td><td></td><td>(dB)</td><td></td></tr>
<tr><td>Frequency</td><td>Lower</td><td>Nominal</td><td>Upper</td></tr>
<tr><td>0.000</td><td>-0.50</td><td>0.00</td><td>0.50</td></tr>
<tr><td>187.5</td><td>-0.61</td><td>-0.11</td><td>0.39</td></tr>
<tr><td>375</td><td>-0.95</td><td>-0.45</td><td>0.05</td></tr>
<tr><td>562.5</td><td>-1.52</td><td>-1.02</td><td>-0.52</td></tr>
<tr><td>750</td><td>-2.36</td><td>-1.86</td><td>-1.36</td></tr>
<tr><td>937.5</td><td>-3.50</td><td>-3.00</td><td>-2.50</td></tr>
<tr><td>1125</td><td>-5.67</td><td>-4.51</td><td>-3.35</td></tr>
<tr><td>1250</td><td>-7.25</td><td>-5.71</td><td>-4.17</td></tr>
<tr><td>1312.5</td><td>-8.08</td><td>-6.37</td><td>-4.66</td></tr>
<tr><td>1500</td><td>-10.74</td><td>-8.54</td><td>-6.35</td></tr>
<tr><td>1687.5</td><td>-13.55</td><td>-10.93</td><td>-8.31</td></tr>
<tr><td>1875</td><td>-16.41</td><td>-13.41</td><td>-10.41</td></tr>
<tr><td>2500</td><td>-26.11</td><td>-21.45</td><td>-16.78</td></tr>
</table></td></tr>
</table>

Table 12: Optical modules - Acquisition (Cont.)

Name	Characteristics
FC1063 (1.0625 Gb/s) Reference Receiver setting frequency response[7]	Scalar frequency response falls within Industry Standard, Bessel-Thompson reference receiver boundary limits. Fiber Channel frequency response boundary limits are described in ANSI FC-PC. For convenience, the scalar frequency response of the output amplitude (for sinusoidal swept optical input) has been interpreted from the Bessel-Thompson transfer function and listed below:

(MHz) Frequency	Lower	(dB) Nominal	Upper
0.000	-0.50	0.00	0.50
159.5	-0.61	-0.11	0.39
318.9	-0.95	-0.45	0.05
478.4	-1.52	-1.02	-0.52
637.9	-2.36	-1.86	-1.36
797.4	-3.50	-3.00	-2.50
956.8	-5.67	-4.51	-3.35
1063	-7.25	-5.71	-4.17
1116	-8.08	-6.37	-4.66
1275	-10.74	-8.54	-6.35
1435	-13.55	-10.93	-8.31
1595	-16.41	-13.41	-10.41
2126	-26.11	-21.45	-16.78

1 **Single-mode fiber (Corning SMF-28 specs).**

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

3 **The optical wavelengths that the product accepts and still provides a reasonable (25% of peak optimum) wavelength conversion gain.**

4 **Vertical accuracy specifications are referenced to an internal optical power meter reading for a given optical input, and limited to a temperature range within ±5° C of previous channel compensation and an ambient temperature within 20° C to 35° C.**

5 **Optical bandwidth is the frequency at which the responsivity of the optical to electrical conversion process is reduced by 50% (6 dB).**

6 **Optical bandwidth of the 50 GHz module is defined as (0.48/risetime).**

7 **This specification is limited to the instrument operating in an ambient temperature between +20° C and +30° C. Nominal freq response is specified for optical input signals of modulation magnitude such that 2mW$_{pp}$ (200 uW$_{pp}$ for 80C03 and 80C07; 500 uW$_{pp}$ for 80C08) or less signal is applied at the sampler input.**

8 **The optical channel noise with no optical noise input (Dark Level).**

9 **Clock recovery versions reduce the power reaching the vertical channel (splitter to clock recovery produces loss). Therefore, the non-clock recovery modules more closely exhibit the typical noise performance.**

10 **The factory calibration and verification of these tolerances are performed in a stable ambient environment of +25° C +/- 2° C. The module is specified to perform within these tolerances over an operating temperature range of +20° C and +30° C.**

11 **Certain performance characteristics such as reference receiver and filter settings may have more restricted power levels in order to maintain guaranteed performance.**

Table 13: Optical Power Meter

Name	Characteristics
Optical power meter range	80C01, 80C02, 80C03, 80C04, 80C07, and 80C09: +4 dBm to -30 dBm, typical
	80C05 and 80C10: +13 dBm to -21 dBm, typical
	80C06: +13 dBm to -21 dBm, typical
	80C08 and 80C08B: +0 dBm to -30 dBm, typical

Table 14: Optical modules - Clock recovery options (CR, CR1, and CR2)

Name	Characteristics	
Effective wavelength range (clock recovery path)	*Module*	*Range*
	80C01	1270 nm to 1600 nm
	80C02	1270 nm to 1600 nm
	80C03, 80C07, and 80C08, and 80C08B	700 nm to 1650 nm
Effective wavelength range (clock recovery path)	80C04 and 80C09	1270 nm to 1600 nm

Table 14: Optical modules - Clock recovery options (CR, CR1, and CR2) (Cont.)

Name	Characteristics	
Operating data rates[5]	80C01-CR:	622.08 Mb/s ±1000 ppm (OC-12/STM-4) 2.48832 Gb/s ±1000 ppm (OC-48/STM-16)
	80C02-CR:	9.95328 Gb/s ±1000 ppm (OC-192/STM-64)
	80C03-CR:	1.0625 Gb/s ±1000 ppm (FC1063) 1.2500 Gb/s ±1000 ppm (GBE) 2.48832 Gb/s ±1000 ppm (OC-48/STM-16) 2.5000 Gb/s ±1000 ppm (2X GBE)
	80C04-CR1:	9.95328 Gb/s ±1000 ppm (OC-192/STM-64)
	80C04-CR2:	9.95328 Gb/s ±1000 ppm (OC-192/STM-64) 10.664 Gb/s ±1000 ppm (OC-192 FEC)
	80C07-CR1:	155.52 Mb/s ±1000 ppm (OC-3/STM-1) 622.08 Mb/s ±1000 ppm (OC-12/STM-4) 2488.32 Mb/s ±1000 ppm (OC-48/STM-16)
	80C08-CR1:	9.95328 Gb/s ±1000 ppm (10GBASE-W) 10.3125 Gb/s ±1000 ppm (10GBASE-R)
	80C08B-CR1:	9.95328 Gb/s ±1000 ppm (10GBASE-W) 10.3125 Gb/s ±1000 ppm (10GBASE-R)
	80C08B-CR2:	10.3125 Gb/s ±1000 ppm (10GBASE-R) 10.51875 Gb/s ±1000 ppm (10GFC)
	80C09-CR1:	9.95328 Gb/s ±1000 ppm (OC-192/STM-64) 10.709 Gb/s ±1000 ppm (FEC)
	For the 80C02-CR and 80C04-CR1 modules, the incoming data stream must be of non-return-to-zero format (NRZ) and must have a data sequence content which provides both isolated 1s and multi-consecutive mark sequences (that is 2,3,4 and so forth logical 1s in a consecutive row). NOTE: a fixed pattern of 10101010. . . does not meet the data sequence content:. The 80C02-CR and 80C04-CR1 clock recovery function**s** may not properly lock to such a pattern. The 80C02-CR and 80C04-CR1 will, however, typically lock to a 11001100. . . pattern (this is equivalent to a 2.48832 GHz optical square wave).[5]	

Table 14: Optical modules - Clock recovery options (CR, CR1, and CR2) (Cont.)

Name	Characteristics		
Optical sensitivity range, clock recovery (optical input power)[1]	Module	Maximum	Minimum
	80C01	+ 5.0 dBm (3.16 mW), typical	-10.0 dBm (100 μW), typical
	80C02	+7 dBm (5.0 mW), typical	-10.0 dBm (100 μW), typical -7.5 dBm, warranted
	80C03	-4.0 dBm (400 μW), warranted	-16.0 dBm (25 μW), warranted
	80C04	+7 dBm (5.0 mW), typical	-10.0 dBm (100 μW), typical -7.5 dBm, warranted
	80C07	-4.0 dBm (400 μW), warranted	-16.0 dBm (25 μW), warranted
	80C08	+0.0 dBm (1.0 mW, all wavelengths), warranted	-13.0 dBm (50 μW, 1310 nm, 1550 nm), warranted -15.0 dBm (32 μW, 1310 nm, 1550 nm), typical -12.0 dBm (64 μW, 780 nm, 850 nm), typical
	80C08B	+0.0 dBm (1.0 mW, all wavelengths), warranted	-13.0 dBm (50 μW, 1310 nm, 1550 nm), warranted -15.0 dBm (32 μW, 1310 nm, 1550 nm), typical -12.0 dBm (64 μW, 780 nm, 850 nm), typical
	80C09	+7 dBm (5.0 mW), typical	-10.0 dBm (100 μW), typical -7.5 dBm, warranted
Clock and data electrical output amplitudes[2]	80C01:		> 300 mV_{pp}, typical
	80C02:	Serial DATA output:	> 700 mV_{pp}, typical
		Serial CLOCK output:	1.5 V_{pp}, typical
		1/16th CLOCK output:	600 mV_{pp}, typical
	80C03:	Serial DATA output:	> 350 mV_{pp}, typical
		Serial CLOCK output:	> 350 mV_{pp}, typical
	80C04-CR1:	Serial DATA output:	> 700 mV_{pp}, typical
		Serial CLOCK output:	1.5 V_{pp}, typical
		1/16th CLOCK output:	600 mV_{pp}, typical
	80C04-CR2:	Serial CLOCK output:	1.5 V_{pp}, typical
		1/16th CLOCK output:	600 mV_{pp}, typical
	80C07:	Serial CLOCK output:	450 mV_{pp}, typical
		Serial DATA output:	450 mV_{pp}, typical
	80C08:	Serial CLOCK output:	1.0 V_{pp}, typical
		1/16th CLOCK output:	600 mV_{pp}, typical
	80C08B:	Serial CLOCK output:	1.0 V_{pp}, typical
		1/16th CLOCK output:	600 mV_{pp}, typical
	80C09:	Serial CLOCK output:	1.5 V_{pp}, typical
		1/16th CLOCK output:	600 mV_{pp}, typical

Table 14: Optical modules - Clock recovery options (CR, CR1, and CR2) (Cont.)

Name	Characteristics
Clock and data rise time and fall times[2]	80C01: Serial DATA output: < 30 ps Serial CLOCK output: < 30 ps 80C02: Serial DATA output: < 30 ps Serial CLOCK output: < 30 ps 1/16th CLOCK output: < 300 ps 80C03: Serial DATA output: < 30 ps Serial CLOCK output: < 30 ps 80C04: Serial DATA output: < 30 ps Serial CLOCK output: < 30 ps 1/16th CLOCK output: < 300 ps 80C04-CR2: Serial CLOCK output: < 30 ps 1/16th CLOCK output: < 300 ps 80C07: Serial DATA output: < 30 ps Serial CLOCK output: < 30 ps 80C08: Serial CLOCK output: < 30 ps 1/16th CLOCK output: < 300 ps 80C08B: Serial CLOCK output: < 30 ps 1/16th CLOCK output: < 300 ps 80C09: Serial CLOCK output: < 30 ps 1/16th CLOCK output: < 300 ps
Jitter Transfer Bandwidth[5]	80C04-CR2, 80C08, 80C08B, 80C09: 4 MHz maximum
	80C09: 3.5 MHz typical
✓Recovered clock timing jitter[3, 4]	80C01: < 8.0 ps RMS maximum < 4.0 ps RMS typical
	80C02: < 2.0 ps RMS maximum < 1.0 ps RMS typical[6]
	80C03: < 8.0 ps RMS maximum < 4.0 ps RMS typical
	80C04: < 2.0 ps RMS maximum < 1.0 ps RMS typical[6]
	OC-3 setting 80C07: < 32.0 ps RMS maximum < 12.0 ps RMS typical[6] OC-12 setting 80C07: < 8.0 ps RMS maximum < 4.0 ps RMS typical[6] OC-48 setting 80C07: < 4.0 ps RMS maximum < 2.2 ps RMS typical[6]
	80C08: < 2.0 ps RMS maximum < 1.0 ps RMS typical[6]
	80C08B: < 2.0 ps RMS maximum < 1.0 ps RMS typical[6]
	80C09: < 2.0 ps RMS maximum < 1.0 ps RMS typical[6]

Table 14: Optical modules - Clock recovery options (CR, CR1, and CR2) (Cont.)

Name	Characteristics
Optical power meter accuracy, typical	5% of reading + connector uncertainty for either 780 nm (80C03 80C07, and 80C08), 850 nm (80C03, 80C07, and 80C08), 1310 nm, or 1550 nm ±20 nm, typical

[1] **These powers are the average optical input coupled into the external Optical Sampling Module optical input connector. The range is defined for recovered clock, a 50% duty cycle of the incoming NRZ data (also referred to as 50% mark density), a PRBS pattern of 2^{23-1}, and an extinction ratio of ≥ 8.2 dB (at eye center).**

[2] **Output is 50 Ω AC coupled: specification is for output amplitude at the bulkhead outputs and does not include RF loss of attached cables.**

[3] **The clock jitter is applicable to both the external electrical output and the system jitter experienced when the recovered clock is the source of the waveform trigger for the system.**

[4] **Jitter performance of the system while using the optical module clock recovery as the trigger source is warranted only while no active signal is applied to the main instrument's External Trigger (or Prescaler) input.**

[5] **The acceptable signal types and patterns for the specified modules are:**

Module	NRZ	RZ	1010 . . .
80C02-CR and 80C04-CR1	Y	N	N
80C03-CR and 80C07-CR	Y	N	Y
80C04-CR2, 80C08-CR1, 80C08B-CR1, 80C08B-CR2, and 80C09-CR1	Y	Y	Y

[6] **Internal use for trigger results in a total system jitter of**

$$\geq \sqrt{sum\ of\ squares}$$

therefore the displayed waveform may normally exhibit something like SQRT(main-frame_jitter)^2 + (OCR_jitter)^2).

Table 15: Optical modules - Mechanical

Name	Characteristics
Construction material	Chassis parts constructed of aluminum alloy; front panel constructed of plastic laminate; circuit boards constructed of glass-laminate. Cabinet is aluminum.
Weight	80C01: 1.13 kg (2.5 lbs) 80C01-CR: 1.34 kg (2.95 lbs) 80C02: 0.95 kg (2.1 lbs) 80C02-CR: 1.22 kg (2.70 lbs) 80C03: 1.13 kg (2.5 lbs) 80C03-CR: 1.34 kg (2.95 lbs) 80C04: 0.95 kg (2.1 lbs) 80C04-CR1: 1.22 kg (2.70 lbs) 80C04-CR2: 1.22 kg (2.70 lbs) 80C05: 0.95 kg (2.1 lbs) 80C06: 0.95 kg (2.1 lbs) 80C07: 1.13 kg (2.5 lbs) 80C07-CR1: 1.34 kg (2.95 lbs) 80C08: .95 kg (2.1 lbs) 80C08B: .95 kg (2.1 lbs) 80C08-CR1: 1.22 kg (2.70 lbs) 80C08B-CR1: 1.22 kg (2.70 lbs) 80C08B-CR2: 1.22 kg (2.70 lbs) 80C09: .95 kg (2.1 lbs) 80C09-CR1: 1.22 kg (2.70 lbs) 80C10: .95 kg (2.1 lbs)
Overall dimensions	Height: 25.6 mm (1.0 in) Width: 166.7 mm (6.5 in) Depth: 307.7 mm (12.0 in)

Table 16: Optical modules - Environmental

Name	Characteristics
Temperature	Installed and operating: +10° C to +40° C Reference receivers frequency response tolerances, 30 GHz mode, and Optical power meter accuracy: +20° C to +30° C Installed and non-operating: -22° C to +60° C
Humidity	Installed and operating: 20% to 80% relative humidity with a maximum wet bulb temperature of 29° C at or below +40° C, (upper limit derates to 45% relative humidity at +40° C) non-condensing. Reference receivers frequency response tolerances: +20° C to +30° C Optical power meter accuracy: +20° C (80% RH) to +30° C (80% RH) Installed and non-operating: 5% to 90% relative humidity with a maximum wet bulb temperature of 29° C at or below +60° C, (upper limit derates to 20% relative humidity at +60° C) non-condensing.
Altitude: installed	Operating: 3,048 m (10,000 feet). Non-operating: 12,190 m (40,000 feet)

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.

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 *Optical Bandwidth* on page 23.

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 instrument mainframe is always mainframe 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:

$$dB = 20\log\left(\frac{Vi}{Vl}\right) \qquad \textit{for optical,} \quad dB = 10\log\left(\frac{Po}{Pi}\right)$$

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, P_i is the power in, and log is the decimal-based logarithmic function. See *Optical Bandwidth* on page 23.

dBm

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

$$dBm = 10\ \log\left(\frac{optical\ power}{1\ mW}\right)$$

Degradation

A deterioration in a signal or system.

Differential Mode

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

Digital signal

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

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.

Digital transmission system

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

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. It's very much like resistance to a DC signal in a DC circuit. Impedance is made up of resistance and 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.

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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