CT440

Passive Optical Component Tester

www.EXFO.com

Copyright

EXFO's Commerce And Government Entities (CAGE) code under the North Atlantic Treaty Organization (NATO) is 0L8C3.

The information contained in this publication is subject to change without notice.

Trademarks

EXFO's trademarks have been identified as such. However, the presence or absence of such identification does not affect the legal status of any trademark.

Units of Measurement

Units of measurement in this publication conform to SI standards and practices.

Version number: 1.0.0.1

Information in this document applies to the CT440 GUI software version 1.2.x
(with DSP version 2.00).

Contents

Regulatory Information

Canada and USA Electromagnetic Interference Regulatory Statement

Electronic test and measurement equipment is exempt from FCC part 15, subpart B compliance in the United States of America and from ICES-003 compliance in Canada. However, EXFO Inc. makes reasonable efforts to ensure compliance to the applicable standards.

The limits set by these standards are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the user documentation, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

European Electromagnetic Compatibility Regulatory Statement

Warning: This is a class A product. In a domestic environment, this product may cause radio interference in which case the user may be required to take adequate measures. Your product is compliant with industrial electromagnetic environments.

European Declaration of Conformity

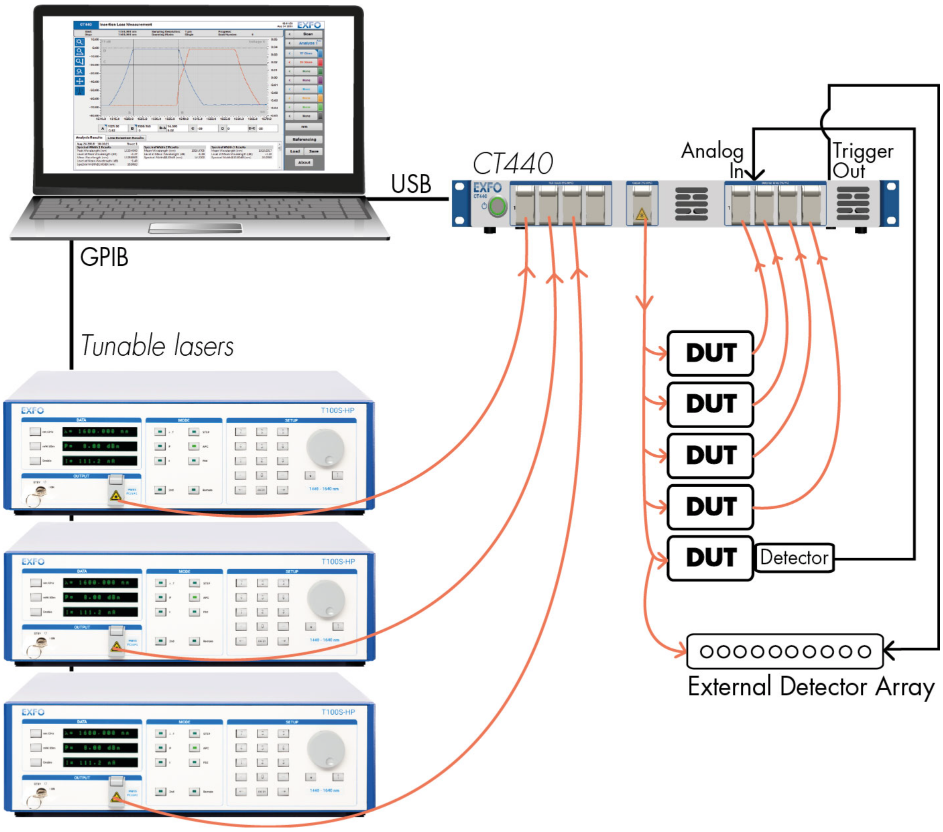
The full text of the EU declaration of conformity is available at the following Internet address: *www.exfo.com/en/resources/legal-documentation*.

1 Introducing the CT440

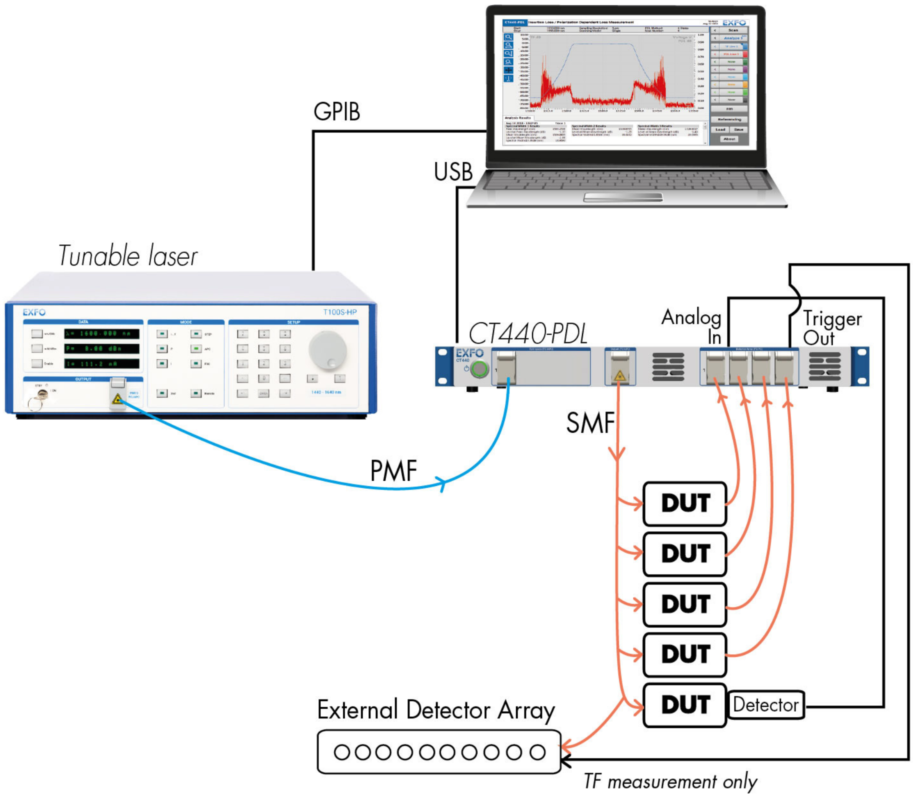
Product Features

The CT440 is a compact instrument designed for spectral characterization of passive optical components by synchronous optical power detection using one or more sweeping laser source(s). It covers the specified transmission band in one run.

The CT440 provides the transmission function (TF) of the device under test (DUT) with the help of one or more sweeping laser sources.
It identifies and switches, from one port to the next, the available laser sources to go through a common output port in order to use a multi TLS source as a unique (usually very wide band) source.



On CT440 with PDL option, the CT440 uses a multiple sweep Mueller method to calculate the transfer function (TF) and the polarization dependent loss (PDL) of the device under test (DUT). The technique relies on collecting spectral data for each of either 4 or 6 polarization state conditions (one sweep by state), before calculating both TF and PDL.



One to four optical detectors enable the CT440 to provide the direct TF and PDL (if available) of the DUT.

The electrical input detector **Analog In** BNC port can also make these measurements, and the synchronization signal coming out of the **Trigger Out** BNC port allows TF measurement on remote detectors (not PDL).

The CT440 is provided with a control software (GUI) that you can install on a computer.

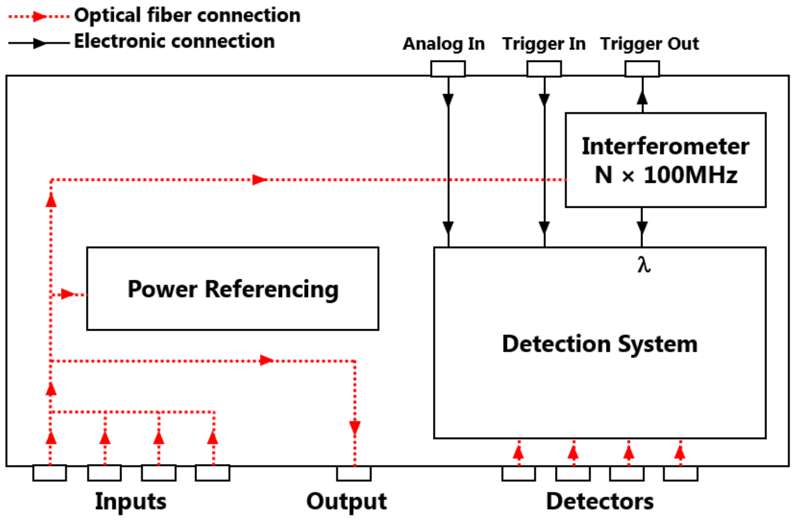
Earlier versions of CT440

EXFO has modified the external design of the CT440. The following figure displays the previous models of CT440 and CT440-PDL.

If you have a previous model of the CT440 or CT440-PDL, you can still download the last version of the GUI software and library, which are fully compatible with all hardware versions of CT440.

You can use the instructions related to the use of the CT440 GUI and CT440 library given in the present *CT440 User Guide*; they apply to the last version of the software whatever the CT440 hardware version.

Measurement Principle



Input and Output

➤ **TLS Input(s)**

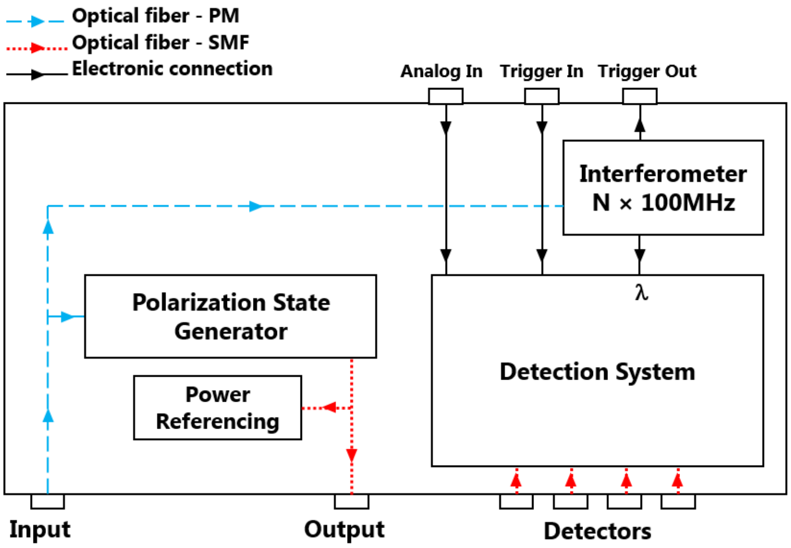
The TLS input(s) of the CT440 includes an interferometric system generating a detection trigger, which provides high wavelength accuracy and removes the need for electrical triggering of the instrument.

The free-spectral range (FSR) of this interferometric system is about 100 MHz, which translates, into the wavelength domain, to a spacing of 0.55 pm at 1260 nm and 0.75 pm at 1550 nm.

➤ **Power Referencing System**

The power referencing system ensures continuous monitoring of the laser power fluctuations during a scan.

➤ **Polarization State Generator (only on CT440 with PDL option)**



On CT440 with PDL option, the signal passes through a polarization state generator (PSG) that produces one of 6 states of polarization at the output port.

Data Acquisition: Raw and Resampled Data

The interferometric system triggers data acquisition every 100 MHz. As a result, the separation between data points is not equidistant in the wavelength domain.

This raw data acquisition is then resampled by software to display the spectrum in nanometer, with the correct sampling resolution in picometer.

➤ On CT440 without PDL option, the graphical user interface (GUI) provided with the instrument enables you to calculate the TF using these resampled data points or raw data (see *Configuring Scan Parameters* on page 35).

➤ On CT440 with PDL option, the graphical user interface (GUI) provided with the instrument calculates the TF and PDL using the resampled data points, not the raw data. In this case, you cannot access raw data through the GUI but you can overcome this limitation and access raw data information by using the Dynamic Link Library (DLL), but it is highly recommended to use resampled data for the PDL calculation.

Detection System

One to four optical detectors enable the CT440 to provide the direct TF and PDL (if available) of the DUT with up to four outputs.

- The additional electrical input port (**Analog In** BNC at the rear of the instrument) can be used either as an additional external detector to perform the same TF and PDL (if available) measurement, or to obtain the spectral dependence of an electrical signal in Volt.

  For more details on this port, see *Performing a Measurement Using the Analog In BNC Connector* on page 47.

- To allow synchronized signal detection from remote detectors, the CT440 also provide an electrical output trigger (**Trigger Out** BNC at the rear of the instrument). The sequence of these TTL pulses depends on the sampling resolution set via software: if a resolution of *n* pm is selected, then a trigger pulse over *n* raw data pulses comes out of the CT440.

  For more details on this port, see *Synchronizing the CT440 with External Measurements* on page 44.

- You can control the CT440 with a trigger signal using the **Trigger In** BNC input port at the rear of the instrument.

  For more details on this port, see *Setting up a Triggered Scan* on page 42.

TLS Requirements

The CT440 is expected to work with TLS sweeping sources having the following performances:

- No mode hops during the wavelength scan

  Few mode hops may appear during the scan, they will be identified if less than one mode hop appears every 1 nm. A correction is then applied and the incidence on the results will concern less than 1 nm around the mode hop position.

- Single mode behavior

  The internal wavelength referencing uses an interferometer device which may be highly sensitive to multimoding. This multimoding will normally be detected in most cases and a warning will be issued.

- 200 pm precision on the definition of the starting wavelength

  The initial wavelength of the scan should be known at 200 pm. In case of more detuning, the whole wavelength referencing could be shifted by exactly 100 GHz. Nevertheless, the relative accuracy is not directly affected by that shift.

- Speed between 10 nm/s and 100 nm/s

  For sweep speed under 10 nm/s, an inaccuracy may appear on the wavelength value in the area of this low speed and an error message may be displayed. This may occur on the acceleration and deceleration phases of the sweep. Moreover, negative sweep during the scan may affect the wavelength scale by a 100 GHz global shift if it leads to a wavelength drift of more than 200 pm.

- Scan span > 5 nm

  The scan span is important for the absolute and relative accuracy. The largest span leads to the most accurate results (the specifications are for a 100 nm span).

  Below 5 nm, the precision cannot be guaranteed and a warning message is issued to prevent such running condition.

- Input power between 1 mW and 10 mW

  The input power of the source is mostly important for the wavelength referencing. An excessively low input power should be detected but if it affects too much the wavelength referencing, the warning message on the input power will be replaced by an error message on the referencing.

The CT440 checks most of these behaviors and issues a warning in non standard running configurations.

Supported TLS

- TUNICS Plus
- TUNICS Purity
- TUNICS Reference
- TUNICS T100S
- T100S-HP
- TUNICS T100R
- VIAVI SWS
- Agilent

Technical Specifications

IMPORTANT

The following technical specifications can change without notice. The information presented in this section is provided as a reference only. To obtain this product's most recent technical specifications, visit the EXFO Web site at *www.exfo.com*.

Measurement Specifications

<table>
<tr><th colspan="2"></th><th>SMF</th><th>PM13</th><th>PM15</th><th>PDL-O</th><th>PDL-SCL</th></tr>
<tr><td colspan="7">Wavelength</td></tr>
<tr><td colspan="2">Operating wavelength range</td><td>1240–1680 nm</td><td>1260–1360 nm</td><td>1440–1640 nm</td><td>1260–1360 nm</td><td>1440–1640 nm</td></tr>
<tr><td rowspan="2">Wavelength accuracy</td><td>Absolute[a, b]</td><td colspan="5">±5 pm</td></tr>
<tr><td>Relative[a]</td><td colspan="3">±1 pm</td><td colspan="2">±5 pm</td></tr>
<tr><td colspan="7">Optical Power</td></tr>
<tr><td rowspan="2">Power range</td><td>On TLS input</td><td colspan="5">0 to 10 dBm</td></tr>
<tr><td>On detector ports</td><td colspan="5">-60 dBm to 7 dBm</td></tr>
<tr><td rowspan="3">Transfer function</td><td>Accuracy[c, d]</td><td colspan="5">±0.2 dB</td></tr>
<tr><td>Sampling resolution</td><td colspan="5">0.02 dB</td></tr>
<tr><td>Dynamic range[d, e]</td><td>65 dB typ. for 1 or 2 TLS inputs
60 dB typ. for 3 or 4 TLS inputs</td><td colspan="4">65 dB typical</td></tr>
<tr><td rowspan="3">Polarization Dependent Loss
(PDL)</td><td>Accuracy[f]</td><td>n/a</td><td>n/a</td><td>n/a</td><td colspan="2">±0.05 dB + 4% PDL</td></tr>
<tr><td>Measurement Range[g]</td><td>n/a</td><td>n/a</td><td>n/a</td><td colspan="2">0 to 20 dB</td></tr>
<tr><td>Repeatability</td><td>n/a</td><td>n/a</td><td>n/a</td><td colspan="2">±0.05 dB</td></tr>
<tr><td colspan="7">Sampling Characteristics</td></tr>
<tr><td colspan="2">Resolution</td><td colspan="3">1 to 250 pm</td><td colspan="2">5 to 250 pm</td></tr>
<tr><td colspan="2">Native sampling resolution</td><td colspan="5">N x 100±10 MHz (N=1 to 250)</td></tr>
<tr><td colspan="2">Compatible sweep speed of TLS</td><td colspan="5">From 10 to 100 nm/s</td></tr>
<tr><td colspan="2">Maximum number of transfer function data points per TLS per detector as a function of number of activated detectors by software[h]</td><td colspan="5">260,000 for 1 detector
219,500 for 2 detectors
164,400 for 3 detectors
131,100 for 4 detectors
110,500 for 5 detectors</td></tr>
</table>

a. For a TLS sweep > 5 nm at sampling resolution of 5 pm for PDL-O and PDL-SCL and 1 pm otherwise, excluding the acceleration and deceleration part of the TLS sweep.
b. After wavelength referencing.
c. For incident power on detectors > -30 dBm. Accuracy: ±0.5 dB for power between -30 dBm and -60 dBm.
d. 1260 to 1640 nm.
e. If laser output power = 10 mW (dynamic range is proportional to laser output power).
f. For incident power on detectors > -30 dBm and determined from a 6-states measurement at 5 pm resolution.
g. Stable testing conditions, 6-states recommended for high PDL measurement.
h. Selected frequency range of the laser divided by the native sampling resolution.

Interfaces & Electrical Specifications

		SMF	PM13	PM15	PDL-O	PDL-SCL
Optical Ports						
TLS inputs & outputs	Number of input ports	1 to 4	1 (PM13)	1 (PM15)	1 (PM13)	1 (PM15)
	Number of output ports	1	1 (PM13)	1 (PM15)	1 (SMF)	
	Connector type	FC/APC narrow key	FC/APC narrow key (PM: slow axis aligned to connector key)			
	PER on input port	n/a	≥20 dB		≥18 dB (recommended)	
Detectors	Number of ports	1; 2 or 4				
	Connector type	FC/PC wide key				
Electrical Ports						
Trigger Out BNC	Trigger output	5 V TTL levels				
Trigger In BNC	Trigger input	5 V TTL levels				
Analog In BNC	Analog voltage input	0-5 V High impedance				
Electrical Specifications						
Input power		100–240 V ～; 50/60 Hz; 0.76 A max.				
Fuse type (x2)		1 A, 250 V, Fast (F) action, Low breaking 5 x 20 mm (0.2 x 0.79 in) Equipment has double fuse in both Line and Neutral conductors.				
Interface with Computer						
Interface with computer / Data rate		USB-B 2.0 / 4 MBaud				
Computer requirements	Operating system	From Windows 7 to Windows 10				
	Interface with TLS	GPIB interface card to TLS				
	Interface with CT440	USB-A 2.0 port to CT440				

Physical Specifications

Physical Specifications	
Dimensions (W x H x D)	440 x 50 x 375 mm (17.3 x 2 x 14.8 in)
Weight	Between 3.5 kg and 3.9 kg (7.7 lb to 8.6 lb), depending on model.

Product Overview

The CT440 is made of two complementary parts:

➤ The CT440 instrument, which makes measurements during the wavelength scan

➤ The CT440 software (GUI), which takes the data from the instrument and performs all the analysis

The CT440 is delivered with the following accessories:

➤ Rack mounting brackets

➤ A power supply cord

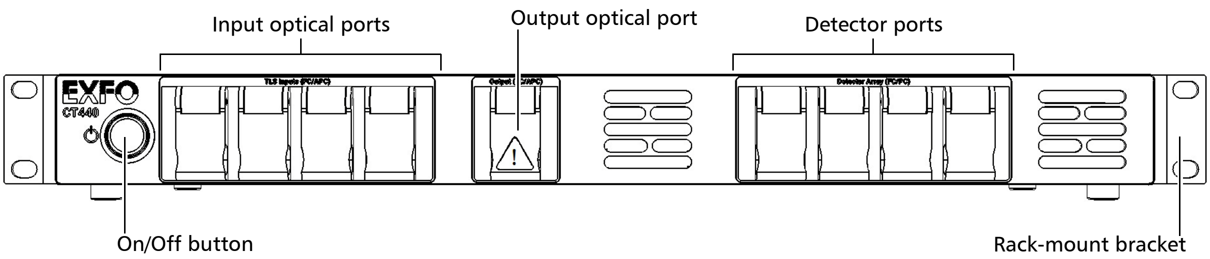
➤ A USB-A to USB-B cable

➤ A USB key containing:

  ➤ The CT440 installation package (GUI software, USB driver and CT440 library for remote control)

  ➤ User documentation

Front Panel



On/Off Button

The On/Off button turns on/off the CT440 and lights the green LED.

Input Optical Port(s)

The **TLS Input** label identifies the APC connectors used to connect the tunable laser source(s) (up to four connectors, depending on the model) to the CT440.

On models with more that one input port, the wavelength range must follow the order of the ports (lower range in port 1).

Output Optical Port

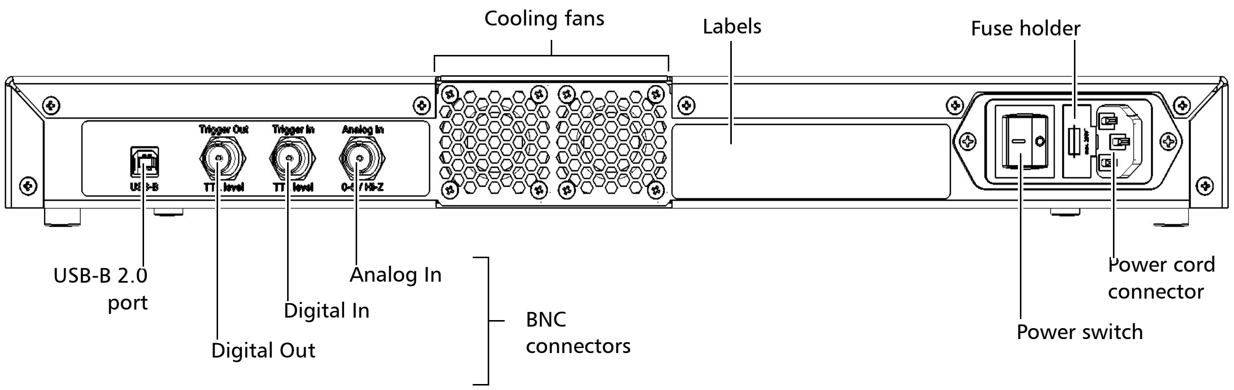
The **Output** label identifies the APC connector providing the signal output to connect the input port of the device under test (DUT) with an SMF fiber.

The  label indicates the location of the laser output. This output requires special safety instructions for proper use (see *Connecting the DUT to the CT440* on page 32).

Detector Ports

The **Detector Array** label identifies the PC connectors used to connect the output ports of the device under test (up to four connectors depending on the model).

Rear Panel



Cooling Fans

The cooling fans extract warm air from inside. A cover grid protects them.

Fuse Holder

The fuse holder contains two fuses (see *Technical Specifications* on page 7 for fuse type) to protect the CT440 from overcurrent. For details on how to replace the fuses, see *Replacing Fuses* on page 81).

Power Cord Connector & Power Switch

The CT440 unit is equipped with a self-regulating power supply (for details, see *Technical Specifications* on page 7).

USB-B 2.0 Port

This port enables you to perform remote control operations from a connected computer. For more information, see *Installing/Updating the CT440 Library* on page 91.

BNC Connectors

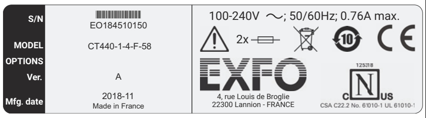
Connector "**Trigger Out**": digital output port to perform simultaneous measurements on remote platforms (for more details, see *Synchronizing the CT440 with External Measurements* on page 44).

Connector "**Trigger In**": digital input port to perform triggered scans (for more details, see *Setting up a Triggered Scan* on page 42).

Connector "**Analog In**": analog input port on which you can perform additional measurements (for more details, see *Performing a Measurement Using the Analog In BNC Connector* on page 47).

See *Interfaces & Electrical Specifications* on page 8 for more details on signal levels.

Labels

Label	Description
	➤ Identification of the product (left side): serial number, model, options (if any), hardware version and manufacturing date. ➤ Information on the product (right side): power requirements, manufacturer information and compliances. The fuse type is described in *Technical Specifications* on page 7.
	Warranty seal The CT440 cover must not be open, otherwise the warranty is not valid anymore.

Conventions

Before using the product described in this guide, you should understand the following conventions:

WARNING

Indicates a potentially hazardous situation which, if not avoided, could result in *death or serious injury*. Do not proceed unless you understand and meet the required conditions.

CAUTION

Indicates a potentially hazardous situation which, if not avoided, may result in *minor or moderate injury*. Do not proceed unless you understand and meet the required conditions.

CAUTION

Indicates a potentially hazardous situation which, if not avoided, may result in *component damage*. Do not proceed unless you understand and meet the required conditions.

IMPORTANT

Refers to information about this product you should not overlook.

Abbreviations Used

Abbreviation	Meaning
DLL	Dynamic Link Library
DSP	Digital Signal Processor
DUT	Device Under Test
FSR	Free-spectral range
GPIB	General Purpose Interface Bus
GUI	Graphical User Interface
IL	Insertion Loss
PDL	Polarization Dependent Loss
PER	Polarization Extinction Ratio
PDL	Polarization Dependent Loss
PSG	Polarization State Generator
TF	Transfer Function
TLS	Tunable Laser Source
TTL	Transistor-Transistor Logic

2 Safety Information

WARNING

Do not install or terminate fibers while a light source is active. Never look directly into a live fiber and ensure that your eyes are protected at all times.

WARNING

The use of controls, adjustments and procedures, namely for operation and maintenance, other than those specified herein may result in hazardous radiation exposure or impair the protection provided by this unit.

WARNING

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

WARNING

Use only accessories designed for your unit and approved by EXFO. For a complete list of accessories available for your unit, refer to its technical specifications or contact EXFO.

IMPORTANT

When you see the following symbol on your unit , make sure that you refer to the instructions provided in your user documentation. Ensure that you understand and meet the required conditions before using your product.

IMPORTANT

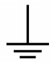
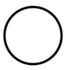
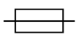
When you see the following symbol on your unit , it indicates that the unit is equipped with a laser source, or that it can be used with instruments equipped with a laser source. These instruments include, but are not limited to, modules and external optical units.

IMPORTANT

Other safety instructions relevant for your product are located throughout this documentation, depending on the action to perform. Make sure to read them carefully when they apply to your situation.

Other Safety Symbols on Your Unit

One or more of the following symbols may also appear on your unit.

Symbol	Meaning
	Direct current
	Alternating current
	The unit is equipped with an earth (ground) terminal.
	The unit is equipped with a protective conductor terminal.
	The unit is equipped with a frame or chassis terminal.
	On (Power)
	Off (Power)
 OR 	On/off (Power)
	Fuse

Optical Safety Information

WARNING

- **The modules and instruments that you use with your unit may have different laser classes. Refer to their user documentation for exact information.**
- **Do not install or terminate fibers while a light source is active.**
- **Never look directly into a live fiber and ensure that your eyes are protected at all times.**
- **Laser radiation may be encountered at the optical output port.**

Electrical Safety Information

This unit uses an international safety standard three-wire power cable. This cable serves as a ground when connected to an appropriate AC power outlet.

WARNING

- **If you need to ensure that the unit is completely turned off, disconnect the power cable.**
- **Use only the certified power cord that is suitably rated for the country where the unit is used.**
- **Replacing detachable MAINS supply cords by inadequately RATED cords may result in overheating of the cord and create a risk of fire.**

The color coding used in the electric cable depends on the cable. New plugs should meet the local safety requirements and include:

- adequate load-carrying capacity
- ground connection
- cable clamp

WARNING

- **Use this unit indoors only.**
- **Do not remove unit covers during operation.**
- **Operation of any electrical instrument around flammable gases or fumes constitutes a major safety hazard.**
- **To avoid electrical shock, do not operate the unit if any part of the outer surface (covers, panels, etc.) is damaged.**
- **Only authorized personnel should carry out adjustments, maintenance or repair of opened units under voltage. A person qualified in first aid must also be present. Do not replace any components while the power cable is connected.**
- **Use only fuses with the required rated current and specified type. Do not use repaired fuses or short-circuited fuse holders. For more information, see the section about replacing the fuses in this user documentation.**
- **Unless otherwise specified, all interfaces are intended for connection to Safety Extra Low Voltage (SELV) circuits only.**
- **Capacitors inside the unit may be charged even if the unit has been disconnected from its electrical supply.**

CAUTION

Position the unit so that the air can circulate freely around it.

Equipment Ratings		
Temperature	Operation	+15 °C to +35 °C (+59 °F to +95 °F)
	Storage	-10 °C to +60 °C (+14 °F to +140 °F)
Relative humidity		< 80% (non condensing)
Maximum operation altitude		2000 m (6562 ft)
Pollution degree		2
Overvoltage category		II
Measurement category		Not rated for measurement categories II, III, or IV
Input power[a]		100–240 V ~; 50/60 Hz; 0.76 A max.

a. Not exceeding ± 10 % of the nominal voltage.

CAUTION

➤ **The use of voltages higher than those indicated on the label affixed to your unit may damage the unit.**

3 Getting Started with Your CT440

Unpacking and Installing the CT440

The CT440 is designed for indoor use only, and is not dedicated to wet locations. It must be operated under proper environment conditions, as explained in the following procedure.

You can use your CT440 as a benchtop instrument or mount it in a rack.

CAUTION

Make sure the location where the CT440 will be installed meets the environmental and electrical characteristics listed in *Safety Information* on page 13.

To unpack the CT440:

1. Open the package with care and remove the protective foam.

IMPORTANT

When unpacking, handle the device with care and do not damage the original shipping container in case the CT440 needs to be returned to EXFO.

2. Set the CT440 on a flat stable surface free of excessive vibration.
3. Do one of the following:
   - To use the CT440 as a bench-top instrument, set it on a flat stable surface free of excessive vibration.
   - To install the CT440 in a 19-inch rack, follow the instructions detailed in *Installing the CT440 in a Rack* on page 18.
4. Allow the flow of air to be pulled in freely from outside to inside the CT440 through the air inlets located on the front panel and be pushed out the instrument through the cooling fan grids on the rear.
5. On the rear panel (see *Rear panel* on page 9), make sure the power switch is set to **O**.

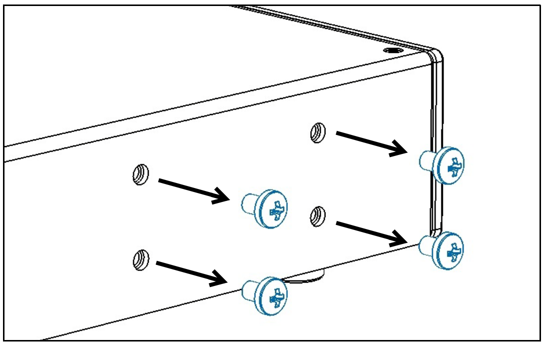
Installing the CT440 in a Rack

To be able to install the CT440 in a rack, you must first install the rack-mounting brackets on each side of the instrument.

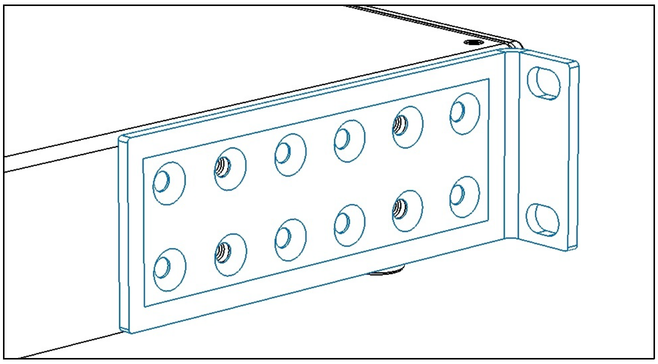
The brackets are delivered with eight screws (8 mm) to fasten it on each side panels of the instrument with a Phillips head screwdriver.

To install the rack-mounting brackets on the CT440:

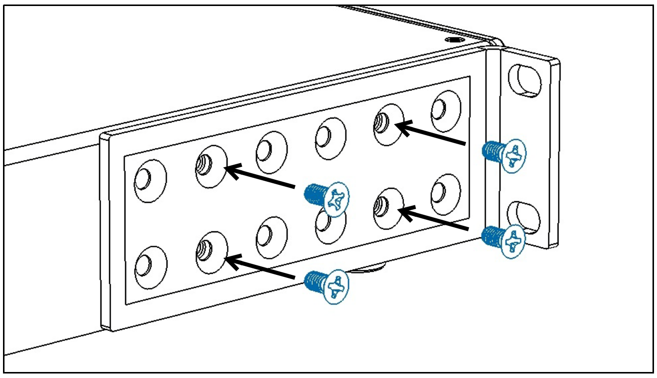
1. Loosen the four screws (6 mm) on each side of the CT440 case, as illustrated in the following figure.



2. Position the left-side bracket on the side panel so that you see the screw holes on the side panel, and it is flush with the front panel of the instrument.



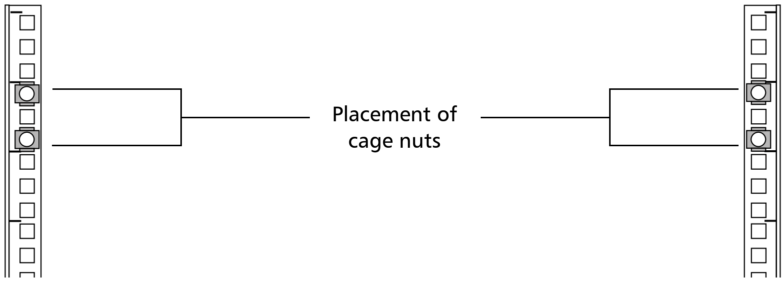
3. Attach the bracket to the side panel with the four 8 mm screws provided with the bracket, using a phillips head screwdriver.



4. Perform steps 2 and 3 with the right-side bracket.

To install the CT440 in a 19-inch rack:

1. Make sure that:
   - ➤ You have a 1U space in your rack
   - ➤ You have four rack mounting screws and cage nuts (no rack fastening kit is provided).
   - ➤ There is enough empty space underneath the space reserved for the CT440, to be able to hold it from below.
2. Install 4 cage nuts at the desired height on the rack:



3. Lift the CT440 to its position in the rack by holding it from below.
4. Use the rack mounting screws to attach the CT440 rack mounting brackets to the front of the rack.

Connecting the CT440 to a Power Source

To connect the CT440 to a wall socket:

1. On the rear panel, make sure the power switch is set to **O**.
2. Remove any equipment that could block the air flow.
3. Connect the power supply cable provided with the instrument to the mains socket located on the rear panel of the CT440.
4. Plug the other end of the power supply cable to the proper voltage wall socket outlet (to know the voltage requirement, see *Technical Specifications* on page 3).
5. On the rear panel, set the power switch to **I**.

Setting Up your Computer

CAUTION

Before connecting the CT440 to your computer, you must install the CT440 GUI software.

Installing/Updating the CT440 Software Package on Your Computer

The CT440 software installer is available on the USB key delivered with the CT440, or on the EXFO website (EXFO Apps).

The CT440 Installer installs the following components on your computer:

- CT440 GUI software
- CT440 Library
- CT440 USB driver
- Samples of traces and configuration that can be loaded in OFFLINE mode (made on a CT440-PDL PM15 with 4 detectors)
- CT440 Documentation

If you have already installed the CT440 software and want to update it with the latest version, see below the update procedure.

To install the CT440 software package:

1. Verify the computer on which you want to install the CT440:

   1a. Make sure that the computer on which you want to install the CT440 software package matches the requirements specified in *Technical Specifications* on page 7.

   1b. Make sure you have writing permission on the folder in which the CT440 software will be installed (the default folder is *C:\Program Files (x86)\EXFO*).

2. Do one of the following:
   - Connect the CT440 USB key to the USB-A port of your computer.
   - From the EXFO website (https://www.exfo.com/en/exfo-apps), download the last CT440 software package (CT440 Installer) and unzip it to a temporary folder on your computer.

3. In the **Installer** folder, double-click the **setup.exe** file.

   The CT440 installation wizard appears.

4. Follow the instructions displayed in the wizard window.

   The CT440 GUI software, library and USB driver are now installed on your computer.

To update the CT440 software:

The last version of the CT440 software is available on the EXFO website.

Updating the CT440 software does not affect the existing traces, configuration, nor selected analysis parameters.

1. From the EXFO website (https://www.exfo.com/en/exfo-apps), download the last CT440 software package and copy it on your computer.
2. Unzip the **CT440 Installer** file to a temporary folder on your computer.
3. Double-click the **setup.exe** file.

   The CT440 Installation wizard appears.
4. Follow the instructions displayed in the wizard window.

   The CT440 GUI software is now updated on your computer.

   At the GUI startup with the CT440, if the new version requires an update of the DSP code of the unit, you are prompted to upgrade the CT440 DSP. In this case, click **Yes** to update the DSP.

Connecting the CT440 to Your Computer

Before starting:

➤ Make sure the CT440 GUI software and USB driver are installed on your computer (see *Installing/Updating the CT440 Software Package on Your Computer* on page 20).

➤ Make sure you have the USB-A to USB-B cable provided with the CT440.

To connect the CT440 to your computer:

Using the USB cable, connect the USB-A 2.0 port of your computer to the CT440 USB-B connector located on the rear panel.

Starting/Stopping the CT440

Turning On/Off the CT440

The green LED located on the front panel indicates that the CT440 is turned on.

To turn on the CT440:

1. On the rear panel, set the power switch to **1**.
2. On the front panel, press the On/Off button.

   The green LED indicator lights, which means that the CT440 is turned on.

To turn off the CT440:

1. On the front panel, press the On/Off button.

   The green LED indicator fades out.
2. On the rear panel, set the power switch to **O**.

Starting/Stopping the CT440 GUI Software

The CT440 GUI allows you to configure the TLS parameters and measurement settings, and to start optical measurements.

Before starting:

- Make sure the CT440 GUI is installed and connected to your computer (see *Setting Up your Computer* on page 20).
- Turn on the CT440 (see *Turning On/Off the CT440* on page 21).

To start the CT440 GUI software

Click the shortcut icon located on your desktop or into **Start\All Programs\EXFO\CT440**

- If the CT440 is detected, the GUI appears, all parameters are set as you left them before the last GUI stop. For more details on the interface, see *Understanding the User Interface* on page 22.
- If no CT440 is detected, the GUI starts in OFFLINE mode, allowing the loading of configuration, the loading and saving of traces and access to the analysis.

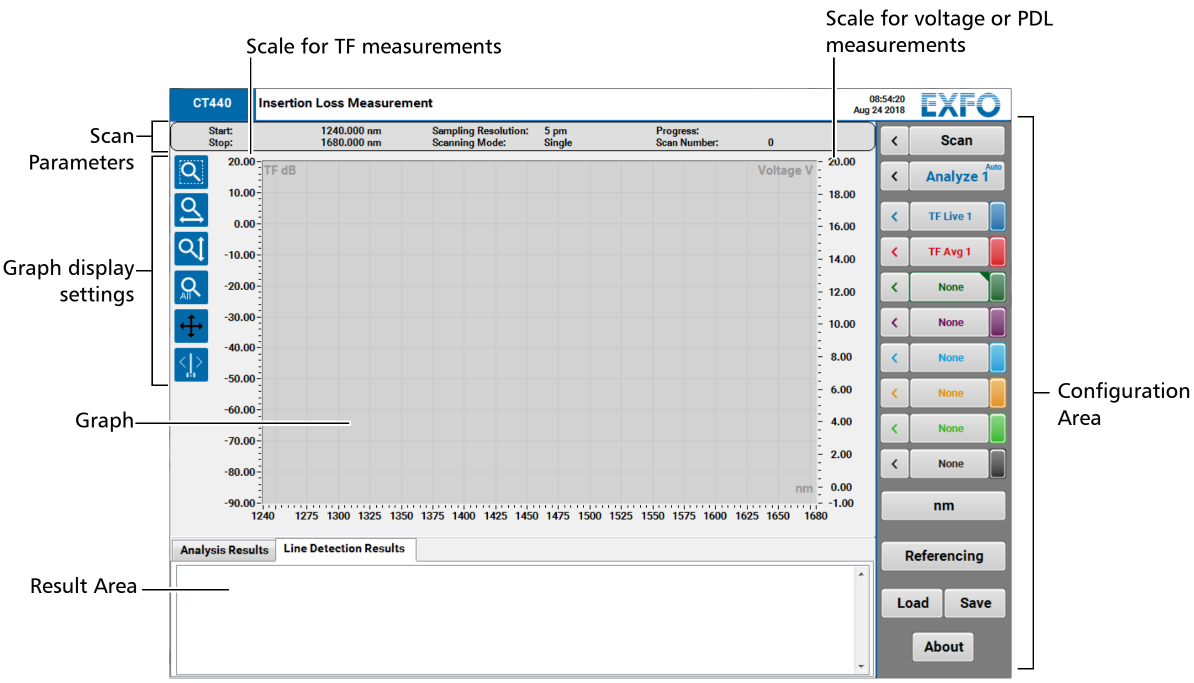
  The OFFLINE mode does not grant access to scan, referencing nor configuration saving.

To stop the CT440 GUI software:

Close the GUI window.

All parameters set are automatically saved for the next startup

Understanding the User Interface



Scan Parameters Area

This area displays the scan parameters selected in the **Scan Parameters** window.
For more details, see *Configuring Scan Parameters* on page 35.

Graph Display Settings

The buttons located in this area enable you to adapt the graph display to your needs.
For more details, see *Adjusting the Graph Display* on page 53.

Graph

The graph area displays the transfer function and/or PDL measurement.
For more details, see *Displaying and Operating Scan Traces on Graph* on page 53.

Configuration Area

This area enables you to control all the CT440 functionalities.

Button	Description
Scan button	This button enables you to configure and operate the scan parameters for the devices connected to the CT440. For more details, see *Configuring Scan Parameters* on page 35.
Analyze button	This button enables you to configure and operate the analysis parameters. For more details, see *Analyzing Traces* on page 57.
Traces buttons	These buttons enable you to configure and operate the scan traces. For more details, see *Configuring Trace Parameters* on page 39.
nm/THz button	This button enables you to select the wanted spectral unit displayed on graph.For more details, see *Changing the Spectral Unit on Graph* on page 54.
Referencing button	This button enables you to check power level on detectors, perform zeroing and auto-referencing on detectors and perform user power referencing. For more details, see *Performing User Referencing* on page 27 and *Verifying the Power and Voltage Levels* on page 34.
Load/**Save** buttons	These buttons enable you to save/load the overall configuration set in all windows of the CT440 GUI. For more details, see *Saving/Loading Configuration Parameters* on page 52.
About button	Provides information about your CT440 and the customer support contact list.

Result Area

The **Analysis Results** tab displays the results of the analysis selected in the **Analysis Parameters** window. For more details, see *Analyzing Traces* on page 57.

The **Line Detection** tab (only for CT440 with two or more TLS inputs) displays the results of the line wavelength measurements. For more details, see *Performing Line Wavelength Measurements* on page 50.

4 Setting Up Your CT440 for Measurements

This section details how to setup connections of the CT440 in a standard use.

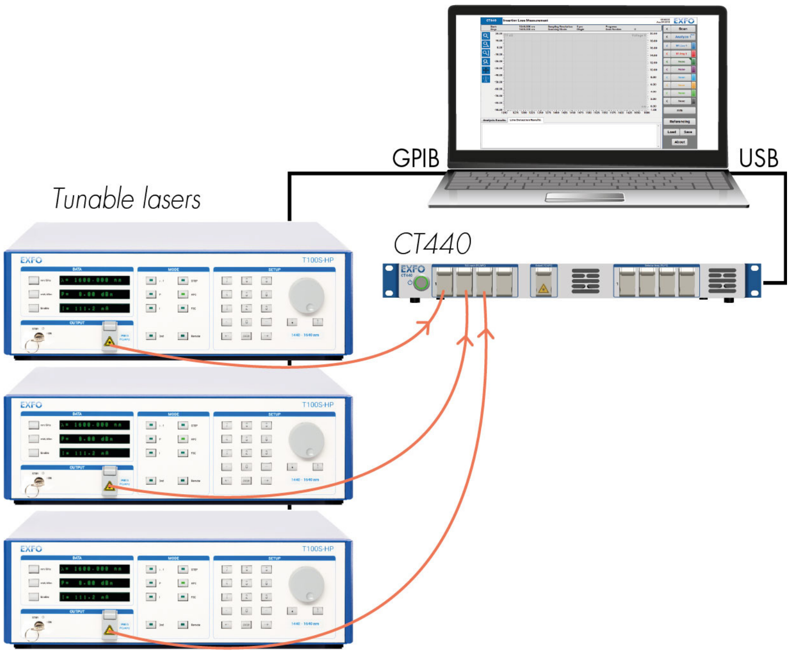
For more information on how to use the trigger, measurement synchronization and external detector, see sections *Setting up a Triggered Scan* on page 42, *Synchronizing the CT440 with External Measurements* on page 44 and *Performing a Measurement Using the Analog In BNC Connector* on page 47.

Connecting the Tunable Laser(s) (GPIB Use)

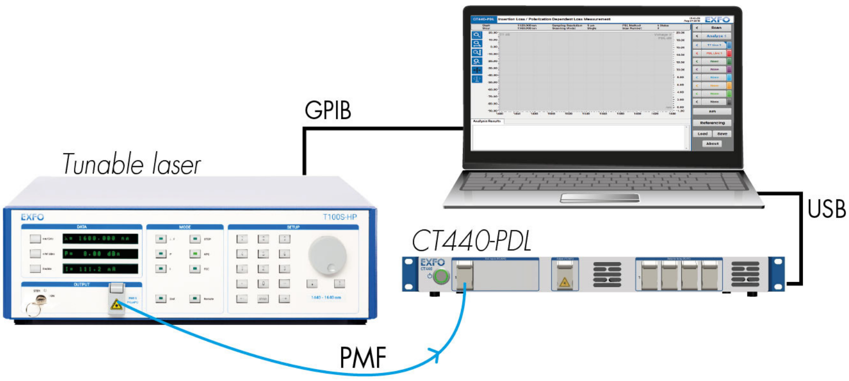
This section explains how to connect the tunable laser(s) to computer and CT440 through GPIB in a standard use.

For more information on how to use the trigger mode, see *Setting up a Triggered Scan* on page 42.

The following figure illustrates the connection of lasers to a CT440 SMF through GPIB (typical use).



The following figure illustrates the connection of a CT440 with PDL option to a laser through GPIB (typical use).



Before starting:

Make sure you have the following material:

- One or more tunable laser(s).
- A GPIB card or GPIB controller (if the CT440 is used in trigger mode, this adapter is not needed: see *Setting up a Triggered Scan* on page 42).
  - For TUNICS or T100S-HP lasers, the CT440 has been developed and tested using the NI GPIB controller.
  - If you want to use another vendor's GPIB/USB adapter, uninstall any existing USB/GPIB driver from your computer before installing the new USB/GPIB driver.
  - Make sure the controller driver is installed on your computer according to the manufacturer's guidelines, and in the controller's utility, make sure the GPIB interface is installed as the primary board 0 (GPIB0).
- The sufficient number of GPIB cables (one GPIB cable per TLS) to connect the computer to the tunable laser(s).
- The sufficient number of optical patch cords with the appropriate connector types, corresponding to the one mounted on your CT440 (see *Technical Specifications* on page 7 for available models) and the appropriate fiber type, corresponding to your CT440.

CAUTION

- **Make sure you use the appropriate connector and fiber types.**
- **Make sure optical connectors are perfectly clean. It is essential to achieve optimum system performance, especially for PDL measurements (see *Cleaning Optical Connectors* on page 80).**

To connect the tunable laser(s):

1. Using the GPIB cable(s), connect your computer to the TLS.
2. Using a clean APC patch cord, connect the TLS to the input port(s) of the CT440.

   If you want to connect two or more TLS, follow the instructions below:

   2a. Connect the TLS with the lowest wavelength range to the TLS Input connector 1 of the CT440.
   The wavelength ranges of the TLS used must follow the CT440's input port order: the source with the lowest wavelength range must always be connected on port 1, and the input port 1 must always be used.

   2b. Connect the TLS with the next lowest starting wavelength to port 2, and so on.

   Wavelength ranges of multiple TLS don't have to overlap for the system to work. For instance, you can connect an O-band (1260nm-1360nm) TLS to CT440 input port 1 and an CL-band (1500nm-1630nm) TLS to port 2.
3. Plug the power cord(s) of the TLS.
4. Turn on the TLS.

Performing User Referencing

Zeroing the Electrical Offset on Detectors

The zeroing function enables you to mitigate the effect of dark current on low power level measurement by first measuring the power on the selected detector when no fiber is connected and then storing that value for power correction.

The correction is automatically taken into account in the next power measurement.

In the **Referencing** window, the **Zero Detector X** buttons enables you to zero the wanted detectors.

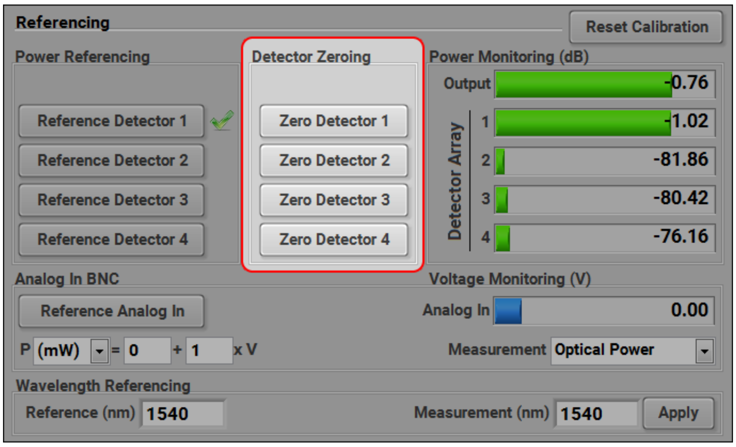
You cannot zero the dark current on the **Analog In** BNC connector located on the rear located on the rear panel of the CT440 (see *Rear Panel* on page 10).

To zero the detectors:

1. Make sure that no fiber is connected to the detector you want to set to zero.

2. In the main window, click the **Referencing** button

The **Detector Zeroing** area enables you to zero the dark current on the wanted detector.



3. In the **Referencing** window, click the **Zero Detector** button corresponding to the wanted detector.

The detector dark current is set to zero. If too much power is measured on the detector, the operation fails.

Performing Power Referencing

The user referencing of the detector array is very important and you must perform it frequently to compensate any change in the insertion loss between the CT440 output and the detector inputs, or to accommodate to specific setups and focus only on the DUT properties.

If the DUT is connected to the CT440 via other elements (patchcords, splitters), you must eliminate the contribution of these elements from the results, to only display the TF of the tested device.

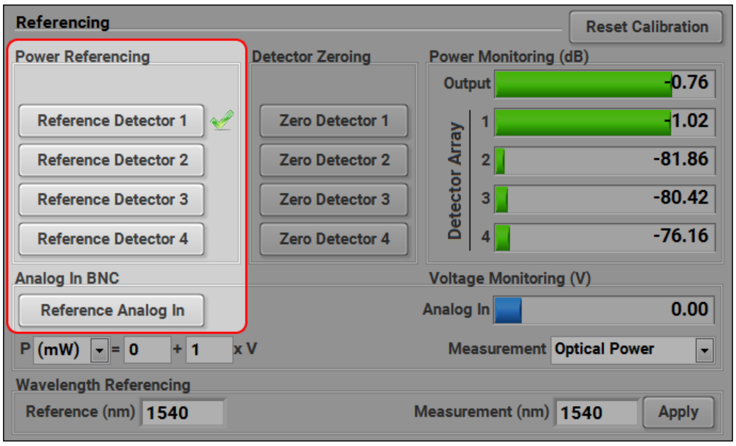
For PDL measurement (on CT440 with PDL option only), it is better to use a short patchcord. If you use a splitter, the PDL measured will be affected by the PDL of the splitter itself, even after referencing.

When using the CT440 GUI for the first time, the factory calibration file is created and stored on the control computer, in the appropriate **Calib** folder:
C:\Users\Public\Documents\EXFO\CT440\Calib

The file name is *<serial number>.bin*. Performing a user referencing updates this file.

Power Referencing Area

In the **Referencing** window, the **Reference Detector X** buttons allow you to reference the wanted detectors..

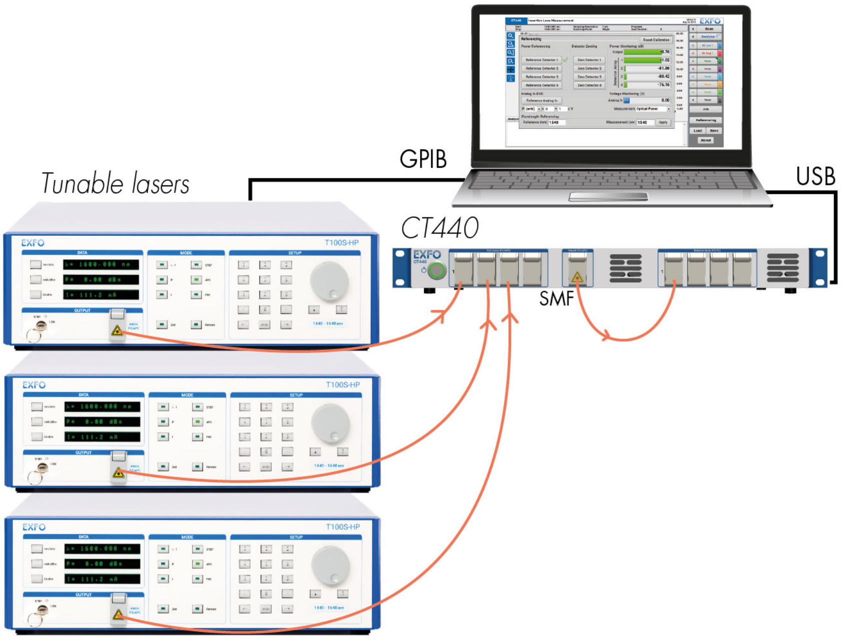


- The **Power Referencing** area enables you to calibrate the offset vs the wavelength for the front panel detectors.
- The **Analog In BNC** area enables you to define the gain and offset parameters linking the Voltage detected on a photodetector connected to the **Analog In** BNC to the optical power. Depending on the amplifier circuit, the relationship can be linear (mW) or logarithmic (dBm).

The detectors properly referenced for your setup are indicated with the  icon next to the referencing button.

To perform power referencing:

1. To obtain the optimum performance of the system, make sure the optical connectors are perfectly clean (see *Cleaning Optical Connectors* on page 80).
2. Connect a verified optical jumper between the output port of the CT440 and the detector port you want to reference.



3. In the **Scan Parameters** window, define the appropriate scanning and laser settings (see *Configuring Scan Parameters* on page 35)
4. Start a scan (see *Manually Starting/Stopping a Scan* on page 41).
5. On the graph, verify that the measurement has been performed.
6. In the main window, click the **Referencing** button

   The **Power Referencing** and **Analog In BNC** areas enable you to reference the wanted detector.
7. In the **Referencing** window, click the **Reference Detector** button corresponding to the connected detector.

The detector is referenced, the  icon appears next to the referenced detector number. If scan conditions are modified, you may be required to reference the system again.

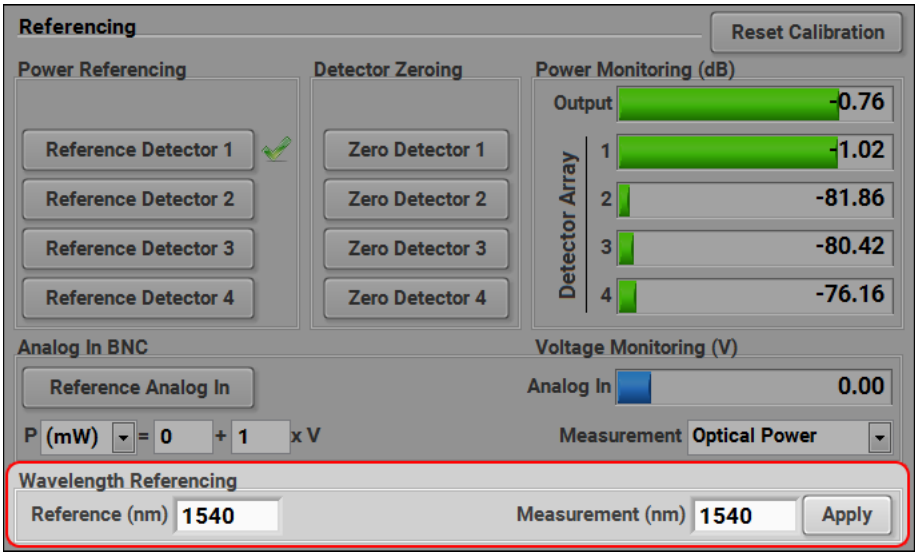
IMPORTANT

User power-referencing file is stored on the computer on which the CT440 is connected. If you change computer you must perform the referencing again.

Performing Wavelength Referencing

The CT440 should not encounter any shift in its wavelength accuracy between factory calibrations.

The **Wavelength Referencing** area of the **Referencing** window enables you to improve the accuracy of the wavelength referencing if needed by adding an offset to the factory calibration.



IMPORTANT

User wavelength-referencing file is stored on the computer on which the CT440 is connected. If you change computer you must perform the referencing again.

The example method explained below uses a gas cell (not provided with the instrument) as device-under-test (DUT), with known absorption lines within the wavelength range of the CT440.

To perform wavelength referencing:

1. Connect the instruments to the CT440 and specify them as follows:

   1a. To the TLS input port, connect a TLS source.

   1b. Connect a gas cell as DUT.

   1c. In the **Scan Parameters** tab, specify the parameters of the connected TLS input source.

2. In the **Scan Parameters** area, specify a wavelength range corresponding to the gas cell with a resolution setting of 1 pm (5 pm on CT440 with PDL option).

3. Click the **Scan** button.

4. On the graph, manually measure the wavelength for a specific absorption line.

5. In the **Referencing** window, in the **Wavelength Referencing** area:

5a. In the **Measurement (nm)** field, enter the measured value.

5b. In the **Reference (nm)** field, enter the expected value for this absorption line (in nm).

6. Click the **Apply** button.

At the next scan, the software will apply the appropriate offset in wavelength to correct the wavelength calibration. The offset is not applied on existing traces.

Resetting Calibration

You can recover the initial factory calibration at any time. Calibration reset erases all calibration modifications done on the wavelength referencing, on detector calibration and on detector zeroing.

To recover the initial factory calibration:

In the **Referencing** window, click the **Reset Calibration** button.

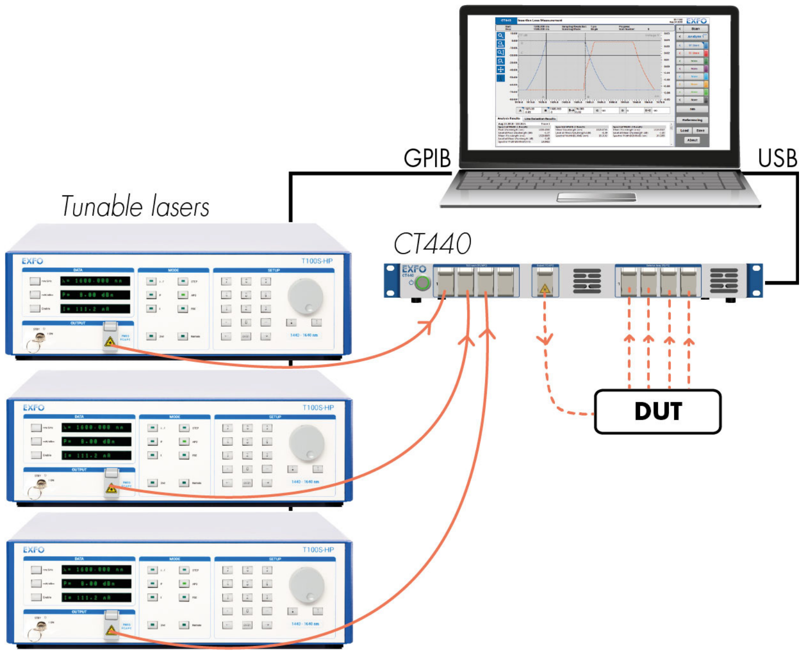
All referencing operations performed on the CT440 are erased.

Connecting the DUT to the CT440

This section explains how to connect the device under test to the CT440 in a standard use.

For more information on how to use the external detector, see *Performing a Measurement Using the Analog In BNC Connector* on page 47.

The following figure illustrates the CT440 connections to DUT (typical use).



Before starting:

➤ Make sure your computer is properly set-up (see *Setting Up your Computer*).

➤ Make sure you have the sufficient number of optical patch cords to connect the CT440 to the device under test (for more details on connector types, see *Technical Specifications* on page 7).

➤ Before connecting the DUT to the CT440, reference the detectors for your setup, as described in *Performing Power Referencing* on page 28.

CAUTION

For TF measurements only: to prevent premature failure of the CT440 optical connectors due to frequent connections/disconnections, we recommend to use an intermediate jumper on the CT440 optical port while you use the jumper's free end to connect to other devices.

Follow the auto-referencing procedure to take into account the additional insertion loss (see *Performing Power Referencing* on page 28). Do not use an intermediate jumper to perform PDL measurements.

To connect the DUT to the CT440:

1. Connect the input (or common) port of the DUT to the CT440 **Output** port.

WARNING

Depending on the safety class of the laser(s) you have connected to the CT440 input port(s), the beam coming from the CT440 output port may be dangerous. For safe use of the CT440 output port, please respect the safety guidelines of the laser(s) connected to the CT440 input port(s).

The CT440 **Output** port is APC type. If the DUT input is PC type, use a clean patch cord APC/PC and an adapter to interface between the CT440 and the DUT.

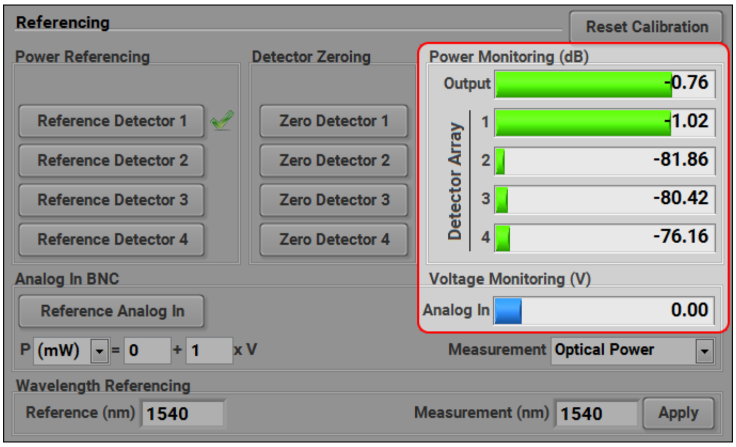
2. Connect the output port of the DUT to the CT440 detector ports.

The detector ports are PC type. If the DUT is APC type, use a clean patch cord APC/PC and an adapter to interface between the CT440 and the DUT.

Verifying the Power and Voltage Levels

In the **Referencing** window, the power control bars only provides an indication of the power, allowing you to adjust the magnitude of the inputs/outputs of your setup before launching scan measurements.

The power levels depend on the current wavelength and power output of the TLS, and on the characteristics of the component inserted between the output and the detector array of the instrument. If the current wavelength provided by the TLS is filtered out by the component, there will be no power on the detector array.



➤ The **Power Monitoring (dB)** area enables you to monitor:

  ➤ Optical power on all the detectors

  ➤ Optical power at the output port of the CT440

➤ The **Voltage Monitoring (V)** area enables you to monitor the voltage at the analog **Analog In** BNC input port on the rear panel.

To verify power and voltage levels:

In the main window, click the **Referencing** button.

The **Power Monitoring** area displays the power level in dB and the **Voltage Monitoring** area displays the voltage level on the **Analog In** BNC:

➤ Green color represents acceptable optical power level on the output port and on the detectors.

➤ Blue color represents acceptable voltage level on the **Analog In** BNC input located on the rear panel.

➤ Red color indicates that the power and voltage values are out of specification for a proper measurement with the CT440. In this case, verify that your laser injects enough power into the CT440 and that your fiber connectors are clean (see *Cleaning Optical Connectors*).

If you start any other action (scan, transfer function visualization …), the power measurement provided here is disabled.

5 Performing Measurement Scans

Configuring the CT440 for Measurements

Before starting a measurement, you must configure the TLS and detectors used, and the wanted scan and measurement parameters.

Configuring Scan Parameters

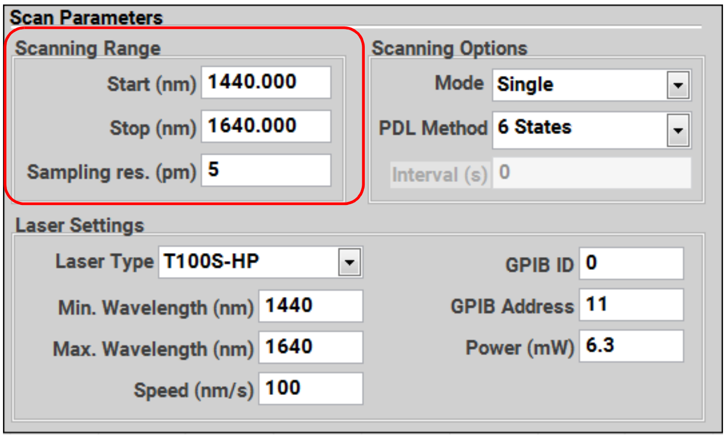
The **Scan Parameters** window enables you to select and configure the appropriate laser type(s) connected to your CT440 and to set the scan parameters.

You cannot set scan parameters during a scan.

To configure the scanning range:

1. Start the CT440 (see *Starting/Stopping the CT440* on page 21).
2. In the main window, click the  button located to the left of the **Scan** button.

   The **Scan Parameters** window appears.



3. Set the wanted scanning range according to the instructions given in the following table.

Parameter	Description
Start/Stop (nm)	Wavelength range you want to scan according to the wavelength limits of the TLS you have connected in the input port.
Sampling res. (pm)	Sampling resolution of the scan (for more details on possible values, see *Technical Specifications* on page 7). The chosen value provides the sampling step. **RAW** button (CT440 without PDL option only): automatically sets the resolution to native, which is 100±10 MHz. In this case, all measurements are done at the native resolution, without re-sampling of data. For more details, see *Data Acquisition: Raw and Resampled Data* on page 4.

Parameter	Description
PDL Method	CT440 with PDL option only. ➤ **4 States**: the CT440 performs 4 polarization-controlled successive sweeps to achieve the PDL measurement. **6 States**: the CT440 performs 6 polarization-controlled successive sweeps to achieve the PDL measurement. This provides the best measurement performance but it takes longer.

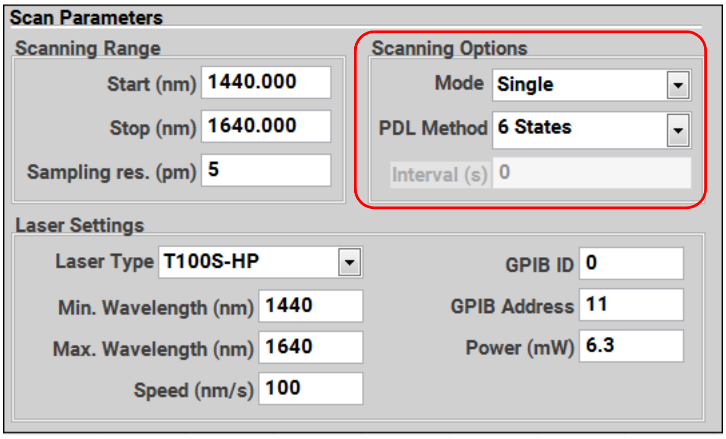
4. Click the button or anywhere on the screen outside the window to exit.

To configure the scanning options:

1. Start the CT440 (see *Starting/Stopping the CT440* on page 21).

2. In the main window, click the ‹ button located to the left of the **Scan** button.

The **Scan Parameters** window appears.



3. Set the wanted scanning options according to the instructions given in the following table.

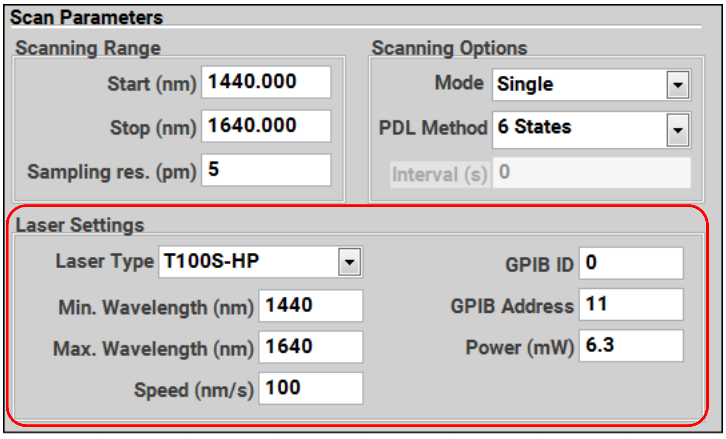
Parameter	Description
Mode	Scanning mode of the CT440: ➤ **Single** The CT440 performs a scan of the wavelength range set in the **Start/Stop** fields and then stops. On CT440 with PDL option: if a PDL measurement is required by one or more traces (see *Configuring Trace Parameters* on page 39), a scan is composed of 4 or 6 successive sweeps (depending on the selected **PDL Method**). ➤ **Continuous** The CT440 performs a continuous series of scans in accordance with the interval set in the Interval parameter (see **Interval (s)** below), until you click the **Abort** button. ➤ **Single Trig** The CT440 waits for an external trigger on the **Trigger In** BNC connector to start a single scan. For more details, see *Setting up a Triggered Scan* on page 42. ➤ **Continuous Trig** The CT440 waits for an external trigger on the **Trigger In** BNC connector to start continuous scanning. For more details, see *Setting up a Triggered Scan* on page 42.
PDL Method	CT440 with PDL option only. ➤ **4 States**: the CT440 performs 4 polarization-controlled successive sweeps to achieve the PDL measurement. ➤ **6 States**: the CT440 performs 6 polarization-controlled successive sweeps to achieve the PDL measurement. This provides the best measurement performance but it takes longer.
Interval (s)	Applies to **Continuous** scan mode only. Number of seconds between the beginning of two successive scans. ➤ If the interval set is greater than the scan time, the CT440 waits before the next scan. ➤ If the period of time is lower than the scan time, the CT440 immediately performs the next scan. In case of PDL measurement, the interval is observed between two series of 4 or 6 successive sweeps.

4. Click the button or anywhere on the screen outside the window to exit.

To configure the laser settings:

1. Start the CT440 (see *Starting/Stopping the CT440* on page 21).
2. In the main window, click the button located to the left of the **Scan** button.

   The **Scan Parameters** window appears.



3. Set parameters for the laser(s) connected to the CT440 (1 tab per connected laser), according to the instructions given in the following table.

Parameter	Description
Laser Type	Type of the laser connected to the CT440.
Selected	Only applies to CT440 with two or more TLS input ports. ➤ : the laser is activated and will be used for the scan. ➤ : the laser is disabled and won't be used for the scan.
Min./Max. Wavelength (nm)	Minimum and maximum wavelength (in nm) that the TLS can provide. You cannot select wavelength values outside the operating wavelength range of the CT440 type connected to your computer (see *Technical Specifications* on page 7). The TLS must cover at least 5 nm.
GPIB ID	GPIB interface ID of the selected tunable laser GPIB controller. Refer to your GPIB controller firmware to set the correct ID number. Possible values: 0 to 100.
GPIB Address	GPIB address of the selected tunable laser.
Speed (nm/s)	Speed of the tunable laser is nm/s, according to the selected laser speed specifications.
Power (mW)	Output power for the tunable laser. Possible values: see *Technical Specifications* on page 7.

4. Click the button or anywhere on the screen outside the window to exit.

Configuring Trace Parameters

The CT440 can displays 8 traces. Each trace is represented by a different color.

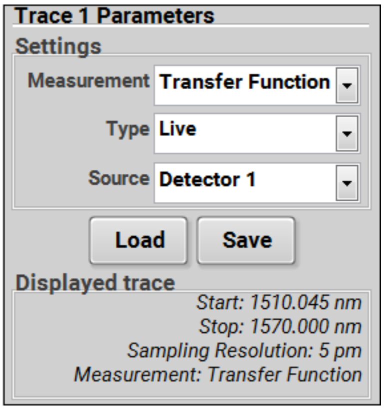
The **Trace x Parameters** window allows you to configure the type of measurement you want the CT440 to perform for each trace.

You cannot set trace parameters during a scan.

To configure trace parameters:

1. Start the CT440 (see *Starting/Stopping the CT440* on page 21).
2. In the main window, click the  button located to the left of the wanted trace button.

   The Trace parameters window appears.



3. Set the wanted settings according to the instructions given in the following table.

Parameter	Description
Measurement	CT440 with PDL option only. The type of measurement you want the selected trace to display after a scan has been started: ➤ **Transfer Function**: the trace will display the transfer function measured on the selected detector (see **Source** below) after a scan is performed. ➤ **PDL**: the trace will display the PDL measured on the selected detector (see **Source** below) after a scan is performed (a scan is composed of 4 or 6 successive sweeps (depending on the **PDL Method** selected in the **Scan Parameters** window). ➤ **Voltage**: (only appears in case the **Source** detector is set to **Analog In BNC** and the Analog In BNC **Measurement** is set to **Voltage** in the **Referencing** window). The trace will display the voltage measured on the **Analog In** BNC connector (for more details on this measurement, see *Performing a Measurement Using the Analog In BNC Connector* on page 47).

Parameter	Description
Type	➤ **Live**: the trace pictures the next scan. ➤ **Store**: the trace is frozen. It won't be modified by next scans. ➤ **Hold Min**: the trace pictures the minimum scanned values point to point. ➤ **Hold Max**: the trace pictures the maximum scanned values point to point. ➤ **Average**: the trace pictures the average of all scans performed from the first scan. This trace type is useful to reduce the noise level if necessary. ➤ **None**: clears the trace content and deactivates the trace.
Source	The CT440 detector corresponding to the selected trace. ➤ **Detector 1** to **Detector 4** are located on the CT440 front panel (see Figure 5, p. 22). ➤ **Analog In BNC** connector is located on the CT440 rear panel and enables you to perform voltage or optical power measurements. For more details on the use of this connector, see *Performing a Measurement Using the Analog In BNC Connector* on page 47.
Load/Save buttons	Buttons to save/load the selected trace in .csv or .tra (CT440 specific format). For more details, see *Saving/Loading Traces* on page 56.
Displayed trace	This area only appears if the trace is displayed on graph. Displays the main characteristics of the trace.

4. Click the button or anywhere on the screen outside the window to exit.

   The Trace button displays the parameters set.

5. Perform steps 2 to 4 for each trace you want to set.

Manually Starting/Stopping a Scan

Once you have set all the appropriate parameters, you can start scanning as explained in the following procedure.

Before starting:

1. Configure the scan parameters so that they correspond to your setup (see *Configuring Scan Parameters* on page 35).
2. Configure the trace parameters, as explained in *Configuring Trace Parameters* on page 39.
3. Make sure the detectors are properly referenced for your setup: see *Performing Power Referencing* on page 28.
4. To improve low power measurement, perform a dark current zeroing on detectors: see *Zeroing the Electrical Offset on Detectors* on page 27.
5. Connect the DUT to the CT440, as explained in *Connecting the DUT to the CT440* on page 32.

To start the scan:

1. Make sure the scanning mode is set to **Single** or **Continuous**.
2. Click the **Start** button.

   The **Scan** button label displays **Abort** and the scan starts according to the selected parameters.

   In the scan parameters area above the graph (see Figure 5, p. 25), you can follow the scan progress and number of scans.

   On CT440 with PDL option:

   - If no active PDL measurement is selected in any of the trace menus, the system only performs a TF measurement, in the Polarization 1 state.
   - If an active PDL measurement is selected in at least one of the trace menus, the system performs a 4 or 6 states PDL+TF measurement (4 or 6 successive sweeps).

     If the icon appears, it means that some points are missing in the PDL calculation: the CT440 could not calculate PDL for a few measurement points. For more details on how to avoid this, see *Troubleshooting* on page 83.

   If the **Single** scanning mode is selected, the acquisition stops automatically.

To stop the scan:

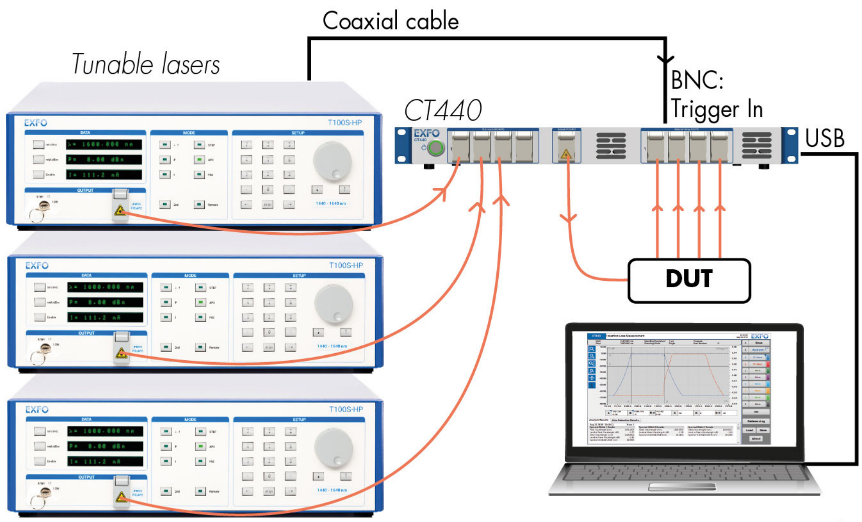
To stop the acquisition, click the **Abort** button.

The CT440 does not finish the current scan and stops as quickly as possible. The button label displays **Aborting** during scan stop.

Setting up a Triggered Scan

You can control the CT440 measurement with a trigger signal by using the **Trigger In** BNC connector, as explained in this section.

The following figure illustrates the hardware setup for a triggered scan: no GPIB controller is required, but a BNC cable.



Scan Synchronization

When the TTL signal is emitted from the laser to the **Trigger In** BNC connector, the start/stop of the scan are synchronized as follows:

- When the TLS has reached the start wavelength, the trigger signal rises (0 to 1) and the CT440 starts collecting data.
  On CT440 with PDL option: if PDL measurement is selected in one of the trace menus, the CT440 measures one state of polarization (out of 4 or 6 depending on the selected parameter) at each rising edge.
- At falling edge (1 to 0) of the input signal, the TLS is expected to have reached its end value and the internal analysis ends.

IMPORTANT

In Continuous Trig mode, the CT440 waits for the end of all data exchanges and analysis before starting a new measurement. If data communication or software analysis is not over when the next logic 1 signal arrives, the CT440 ignores the signal and waits for the following logic 1 to start a new measurement.

On CT440 with PDL option: **if PDL measurement is selected in one of the trace menus, several sweeps are needed to complete the measurement. Each sweep requires a triggered start to be performed.**

To set up a triggered scan:

1. Using a BNC 50 Ω coaxial cable, connect the Trigger out port (providing the TTL signal) of the laser to the input digital **Trigger In** BNC connector located on the rear panel of the CT440 (see *Rear Panel* on page 10).

   On the T100S-HP laser, you must configure the λ BNC port as a trigger output, as explained in *T100S-HP User Manual*.

2. In the CT440 GUI, in the **Scan Parameters** window (for more details, see *Configuring Scan Parameters* on page 35):

   2a. Set the wavelength boundaries of the scan.

   2b. Set the scanning **Mode** to **Single Trig** or **Continuous Trig**.

3. Click the **Scan** button.

   The CT440 waits for an external trigger on the **Trigger In** BNC connector to start measurements (one trigger starts one sweep; a PDL measurement requires either 4 or 6 sweeps).

   When the TTL signal is emitted, the start/stop of the scan are synchronized as described in the above *Scan Synchronization* on page 42.

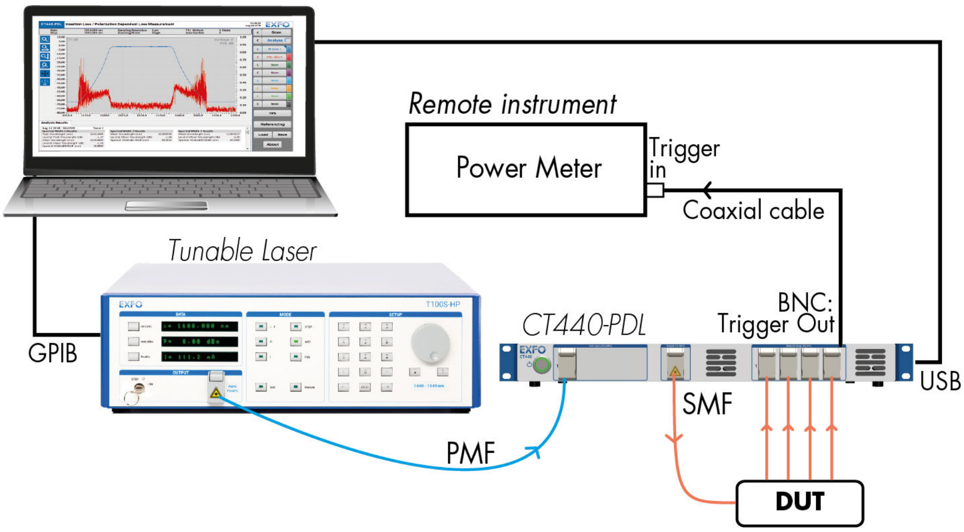
Synchronizing the CT440 with External Measurements

If additional detectors are required for any reason, you can use the synchronization signal (TTL) provided at the **Trigger Out** BNC connector of the CT440 to perform simultaneous measurements on remote platforms.

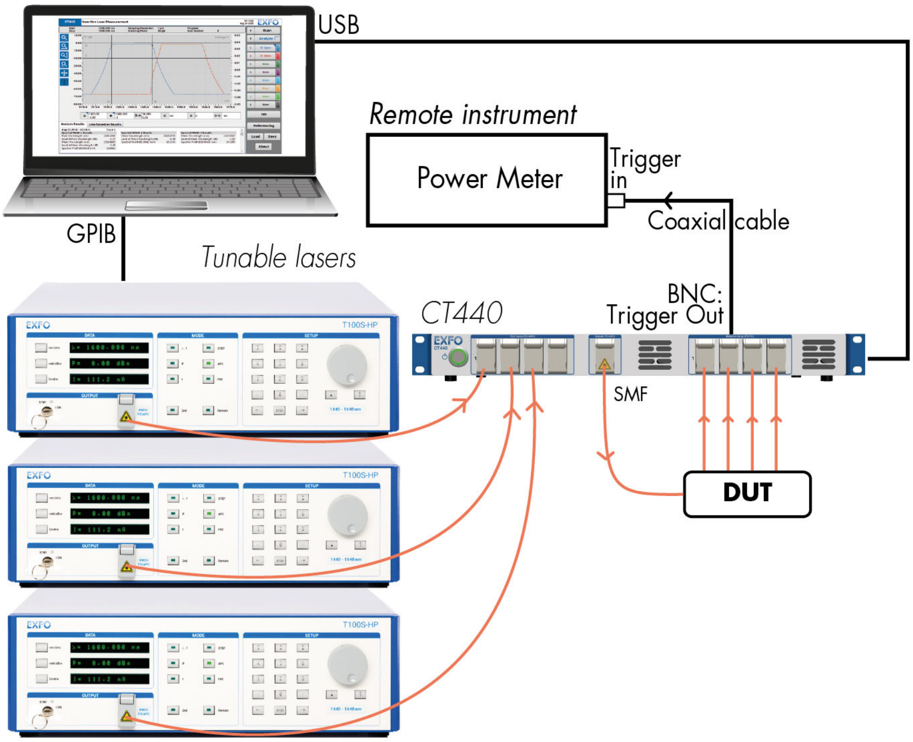
IMPORTANT

You cannot use the Trigger Out BNC connector to perform PDL measurements.

The following figure illustrates the hardware setup for external TF measurements with a CT440 with PDL option.



The following figure illustrates the hardware setup for external TF measurements with a CT440 SMF.



CT440 Pulses

During the scan of the laser, the CT440 generates TTL pulses at the **Trigger Out** BNC connector.

The sequence of pulses depends on the resolution (**Sampling res. (pm)**) set in the **Scan Parameters** window: if a resolution of *n* pm is selected, then a trigger pulse over *n* pulses comes out of the CT440. For more details on data acquisition, see *Measurement Principle* on page 3).

➤ The time duration of the generated pulses is around 4 µs.

➤ The separation between pulses depends on the following settings:

  ➤ the scan speed of the laser

  ➤ the selected resolution in the CT440.

For example, for a speed of 100nm/s and 1 pm resolution, the time slot between pulses will be roughly 10 µs $((100\text{nm/s} / 1\text{pm})^{-1})$.

The CT440 provides a sequence of TTL pulses in the wavelength domain, so separation between pulses is not equidistant as it would be in the frequency domain.

Before starting:

Make sure you have a BNC 50 Ω coaxial cable.

To synchronize the CT440 with external measurements:

1. Using the coaxial cable, connect the Trigger In port of the remote instrument receiving the TTL signal to the **Trigger Out** BNC connector located on the rear panel of the CT440 (see *Rear Panel* on page 10).
2. In the **Scan Parameters** window, select **Single** scanning mode.
3. Click **Scan** to run a single scan.

   The CT440 generates a TTL periodic signal during the measurement acquisition, as explained in the above *CT440 Pulses*.

Performing a Measurement Using the Analog In BNC Connector

The CT440 enables you to measure an electric signal through the **Analog In** BNC input port during the scan. You can measure the voltage of the electric signal or the optical power of the signal.

The most common case requiring this kind of measurement happens when the output of the DUT cannot be collected into a fiber or because of unacceptable losses. In such case, free-space photodetectors are used, providing an electrical output that feed the **Analog In** BNC input (voltage input from 0-5 V High impedance) and plotted simultaneously with the results obtained on the detectors of the front panel array.

The voltage information might not be relevant and specific operations on the output recorded files should be done to allow comparisons. For this reason, an internal conversion of the measured data into optical power might be required, which you can set in the **Referencing** window as explained in the following procedure.

IMPORTANT

On CT440 with PDL option: PDL measurement is not guaranteed if you use the Analog In BNC interface.

System Setup

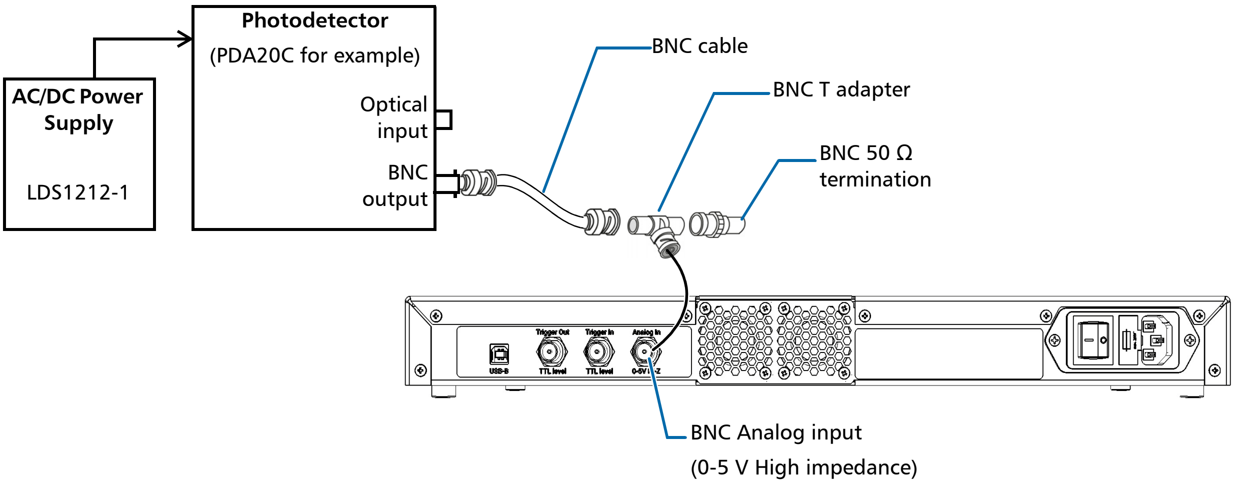
To build your detection system using the **Analog In** BNC port as an external detector, follow these instructions concerning the BNC connections:

➤ If your photodetector has a 50 Ω output (0-5 V), you need an adaptation with a BNC 50 Ω termination (see the setup example below)

➤ If you have a high impedance output (0-5 V) photodetector, you can directly connect it to the **Analog In** BNC input of the CT440.

Example

To use the **Analog In** BNC input port as an external detector, you can build your detection system as illustrated below. We recommend the PDA20C InGaAs transimpedance amplified photodetector from Thorlabs.

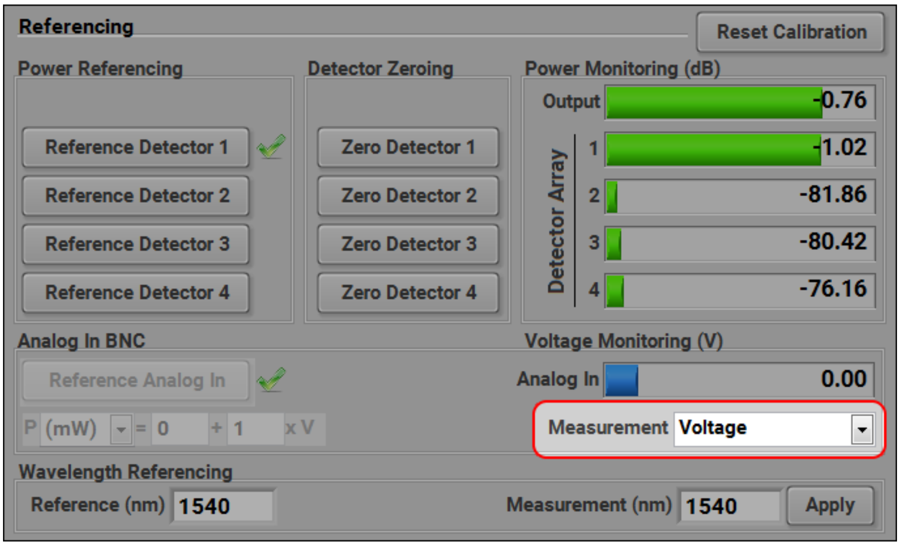


To measure the voltage of the electric signal:

1. In the **Referencing** window, in the **Analog In BNC** area, select **Voltage** in the **Measurement** list.

IMPORTANT

This operation clears all traces related to an active TF or PDL measurement on Analog In BNC.



2. In the **Trace Parameters** window:

2a. In the **Source** list, select **Analog In BNC**.

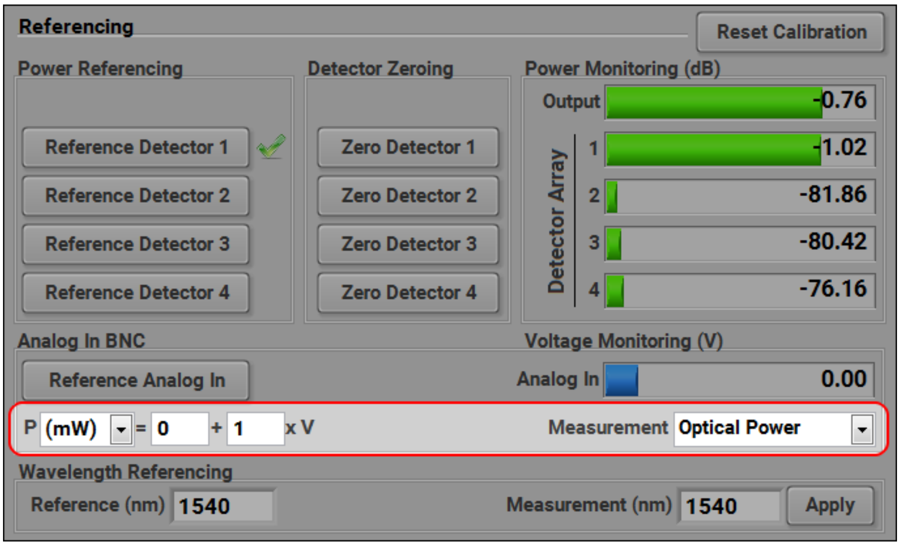
2b. On CT440 with PDL option: in the **Measurement** list, select **Voltage**.

3. Start a scan (see *Manually Starting/Stopping a Scan* on page 41).

The graph displays the measured voltage with a separated scale (in Volts) on the right axis.

To measure the optical power of the signal:

1. In the **Referencing** window, in the **Analog In BNC** area:



1a. In the **Measurement** list, select **Optical Power**.

The **P** fields become available.

IMPORTANT

This operation clears all traces related to an active voltage measurement on Analog In BNC.

1b. In the **P** fields, enter the conversion parameters from electrical to optical power: **P** (unit)=<optical power>+<conversion factor>x<BNC input voltage>:

P=:
- Select the optical power unit of the conversion (mW or dBm)
- Field 1: optical power (offset) in mW or dBm
- Field 2: conversion factor (slope) in mW/V or dBm/V

V: BNC input voltage (Volts).

2. In the **Trace Parameters** window:

2a. In the **Source** list, select **Analog In BNC**.

2b. On CT440 with PDL option: in the **Measurement** list, select the type of measurement you want the trace to display (Transfer function or PDL).

3. Start a measurement (see *Manually Starting/Stopping a Scan* on page 41)

The graph displays the measured TF or PDL.

Performing Line Wavelength Measurements

Line wavelength measurement is only available for CT440 SMF models with two or more TLS inputs.

CT440 featuring two or more TLS inputs include a powerful heterodyne detection system: it detects precisely when the source of an input port crosses the wavelength of the source connected to the next input.

Multiple Lines Measurement

The CT440 benefits from the heterodyne detector to allow the detection of multiple spectral lines on one port.

The **Line detection** tab provides the list of all spectral lines detected during the scan in a table. This allows you to use the CT440 as a multi-source wavemeter. It is possible to detect up to 16 spectral lines.

Single Line Measurement

The heterodyne detection is useful if two or more TLS are used to perform a scan.

In that case, the sources are connected to two adjacent ports. Both sources are active. While one source is sweeping, the second source waits until the wavelength of the sweeping source coincides with the wavelength of the idle source before taking over the sweeping. At this moment a signal is detected.

It provides a very accurate way to know precisely the wavelength at which a sweeping source crosses the wavelength of the idle source.
This allows to verify how well referenced the TLS sources are and to correct the measurement if one of the sources does not fulfill the performance specifications.

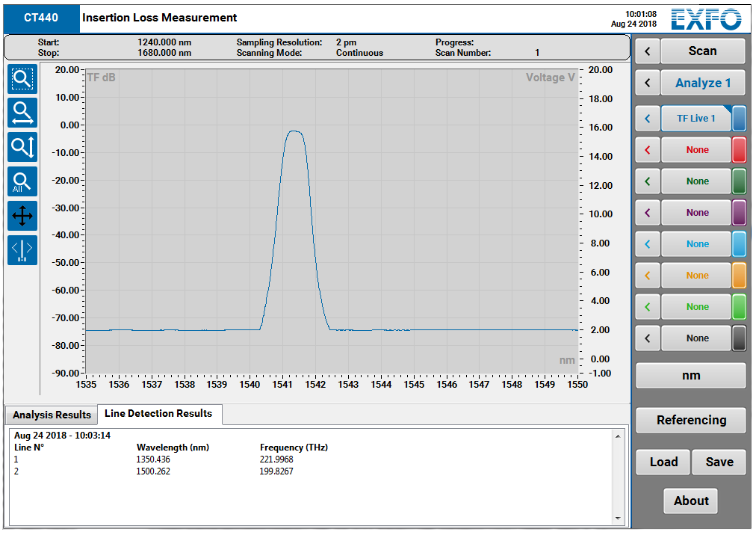
Limitations

- The heterodyne detection is provided here as a powerful tool to enhance the applications of the CT440. Nevertheless, the input optical ports are not specified here in term of polarization whereas the heterodyne signal comes from the interference pattern of two independent signals from two adjacent input ports. This interference signal is optimal if the two sources arrive in the detector with the same polarization but could be not detected if the two polarizations are orthogonal.
- If the power of both sources (line power) is over 0.2 mW, the detection occurs in most configurations.
- If this tool is strongly required in your application, it is recommended to check first that the spectral lines are well detected at the required power level and then leave the inputs setup unaffected during all the measurement period.

To perform line wavelength measurements:

1. Connect a TLS to input port 1 and a laser source to input port 2 with an overlapped wavelength.
2. Start a measurement (see *Manually Starting/Stopping a Scan* on page 41).

All spectral lines present in the source are detected in one scan and displayed in the **Line detection** tab, as illustrated in the following example window.



Saving/Loading Configuration Parameters

The following procedure explains how to save/load the overall configuration of the CT440. The configuration includes:

- All parameters set in all windows of the CT440 GUI: scan parameters, trace parameters, analysis parameters
- All the associated traces (in a separate folder).

The default location of the CT440 configuration folder is:
C:\Users\Public\Documents\EXFO\CT440\Config

To save your configuration parameters:

1. In the main window, click the **Save** button.
2. In the Explorer window:
   - Select **Configuration Files (.conf)**.
   - Select the wanted location and enter a name for the configuration file.
3. Click the **Save** button to save the configuration and all associated traces.

To load your configuration parameters:

1. In the main window, click the **Load** button.
2. In the Explorer window, select the wanted configuration file.

IMPORTANT

In case no trace is associated with the loaded configuration, all current traces are preserved.

3. Click the **Load Setup** button to load the configuration file.

6 Displaying and Operating Scan Traces on Graph

The graph area tab displays the scan results measured by the CT440 and enables you to manage scans and traces.

- The left scale in dB applies to the transfer function measurement.
- The right scale depends on the trace displayed on graph:
  - If the trace displays a PDL measurement, the right scale is in dB
  - If the trace displays the voltage measured at the **Analog In** BNC input port, the right scale is in Volts.

Adjusting the Graph Display

Display command buttons enable you to adapt the scale of the graph to your needs.

To adjust the graph display:

- To adjust the graph display, click the wanted display command button located in the graph display settings area (see *Understanding the User Interface* on page 22).

Command Button	Description
	Enables you to select the exact region of the spectrum that you want to display: 1. Click the button to activate the rectangle zoom. The button becomes darker. To deactivate the rectangle zoom, click the button again. 2. Drag your mouse across the graph to draw a rectangle corresponding to the region you want to zoom in.
	Fits the wavelength range to the total range covered by all displayed traces.
	Fits the power range to the to the total range covered by all displayed traces.
	Automatically sets the display to the maximum wavelength and power range (defined in the technical specifications, see *Technical Specifications* on page 7).
	Enables you to move in the graph by dragging the mouse across the graph. 1. Click the button to activate the moving function. The button becomes darker. To deactivate the moving function, touch the button again. 2. Drag your mouse across the graph to move the graph to the region you want to explore.
	Displays/Hides the markers on graph. For more details, see *Performing Measurements with Markers* on page 54.

- To zoom in and out, point your mouse cursor on the graph and use the mouse wheel.

Changing the Spectral Unit on Graph

You can switch the x-axis unit of the graph to THz or nm by using the unit button located in the configuration area.

To modify the spectral unit:

➤ To set the graph spectral unit to THz, click the **nm** button so that is displays **THz**.

➤ To set the graph spectral unit to nm, click the **THz** button so that is displays **nm**.

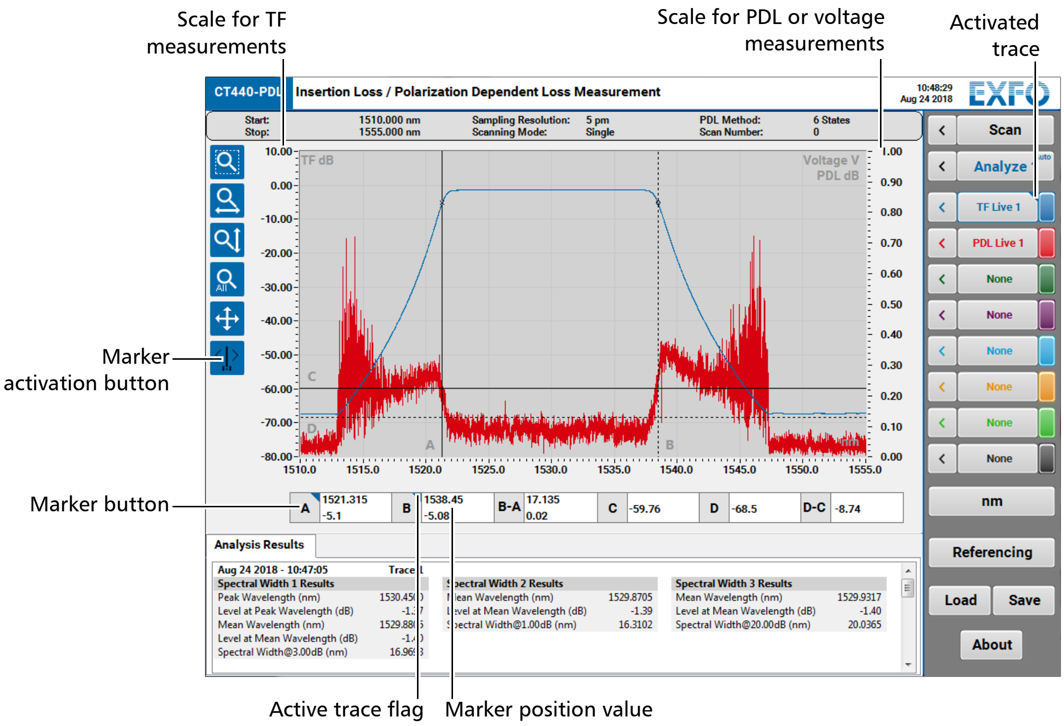
Performing Measurements with Markers

Four markers are available:

➤ Two vertical markers (A and B): associated with the displayed trace, to indicate the detected power at the wavelength on which they are positioned.

➤ Two horizontal markers (C and D) to indicate the optical power on the activated trace.

The following figure describes the marker commands.



To perform measurements with markers:

1. Activate the trace on which you want to position markers by clicking on its label.

The trace button is circled anda colored flag appears on the corner of the activation button to indicate that the trace is brought to front and activated.

2. Touch the  button to display the markers.

The button becomes darker, the markers appears on the graph, and their corresponding values on a line below the graph.

3. Place the markers at the wanted position on the graph using one of the following methods:

3a. On the graph, click the line corresponding to the marker you want to move and slide it to the wanted position.

3b. Below the graph, select the value corresponding to the marker position you want to set and type the wanted wavelength value (for markers A & B) or power value (for markers C & D) to precisely position the marker.

4. To hide markers, touch the  button.

The marker positions are kept in memory.

Handling Traces

Displaying/Hiding/Activating Traces

By default all traces are displayed on graph, each one has a different color.

The trace button displays the trace measurement and type. It is circled with a colored flag on the corner if the trace is activated.

To display/hide a trace:

To display/hide a trace, click the corresponding colored button located at the right of the trace button.

To activate a displayed trace:

To activate a displayed trace, click the trace button.

The trace button is circled with a colored flag on the corner.

Saving/Loading Traces

You can save traces in .csv, or .tra (CT440 specific format) formats

To save a trace:

1. In the main window, click the button located to the left of the wanted trace button.

   The Trace parameters window appears.

2. Click the **Save** button.

   The trace saving window appears.

3. Type a name and select a format for the trace:

   ➤ .tra: binary CT440-specific format (smaller size than .csv format).

   ➤ .csv: ASCII file for export in Excel or similar program:

   Trace data is saved according to the sampling resolution defined in the scan parameters.

   The data unit in the file is the unit set on the graph (see *Changing the Spectral Unit on Graph* on page 54), apart from the resolution which is in pm only.

4. Click the **Save** button.

To load a trace:

1. In the main window, click the button located to the left of the wanted trace button.

   The Trace parameters window appears.

2. Click the **Load** button.

   The trace loading window appears.

3. Browse the explorer window and select the trace file you want to load (in .csv or .tra format).

4. Click the **Load** button.

   The loaded trace appears on graph. The trace type is automatically set to **Store**.

7 Analyzing Traces

The **Analysis Parameters** window provides analysis tools specific to the characterization of pass band filters, stop band filters and isolators.

For each trace displayed on graph, a set of analysis tools adapted to the tested component is available, according to the appropriate detection threshold.

Defining the Analysis Parameters

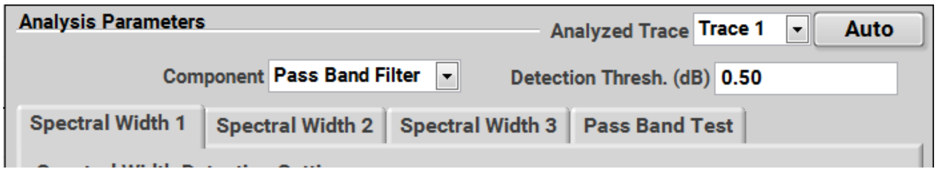
The **Analysis Parameters** window displays all parameters of the analysis you can perform on traces.

Before starting:

Perform an appropriate measurement (see *Setting Up Your CT440 for Measurements* on page 25).

To define the analysis parameters:

1. In the main window, click the < button located to the left of the **Analyze** button.
2. The **Analysis Parameters** window appears.
3. In the **Analyzed Trace** list, select the trace you want to analyze.
4. In the top part of the window, define the general analysis parameters as explained below.



Parameter	Description
Analyzed Trace	Trace on which you want the analysis parameters to apply. The color text of the **Analyze** button changes to reflect the selected analyzed trace.
Auto button	➤ Auto (button selected): the analysis is automatically performed in the following cases: - at the end of each scan - after the change of an analysis parameter - after the load of a trace - after the change of the graph unit (see *Changing the Spectral Unit on Graph* on page 54) The "Auto" flag appear on the top right corner of the **Analyze** button to indicate that auto-analysis is activated. ➤ Auto (button cleared): the analysis is only performed when you click the **Analyze** button.
Detection Thresh.	Power value in dB only below which you do not want the signal to be analyzed.

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>Component</td><td>Type of component to test (corresponding to the selected Analyzed Trace). The selection of a component makes available the analysis tools adapted to the selected component.
<table>
<tr><th>Component / Analysis Tool</th><th>Pass Band Filter</th><th>Stop Band Filter</th><th>Isolator</th></tr>
<tr><td>Spectral Width 1/2/3</td><td>•</td><td></td><td></td></tr>
<tr><td>Notch Width 1/2/3</td><td></td><td>•</td><td>•</td></tr>
<tr><td>Pass Band Test</td><td>•</td><td></td><td></td></tr>
<tr><td>Stop Band Test</td><td></td><td>•</td><td></td></tr>
</table></td></tr>
<tr><td>Spectral Width X tabs</td><td>For more details on how to configure Spectral Width parameters, see Defining Spectral Width Analysis Parameters on page 59</td></tr>
<tr><td>Notch Width X tabs</td><td>For more details on how to configure Notch Width parameters, Defining Notch Width Analysis Parameters on page 63</td></tr>
<tr><td>Pass Band Test tab</td><td>For more details on how to configure Pass Band Test parameters, Defining Pass Band Test Analysis Parameters on page 65</td></tr>
<tr><td>Stop Band Test tab</td><td>For more details on how to configure Stop Band Test parameters, Defining Stop Band Test Analysis Parameters on page 70</td></tr>
</table>

Defining Spectral Width Analysis Parameters

The **Spectral Width 1**, **Spectral Width 2** and **Spectral Width 3** analysis tools are available for Pass Band Filter component analysis.

They allow you to identify in a spectral trace the width of the main peak at three given thresholds below the peak power and the central wavelength.

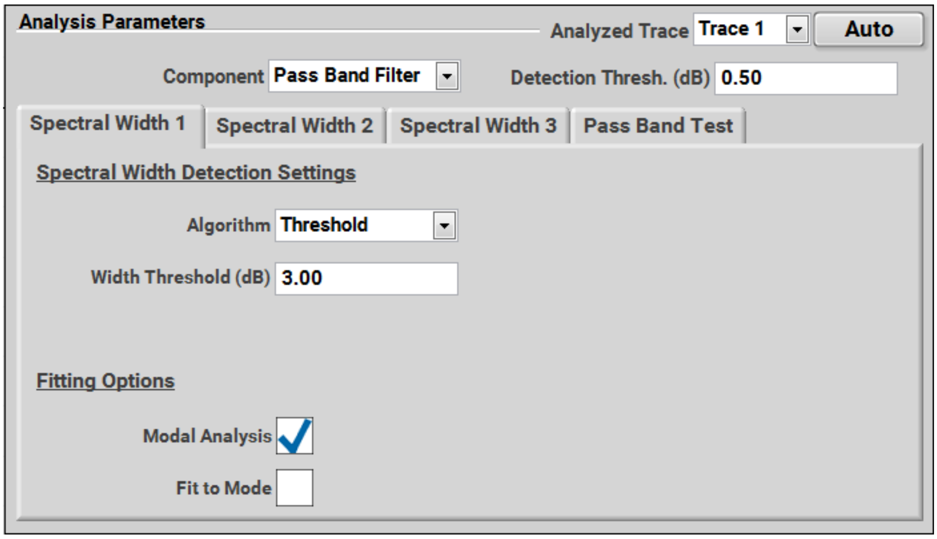
Before starting:

Make sure you have defined the general analysis parameters (see *Defining the Analysis Parameters* on page 57).

To define Spectral Width parameters:

1. In the main window, click the ‹ button located to the left of the **Analyze** button.
2. The **Analysis Parameters** window appears.
3. In the **Component** list, select **Pass Band Filter**.
4. In the **Spectral Width 1**, **Spectral Width 2** and **Spectral Width 3** tabs, define the analysis parameters as explained in the *Spectral Width Parameters Description* on page 59.

Spectral Width Parameters Description

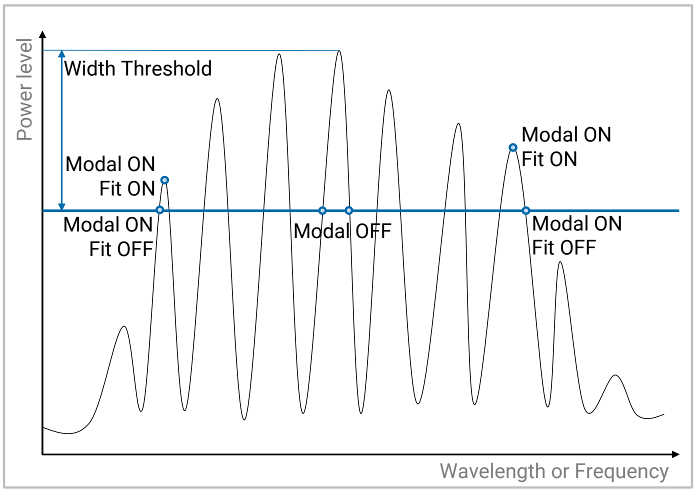


Spectral Width Detection Settings

➤ **Algorithm**: method used for the calculation of the width.

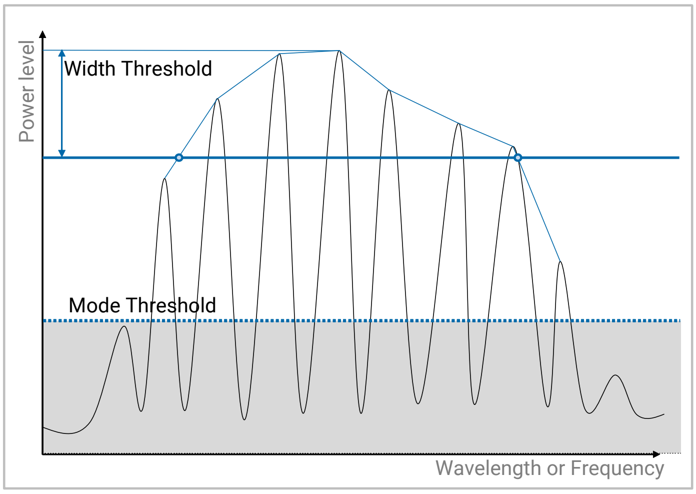
➤ **Threshold** (default)

The Threshold algorithm detects the wavelengths λ^- and λ^+ at which the power falls below [Peak Power]-[Width Threshold]. To account for the multimodal nature of some sources, several options are available for this algorithm (see *Fitting Options* below), illustrated in the following figure.



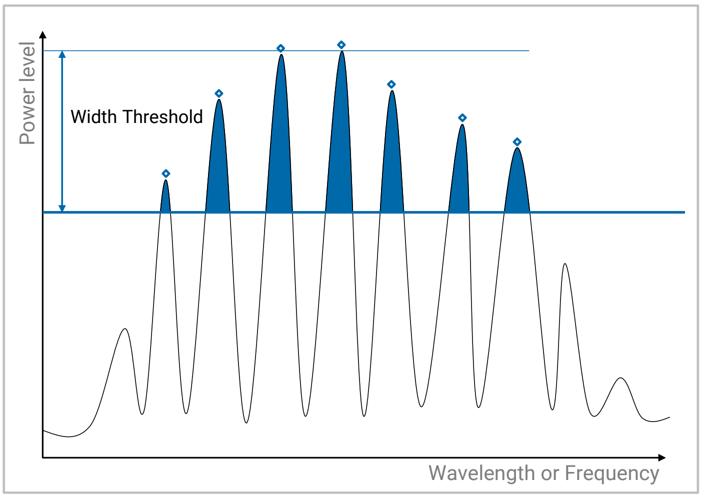
➤ **Envelope**

The Envelope algorithm defines an envelope from the peaks of the spectrum above **Mode Threshold** (linear fit between each peak on log scale) and deduces the width based on that envelope, as shown in the following figure.



➤ **RMS/RMS Peak**

The RMS and RMS Peak algorithms calculate the root mean square value σ of the power data above a given **Width Threshold**, taking the full power data (RMS) or simply the Power at Peak (RMS Peak) for the calculation.

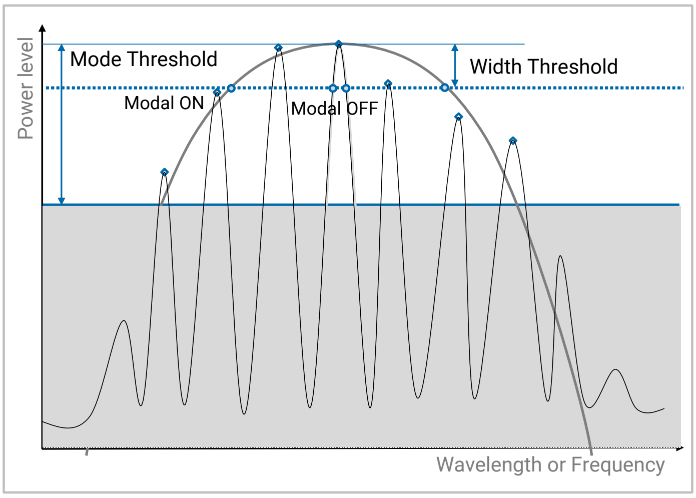


➤ **Gaussian Fit/Lorentzian Fit**

The Gaussian Fit and Lorentzian Fit algorithms fit a curve to the data and calculate the spectral parameters using **Width Threshold** from this fit.

If **Modal Analysis** is set to OFF (see *Fitting Options* below), the curve fits a Gaussian or Lorentzian to the main peak.

If **Modal Analysis** is set to ON, the curve fits a Gaussian or Lorentzian to all peaks above **Mode Threshold**.



➤ **Width Threshold**

Threshold level used in the calculation of the width. It defines two wavelengths λ- and λ**+** with Power $P = P_{peak}$ – **Width Threshold**.

Default values:

- **Spectral Width 1** tab: 3 dB

- **Spectral Width 2** tab: 5 dB

- **Spectral Width 3** tab: 20 dB

➤ **Mode Threshold** (only for **Envelope**, **Gaussian Fit** and **Lorentzian Fit** algorithms).

Retains peaks with power $P > P_{peak}$ – **Mode Threshold**.

Default value: 50 dB

Fitting Options

➤ **Modal Analysis** (only for **Threshold**, **Gaussian Fit** and **Lorentzian Fit** algorithms).

➤ ☑: the measurement includes all detected peaks above **Width Threshold** (Threshold algorithm) or **Mode Threshold** (Gaussian Fit/Lorentzian Fit algorithms).

➤ ☐: the measurement includes a single peak (the main peak).

Default value: ☑

➤ **Fit to Mode** (only for **Threshold** algorithm, if **Modal Analysis** check-box is selected).

➤ ☑: the calculation of width is fitted to the nearest detected peaks.

➤ ☐ (default): the calculation of width is fitted to the curve-threshold crossing.

Defining Notch Width Analysis Parameters

The **Notch Width 1**, **Notch Width 2** and **Notch Width 3** tools are available for the stop band filter and isolator components analysis. They allow you to identify in a spectral trace the width of a trough at a given threshold above the trough power.

Before starting:

Make sure you have defined the general analysis parameters (see *Defining the Analysis Parameters* on page 57).

To define Notch Width Analysis parameters:

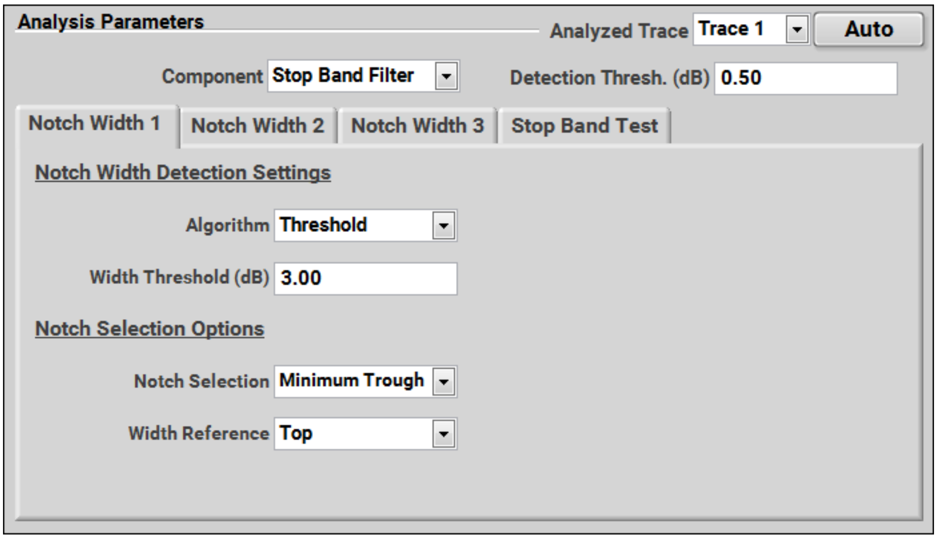
1. In the main window, click the button located to the left of the **Analyze** button.

   The **Analysis Parameters** window appears.

2. In the **Component** list, select **Stop Band Filter** or **Isolator**.

3. In the **Notch Width 1**, **Notch Width 2** and **Notch Width 3** tabs, define the analysis parameters as explained in *Notch Width Parameters Description* on page 63.

Notch Width Parameters Description



Notch Width Detection Settings

➤ **Algorithm**: fit to apply for the determination of the width.

The fitting is mono-modal (the **Modal Analysis** option is not available).

➤ **Threshold** (default): no fit is applied.

➤ **Gaussian/Lorentzian Fit**: the Gaussian Fit and Lorentzian Fit algorithms fit a curve to the data and calculate the spectral parameters using **Width Threshold** from this fit. The curve is fitted to the main trough.

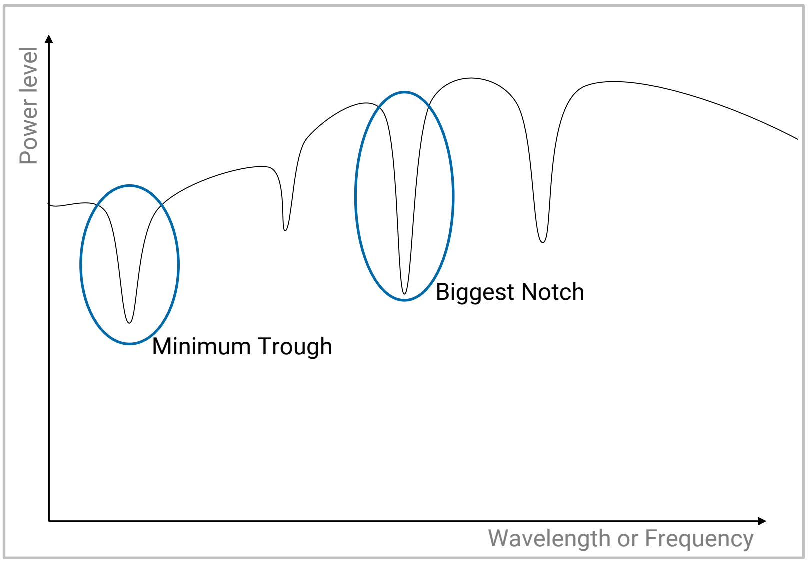
➤ **Width Threshold**

Threshold level used in the calculation of the width. It defines two wavelengths λ- and λ**+** with Power $P = P_{peak} -$ **Width Threshold**.

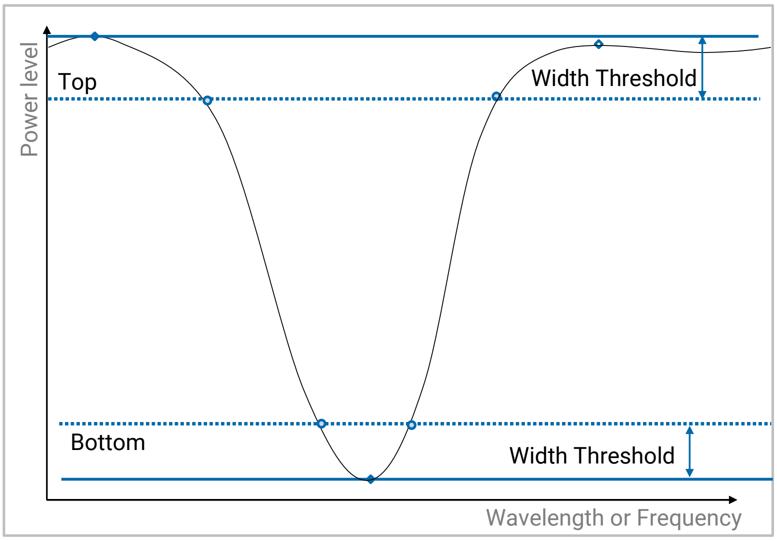
Default value: 3 dB

Notch Selection Options

- **Notch Selection**: method used for the selection of the trough to analyze.
  - **Deepest Notch**: selection of the feature with biggest difference between trough and adjacent peaks.
  - **Minimum Trough** (default): selection of the lowest level trough.



- **Width Reference**: method used for the measurement of the width.
  - **Bottom** (default): the width is calculated from the trough.
  - **Top**: the width is calculated from the two surrounding peaks on either side of the notch to be analyzed.



Defining Pass Band Test Analysis Parameters

The **Pass Band Test** tool is available for the pass band filter component analysis. It allow you to get cross-talk, average loss, ripple and roll-off characteristics for a pass band filter.

Before starting:

Make sure you have defined the general analysis parameters (see *Defining the Analysis Parameters* on page 57).

To define Pass Band Test analysis parameters:

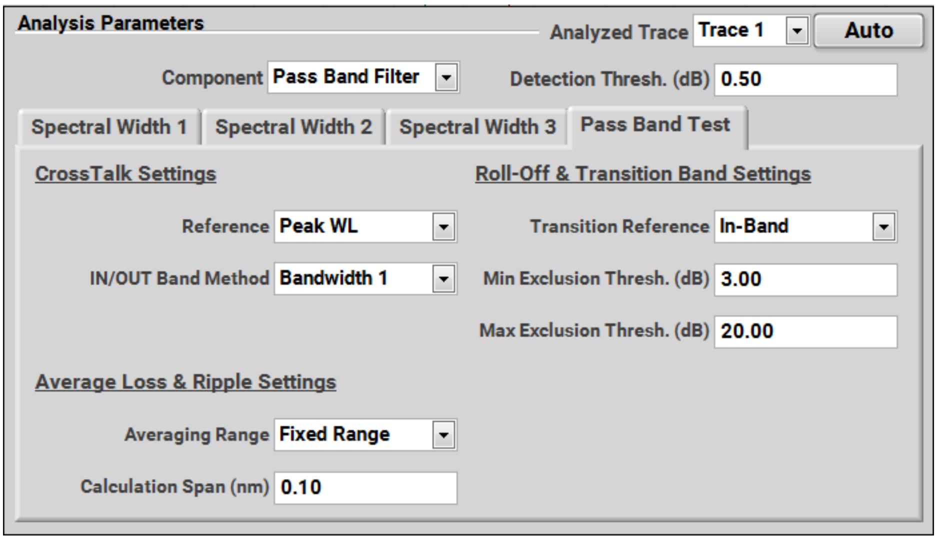
1. In the main window, click the button located to the left of the **Analyze** button.

The **Analysis Parameters** window appears.

2. In the **Component** list, select **Pass Band Filter**.

3. In the **Pass Band Test** tab, define the analysis parameters as explained in *Pass Band Test Parameters Description* on page 65.

Pass Band Test Parameters Description



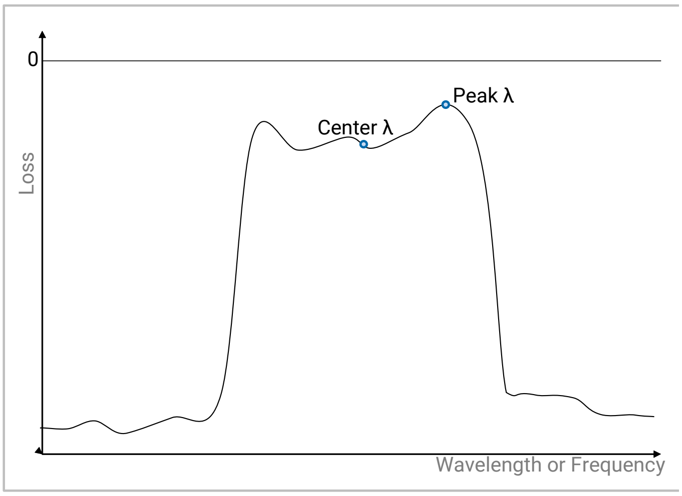
CrossTalk Settings

➤ **Reference**

Reference point taken for the analysis of the characteristics of the filter:

➤ **Peak WL** (default): peak wavelength found in the **Spectral Width 1** tool results (see *Spectral Width x Results* on page 75).

➤ **Center WL**: center wavelength found in the **Spectral Width 1** tool results (see *Spectral Width x Results* on page 75).

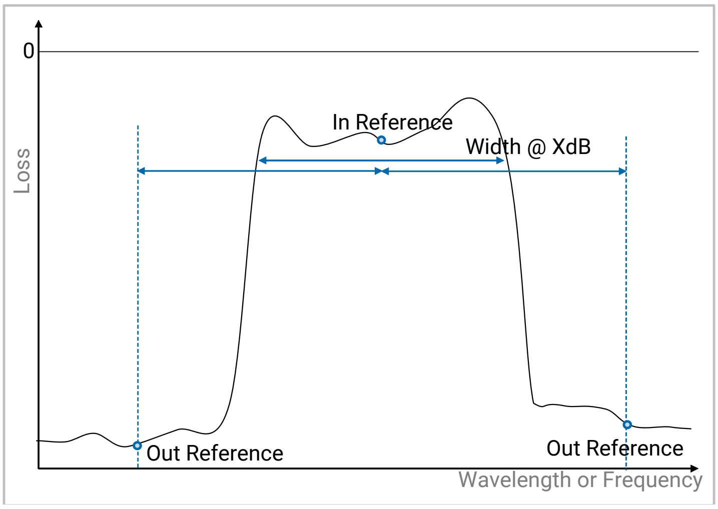


➤ **IN/OUT Band Method**

Method used in crosstalk calculation for the estimate of the spectral spacing between in and out bands:

➤ **Bandwidth 1** (default): selects the out band reference points to be exactly a bandwidth away from the in-band point, using the result in **Spectral Width 1** tool (see *Spectral Width x Results* on page 75).

➤ **Set Distance**: enables you to set the spacing via the **In/Out Band Distance** parameter.



➤ **IN/OUT Band Distance** (only if **In/Out Band Method** is set to **Set Distance**)

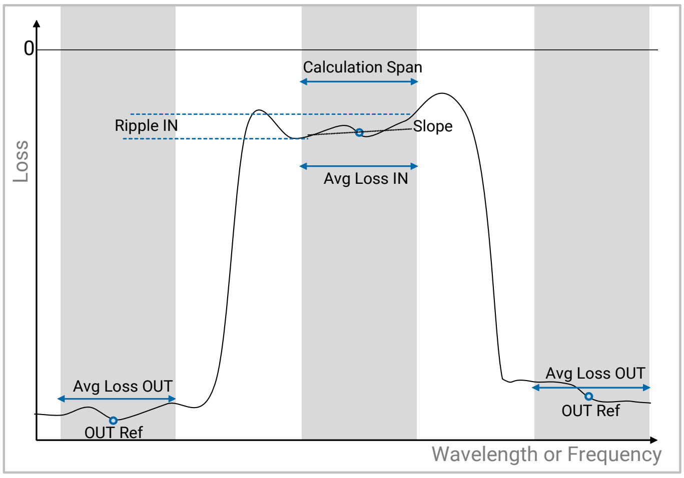
Spectral spacing in nm/THz between the in-band reference point and the out-band reference points to be used for the crosstalk calculation. Default value: 1 nm

Average Loss & Ripple Settings

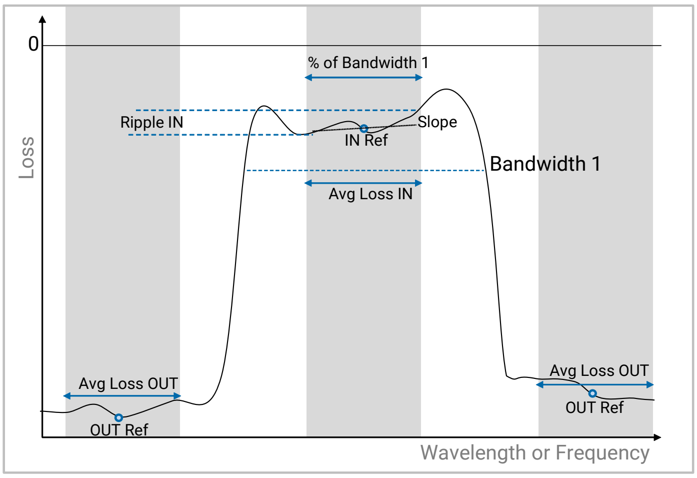
➤ **Averaging Range**

Spectral range used in the analysis of in-band and out-band average loss and ripple.

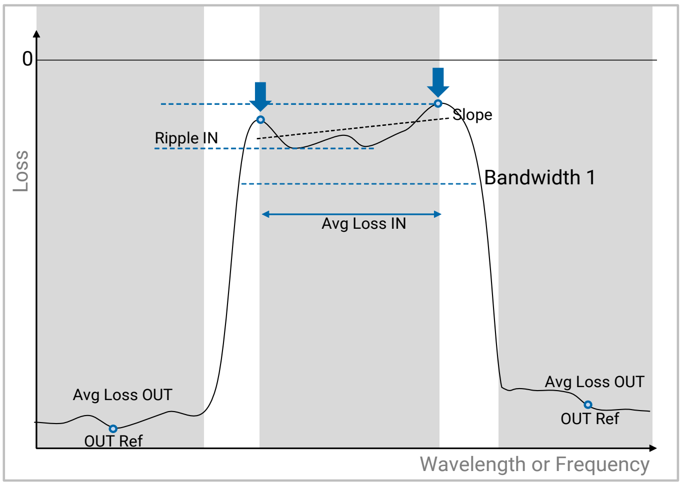
➤ **Fixed Range**: provides a fixed calculation span (see **Calculation Span** parameter).



➤ **% Bandwidth**: sets the range to a fraction of the bandwidth measured from the **Spectral Width 1** tool (see *Spectral Width x Results* on page 75).



- **PT Detection**: detects all peaks and troughs within the Bandwidth 1 using **Detection Threshold**, The span is then set as the distance between the first and last peak detected for a pass band filter.



In-band and out-band average loss and ripple/slope calculations are performed across a given calculation span centered on their respective reference points as defined in crosstalk settings.

- **Calculation Span** (only if **Averaging Range** is set to **Fixed Range**)

  Fixed Range in nm/THz over which calculations are done. The range is centered on the reference points for in-band and out-band (set in *CrossTalk Settings* on page 66). A range of 0 takes a single point for the calculation.

  Default value: 0.1 nm

- **% Bandwidth** (only if **Averaging Range** is set to **% 3dB Bandwidth**)

  Fraction (in %) of the bandwidth calculated in Spectral Width 1 over which calculations are done. The range is centered on the reference points for in-band and out-band (set in *CrossTalk Settings* on page 66).

  Default value: 50 %

- **Detection Threshold** (only if **Averaging Range** is set to **PT Detection**)

  Threshold in dB for the detection of in-band extreme peaks over which calculations are done. The range is centered on the reference points for out-band (set in *CrossTalk Settings* on page 66).

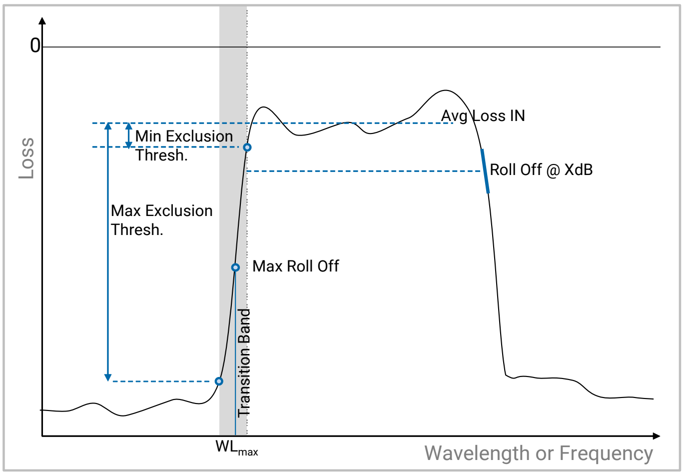
  Default: 0.1 dB

Roll-Off & Transition Band Settings

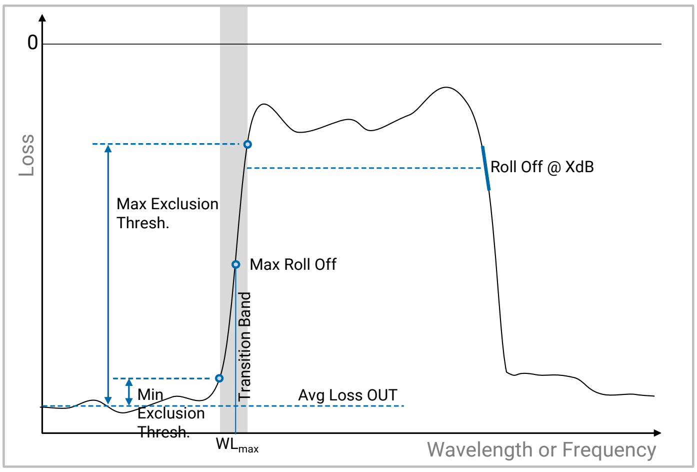
➤ **Transition Reference**

Reference point to be used in the transition calculation:

➤ **In-Band** (default): the transition band is defined as the part of the trace between Level@ **Transition Reference - Min Exclusion Threshold** and Level@ **Transition Reference - Max Exclusion Threshold**.



➤ **Out-Band**: the transition band is defined as the part of the trace between Level@ **Transition Reference + Min Exclusion Threshold** and Level@ **Transition Reference + Max Exclusion Threshold**



➤ **Min Exclusion Thresh.**

(in dB) Minimum threshold for the exclusion of data outside of the transition band.

Default value: 3 dB

➤ **Max Exclusion Thresh.**

(in dB) Maximum threshold for the exclusion of data outside of the transition band.

Default value: 20 dB

Defining Stop Band Test Analysis Parameters

The **Stop Band Test** tool is available for the stop band filter component analysis. It allow you to get isolation depth, average loss, ripple and roll-off characteristics for a pass band filter.

Before starting:

Make sure you have defined the general analysis parameters (see *Defining the Analysis Parameters* on page 57).

To define Stop Band Test analysis parameters:

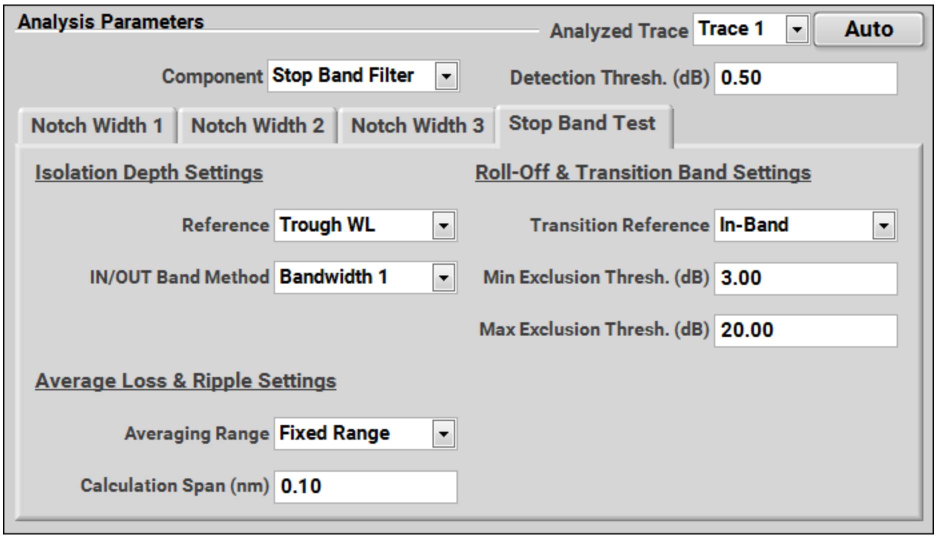
1. In the main window, click the  button located to the left of the **Analyze** button.

   The **Analysis Parameters** window appears.

2. In the **Component** list, select **Stop Band Filter**.

3. In the **Stop Band Test** tab, define the analysis parameters as explained in *Pass Band Test Parameters Description* on page 65.

Stop Band Test Parameters Description

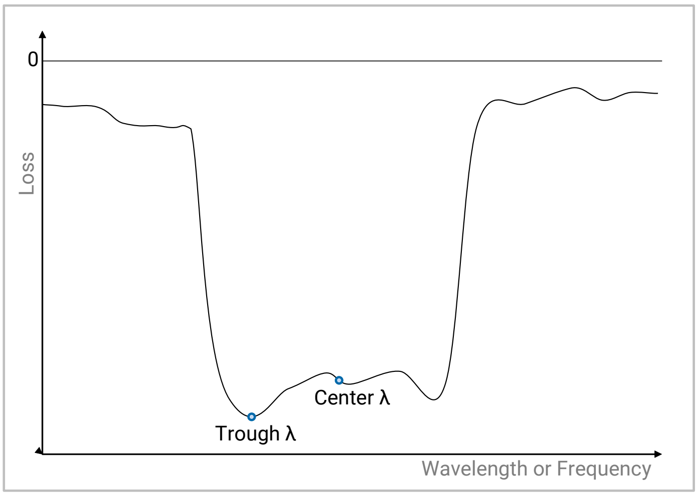


Isolation Depth Settings

- **Reference**

  Reference point taken for the analysis of the characteristics of the filter:

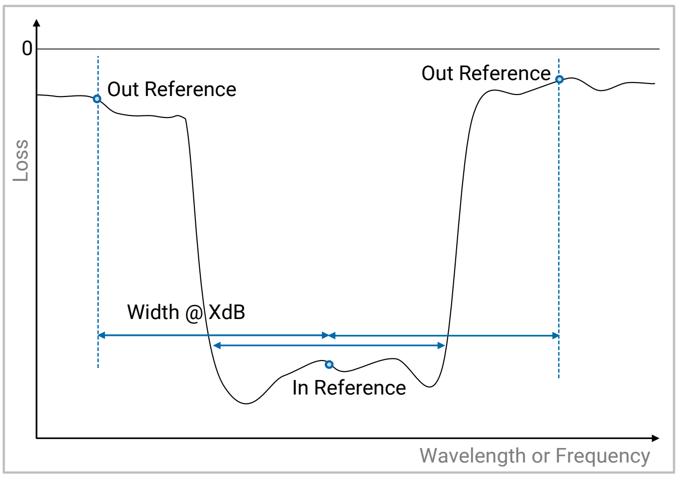
  - **Trough WL** (default): peak wavelength found in the **Notch Width 1** tool results (see *Notch Width x Results* on page 75).
  - **Center WL**: center wavelength found in the **Notch Width 1** tool results (see *Notch Width x Results* on page 75).



- **IN/OUT Band Method**

  Method used in isolation depth calculation for the estimate of the spectral spacing between in and out bands:

  - **Bandwidth 1** (default): selects the out band reference points to be exactly a bandwidth away from the in-band point, using the result in **Notch Width 1** tool (see *Spectral Width x Results* on page 75).
  - **Set Distance**: enables you to set the spacing via the **In/Out Band Distance** parameter.



➤ **IN/OUT Band Distance** (only if **In/Out Band Method** is set to **Set Distance**)

Spectral spacing in nm/THz between the in-band reference point and the out-band reference points to be used for the isolation depth calculation.

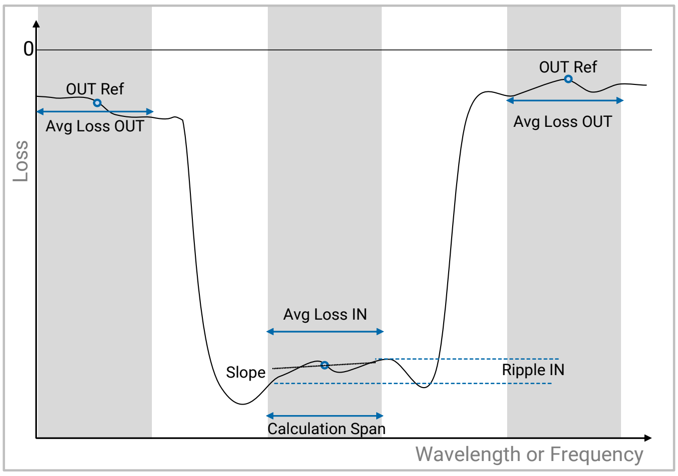
Default value: 1 nm

Average Loss & Ripple Settings

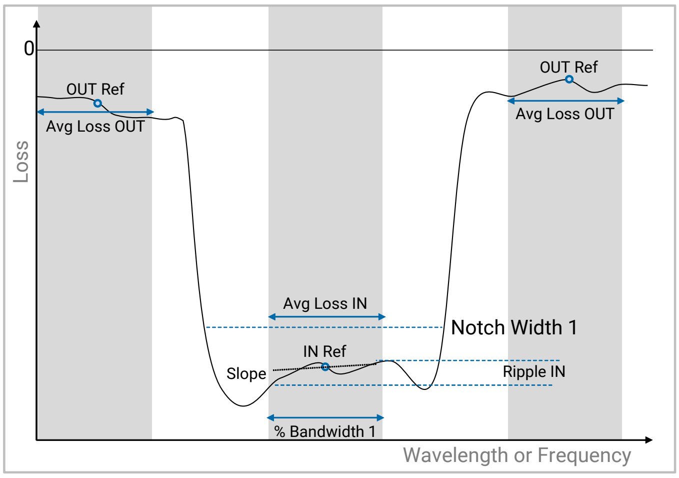
➤ **Averaging Range**

Spectral range used in the analysis of In-band and out-band average loss and ripple.

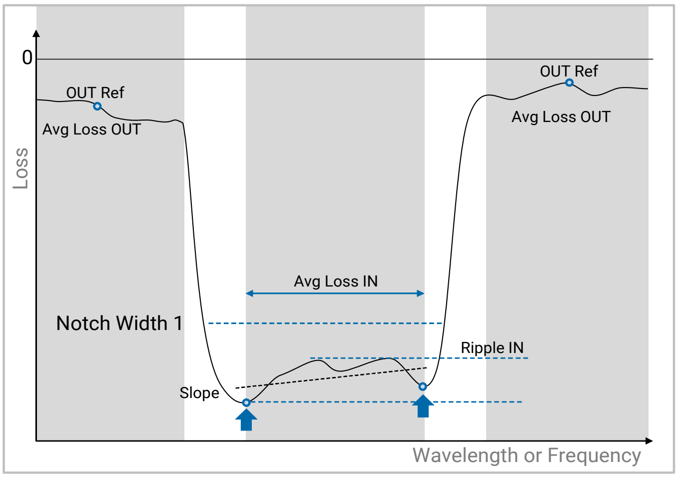
➤ **Fixed Range**: provides a fixed calculation span (see **Calculation Span** parameter).



➤ **% Bandwidth**: sets the range to a fraction of the bandwidth measured from the **Notch Width 1** tool (see *Spectral Width x Results* on page 75).



➤ **PT Detection**: detects all peaks and troughs within the Bandwidth 1 using **Detection Threshold**, The span is then set as the distance between the first and last trough detected for a stop band filter.



In-band and out-band average loss and ripple/slope calculations are performed across a given calculation span centered on their respective reference points as defined in isolation depth settings.

➤ **Calculation Span** (only if **Averaging Range** is set to **Fixed Range**)

Fixed Range in nm/THz over which calculations are done. The range is centered on the reference points for in-band and out-band (set in isolation depth settings). A range of 0 takes a single point for the calculation.

Default value: 0.1 nm

➤ **% Bandwidth** (only if **Averaging Range** is set to **% 3dB Bandwidth**)

Fraction (in %) of the bandwidth calculated in **Notch Width 1** over which calculations are done. The range is centered on the reference points for in-band and out-band (set in isolation depth settings).

Default value: 50 %

➤ **Detection Threshold** (only if **Averaging Range** is set to **PT Detection**)

Threshold in dB for the detection of in-band extreme troughs over which calculations are done. The range is centered on the reference points for in-band (set in isolation depth settings).

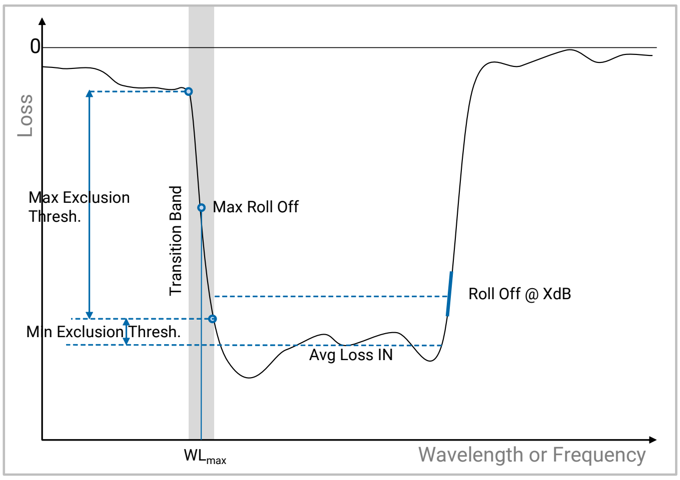
Default: 0.1 dB

Roll-Off & Transition Band Settings

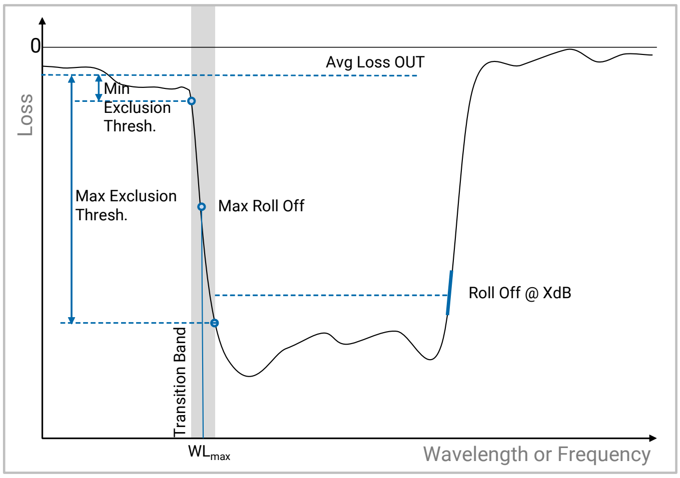
➤ **Transition Reference**

Reference point to be used in the transition calculation:

➤ **In-Band** (default): the transition band is defined as the part of the trace between Level@ **Transition Reference - Min Exclusion Thresh**. and Level@ **Transition Reference - Max Exclusion Thresh**.



➤ **Out-Band**: the transition band is defined as the part of the trace between Level@ **Transition Reference** + **Min Exclusion Thresh**. and Level@ **Transition Reference** + **Max Exclusion Thresh**.



➤ **Min Exclusion Thresh**.

(in dB) Minimum threshold for the exclusion of data outside of the transition band.

Default value: 3 dB

➤ **Max Exclusion Thresh**.

(in dB) Maximum threshold for the exclusion of data outside of the transition band.

Default value: 20 dB.

Displaying and Understanding the Analysis Results

In the main window, the **Analysis Results** tab under the graph provides the results of the analysis.

Before starting:

Make sure you have configured the analysis parameters according to your needs as explained in *Defining the Analysis Parameters* on page 57. The trace number selected for analysis appears on the **Analyze** button.

To display the analysis results:

1. In the main window, click the **Analyze** button.

   If you have activated the automatic analysis, the **Auto** flag appears on the top right corner of the **Analyze** button.

   The **Analysis Results** tab under the graph provides the results of the analysis corresponding to the parameters you have set in the **Parameters** panel (see *Defining the Analysis Parameters* on page 57).

2. For a detailed description of the results, see the tables below.

Spectral Width x Results

Result	Meaning
Peak Wavelength	Calculated peak wavelength/frequency and its associated power.
Level at Peak Wavelength	
Mean Wavelength	Calculated central wavelength/frequency and its associated power.
Level at Mean Wavelength	
Spectral Width@xxdB	Width at **Width Threshold** using the selected algorithm method. For RMS and RMS Peak algorithms, the width is the standard deviation (Sigma).
Sigma	Only for **RMS** and **RMS Peak** algorithms. Standard deviation value of the measured peak.

Notch Width x Results

To be detected correctly, the trough must not be below the **Detection Threshold** value (see *Defining the Analysis Parameters* on page 57).

Result	Meaning
Trough Wavelength	Calculated trough wavelength/frequency and its associated power.
Level at Trough Wavelength	
Notch Wavelength	Calculated central wavelength/frequency and its associated power.
Level at Notch Wavelength	
Notch Width@xxdB	Spectral notch width at **Width Threshold** using the selected algorithm method.

Pass Band Test Results

➤ In-Band Results

Result	Meaning
Average Loss	Average loss in dB measured across **Averaging Range** around the in-band reference point.
Ripple	Uniformity in dB as the min/max level difference measured within **Averaging Range** around the **In-Band** reference point.
Slope	Linear fit slope calculated within **Averaging Range** around the **In-Band** reference point.

➤ Out-Band Side 1 & Out-Band Side 2 Results

Result	Meaning
Average Loss	Average loss in dB measured across **Averaging Range** around the Out-Band reference point.
Ripple	Uniformity in dB as the min/max level difference measured within **Averaging Range** around the **Out-Band** reference point.
CrossTalk	Crosstalk (pass band) in dB measured between the **In-Band** Reference point and the **Out-Band** reference point. The crosstalk is given as difference between points, not between **Average Losses**.
RollOff@xxdB[a]	Roll off in dB/nm (or dB/THz) measured at XdB (set by the **Spectral Width 1** tool) from the **Transition Reference** point.
Max RollOffa	Maximum roll off in dB/nm (or dB/THz), within the transition band.
Max RollOff Wavelength	Wavelength of maximum roll off in nm.
Transition Band[a]	Wavelength region between **Transition Reference** -/+ **Minimum Threshold** and Reference point -/+ **Maximum Threshold**.

a. : This result is calculated between the two reference points set in *CrossTalk Settings* on page 66.

Stop Band Test Results

➤ **In-Band Results**

Result	Meaning
Average Loss	Average loss in dB measured across **Averaging Range** around the in-band reference point.
Ripple	Uniformity in dB as the min/max level difference measured within **Averaging Range** around the **In-Band** reference point.
Slope	Linear fit slope calculated within **Averaging Range** around the **In-Band** reference point.

➤ **Out-Band Side 1 & Out-Band Side 2 Results**

Result	Meaning
Average Loss	Average loss in dB measured across **Averaging Range** around the Out-Band reference point.
Ripple	Uniformity in dB as the min/max level difference measured within **Averaging Range** around the **Out-Band** reference point.
Isolation Depth	Isolation depth in dB measured between the **In-Band** Reference point and the **Out-Band** reference point. The crosstalk is given as difference between points, not between **Average Losses**.
RollOff@xxdB[a]	Roll off in dB/nm (or dB/THz) measured at XdB (set by the **Notch Width 1** tool) from the **Transition Reference** point.
Max RollOffa	Maximum roll off in dB/nm (or dB/THz), within the transition band.
Max RollOff Wavelength	Wavelength of maximum roll off in nm.
Transition Band[a]	Wavelength region between **Transition Reference** -/+ **Minimum Threshold** and Reference point -/+ **Maximum Threshold**.

a. : This result is calculated between the two reference points set in *CrossTalk Settings* on page 66.

Saving Analysis Results

The following procedure explains how to save the analysis results of the CT440 in a .csv file. The file contains the analysis parameters and the corresponding results.

To save analysis results:

1. In the main window, click the **Save** button.
2. In the Explorer window:
   - *2a.* Select **Analysis Results (.csv)**.
   - *2b.* Select the wanted location and enter a name for the file.
3. Click the **Save** button to save the analysis results.

8 Maintenance

To help ensure long, trouble-free operation:

- Always inspect fiber-optic connectors before using them and clean them if necessary.
- Keep the unit free of dust.
- Clean the unit casing and front panel with a cloth slightly dampened with water.
- Store unit at room temperature in a clean and dry area. Keep the unit out of direct sunlight.
- Avoid high humidity or significant temperature fluctuations.
- Avoid unnecessary shocks and vibrations.
- If any liquids are spilled on or into the unit, turn off the power immediately, disconnect from any external power source and let the unit dry completely.

WARNING

The use of controls, adjustments and procedures, namely for operation and maintenance, other than those specified herein may result in hazardous radiation exposure or impair the protection provided by this unit.

WARNING

To avoid personal injury, never remove the protective cover of the chassis to perform servicing or maintenance operations. You must refer to your EXFO service representative.

Cleaning Optical Connectors

To ensure measurement accuracy and prevent loss of optical power, you must verify that optical connectors are clean every time you connect a fiber.

Handle optical fiber with appropriate care and preserve the integrity of optical connectors by keeping them free of contamination.

IMPORTANT

To reduce the need for cleaning, immediately replace protective caps on the optical connectors when not in use.

Before starting:

Make sure you have the following material:

- Optical grade cleaning cotton swabs
- Clean compressed air
- Isopropyl alcohol
- Fiberscope or similar if available

IMPORTANT

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

To clean optical connectors:

1. Turn the CT440 off (see *Turning On/Off the CT440* on page 21) and unplug the power supply cord from the wall socket.
2. Gently clean the connector end, with the following instructions:
   - **2a.** Hold the can of compressed air upright and spray the can into the air to purge any propellant.
   - **2b.** Spray the clean compressed air on the connector to remove any loose particles or moisture.
   - **2c.** Moisten a clean optical swab with isopropyl alcohol and lightly wipe the surfaces of the connector with gentle circular motion.
   - **2d.** Spray the clean compressed air on the connector again to remove any loose particles or isopropyl alcohol.
   - **2e.** Check that the connector is clean with a fiberscope (or similar).

Replacing Fuses

You must verify the power fuses in case you cannot turn on the CT440.

WARNING

To avoid fire hazard, only use the correct fuse type, voltage and current ratings.

The unit contains two fuses (see *Technical Specifications* on page 3 for details). The fuse holder is located at the back of the unit, at the right of the power inlet.

Before starting:

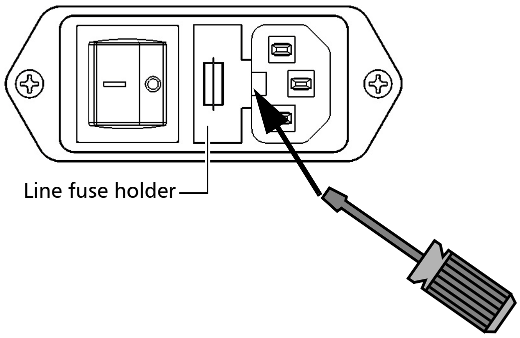
Make sure you have the following equipment:

➤ 1 small flat-head screwdriver.

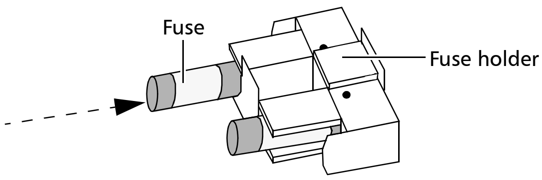
➤ 1 or 2 replacement fuses (for fuse type, see *Technical Specifications* on page 3).

To replace a fuse:

1. Turn off the unit and unplug the power cord.
2. Using a flat-head screwdriver as a lever, pull the fuse holder out of the unit.



3. Check and replace the fuses if necessary.
4. Insert the new fuse into the fuse holder.



5. Make sure the fuses are placed firmly in the holder prior to reinsertion.
6. Firmly push the fuse holder into place.

Cleaning the CT440

If the external cover of the CT440 becomes dirty or dusty, clean it by following the instruction below.

CAUTION

Do not use chemically active or abrasive materials to clean the CT440.

Before starting:

Make sure you have the following material:

➤ Cleaning cloth

➤ Isopropyl alcohol

To clean the CT440:

1. Turn the CT440 off (see *Turning On/Off the CT440* on page 21) and unplug the power supply cord from the wall socket.
2. Slightly damp the cloth with an isopropyl alcohol liquid and gently swipe dirt and dust on the external cover of the CT440, without applying excessive force onto it.

Recalibrating the CT440

Some calibration steps require the adjustment of internal optical components.

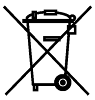
The calibration validity period depends on the intensity of use and environmental conditions. You can determine the adequate calibration interval for your CT440 according to your accuracy requirements.

Under normal conditions of use, we recommend to perform a factory recalibration of the CT440 after one year of normal use.

To ask for a factory recalibration:

Contact the EXFO customer support service (see *Contacting the Technical Support Group* on page 89)

Recycling and Disposal



This symbol on the product means that you should recycle or dispose of your product (including electric and electronic accessories) properly, in accordance with local regulations. Do not dispose of it in ordinary garbage receptacles.

For complete recycling/disposal information, visit the EXFO Web site at www.exfo.com/recycle.

9 Troubleshooting

Trouble	Possible Resolution
The CT440 is not recognized by the computer	See *Activating the USB Driver* on page 88.
The CT440 GUI does not start	See *Warning & Error Messages* on page 83.
The CT440 comes offline during use	Restart both GUI and instrument to detect the CT440 again.
The GUI displays an error or warning message	See *Warning & Error Messages* on page 83.
The ⚠ icon appear in the GUI (at the left of the date and time)	See *Warning & Error Messages* on page 83.

Warning & Error Messages

The following table lists all the possible warning and error messages, and how to handle them.

Error or warning	Possible Cause	Possible solution
The ⚠ icon appear in the GUI, at the left of the date and time (on CT440 with PDL option only).	Some points are missing in the PDL calculation: the CT440-PDL could not calculate PDL for a few measurement points.	➤ Verify that the CT440-PDL is set on a flat stable surface without vibration. ➤ Verify that optical connectors are clean. ➤ Verify that optical connectors are properly connected to the CT440-PDL and tightly locked in position. ➤ Use the 6-state PDL measurement method: in the **Scan Parameters** window, select **6 States** in the **PDL Method** list (see *Configuring Scan Parameters* on page 35).
No Supported Languages - Unable to open resource files	The CT440 GUI uses LabVIEW2013 RunTime. If the CT440 GUI does not start, it may be necessary to repair the RunTime files.	➤ From the Windows Control panel, in the **Remove Programs** window, right-click the National Instruments program and select **Unistall/Change**. ➤ Repair the NI LabVIEW Runtime Engine 2013. ➤ Restart the PC.
[warning code 100] **Mode hops on the scan**	Mode hopping occurred during the scan on one TLS.	Make sure the source performances meet the requirements detailed in *Product Features* on page 1.
[warning code 101] **Scan speed too low**	➤ The mean sweeping speed of the TLS is too low (< 8nm/s) ➤ The reference file is not located in the correct folder.	➤ Raise the scan speed. ➤ Make sure the reference file is located in the proper **Calib** folder: C:\Users\Public\Documents\EXFO\CT440\Calib

Error or warning	Possible Cause	Possible solution
[warning code 102] **Scan speed too high**	➤ The mean scanning speed of the TLS is too high (> 120nm/s). ➤ The reference file is not located in the correct folder.	➤ Decrease the scan speed. ➤ Make sure the reference file is located in the proper Calib folder: C:\Users\Public\Documents\EXFO\CT440\Calib Make sure the reference file is located in the proper Calib folder: C:\Users\Public\Documents\EXFO\CT440\Calib
[warning code 103] **High dynamical changes at low level, reduce scan speed**	The scan speed and input power are not suited for the measurement.	Decrease the scan speed.
[warning code 104] **Unexpected source behavior, check TLS performance**	The internal wavelength referencing has detected a troubling behavior.	➤ Make sure the source performances meet the requirements detailed in *Product Features* on page 1. ➤ Make sure that the input power meet the requirements detailed in *Technical Specifications* on page 7.
[warning code 106] **Low power on one TLS input**	The power in the input port is below -16 dBm.	➤ Make sure the jumper is clean and properly connected to the optical input of the CT440. ➤ Make sure the TLS performances meet the requirements detailed in *Product Features* on page 1.

Error or warning	Possible Cause	Possible solution
[warning code 108] **Numerous mode hops or multimoding behavior**	➤ The TLS is out of specification due to multimode behavior or numerous mode hops. ➤ The reference file is not located in the correct folder or is corrupted.	➤ Make sure the source performances meet the requirements detailed in *Product Features* on page 1. ➤ Make sure that the coherence control is disabled on the TLS. ➤ Make sure the reference file is located in the proper Calib folder: C:\Users\Public\Documents\EXFO\CT440\Calib Make sure the reference file is located in the proper Calib folder: C:\Users\Public\Documents\EXFO\CT440\Calib ➤ Reset the reference file as follows: 1. In the **Calib** folder, delete the reference file *File<serial number>.dat* file. 2. Restart the program. The original factory calibration file is automatically downloaded from the CT440. 3. Perform a power referencing (see *Performing Power Referencing* on page 28). ➤ Make sure to perform a wavelength referencing operation in the laser (see the corresponding laser user manual).
[warning code 109] **High TLS input power variations: check TLS sources**	The power in the input port varies randomly above the specified value.	Make sure the source performances meet the requirements detailed in *Product Features* on page 1.
[warning code 110] **Too high input power during the scan: check input power**	The power in the input port is above the specified value.	Decrease the input power to meet the specifications detailed in *Technical Specifications* on page 7.
[warning code 111 to 114] **Power on DET1/DET2/DET3/DET4 too high: check set up**	The power on the detector is above specified value.	Decrease the input power to meet the specifications detailed in *Technical Specifications* on page 7. Do not use and optical amplifier before the detector.
[warning code 115] **Spurious input power: check set-up**	Optical power has been detected where it is not supposed to happen.	Verify that the lasers are connected to the correct input ports of the CT440.

Error or warning	Possible Cause	Possible solution
[warning code 117 to 120] **Power too low on IN port 1/port 2/port 3/port 4**	The power in the TLS input port is below the specified value.	➤ Make sure the jumper is clean and properly connected to the corresponding optical inputs ➤ Make sure the TLS performances meet the requirements detailed in *Technical Specifications* on page 7.
[warning code 121 to 124] **Power too high on IN port 1/port 2/port 3/port 4**	The power in the TLS input port is above the specified value.	Decrease the input power to meet the specifications detailed in *Technical Specifications* on page 7.
[warning code 999] **The current sampling resolution does not allow to memorize all the points. The sampling resolution has been set to x pm.**	The resolution is too high for the running conditions. Scan is performed.	The selected resolution is automatically replaced by a more appropriate resolution.
Invalid laser power (x mW)	➤ The type of laser used (TUNICS T100R or TUNICS Reference) is not properly selected in the **Scan Parameters** window, in the **Laser Type** list. ➤ The wavelength range selected for the scan is not allowed on the laser.	➤ Restart the laser and properly configure the measurement parameters in the **Scan Parameters** window before starting a scan.
[error code 1] **The measurement has been canceled by the user**	This error only occurs if the **Abort** button has been activated by the user or the **CT440_ScanAbort** function has been called by the user.	-
[error code 2] **Failure in data exchange with the DSP**	A failure occurred during the communication between the computer and the internal DSP. For example, the number of points expected by the computer does not correspond to the number of points sent by the DSP.	➤ Check the USB connection. ➤ Contact the EXFO customer support service (see *Contacting the Technical Support Group* on page 89).

Error or warning	Possible Cause	Possible solution
[error code 3] **Error in the wavelength referencing**	➤ The reference file is not saved in the correct folder. ➤ If more than one laser is used, at least one input port is inversed.	➤ Check the input power of the laser ➤ Make sure the reference file is located in the proper Calib folder: C:\Users\Public\Documents\EXFO\CT440\Calib *Make sure the reference file is located in the proper Calib folder: C:\Users\Public\Documents\EXFO\CT440\Calib* ➤ Verify that the lasers are connected to the correct input port of the CT440, so that the wavelength ranges follow the port order.
[error code 4] **Switch failure**	Hardware failure on the optical switch.	Contact the EXFO customer support service (see *Contacting the Technical Support Group* on page 89).
[error code 5] **Failure in the communication with the DSP**	No communication at all is established between the computer and the internal DSP.	➤ Check the USB connection. ➤ Contact the EXFO customer support service (see *Contacting the Technical Support Group* on page 89).
[error code -1001] **The DSP version of the CT440 is incompatible with the DLL**	The version of the CT440 library is not compatible with the version of the CT440 DSP.	Install the last version of the GUI software on the PC as described in *Installing/Updating the CT440 Software Package on Your Computer* on page 20.

Activating the USB Driver

When you connect a CT440 to your computer, the appropriate USB driver may not be selected. You may have to install it again in case you connect another CT440 model to your computer.

The CT440 software is fully-compatible with USB 2.0.

Before starting:

➤ Make sure the CT440 software package is installed (see *Installing/Updating the CT440 Software Package on Your Computer* on page 20).

➤ Make sure you have the USB-A to USB-B cable delivered with the product.

To activate the USB driver:

1. Turn on the CT440 (see *Turning On/Off the CT440* on page 21).
2. Using the USB cable, connect the USB-A 2.0 port of your computer to the CT440 USB-B connector located on the rear panel.
   ➤ The first time you connect the CT440 to your computer, it prompts you to select the USB driver.
   ➤ If you are not prompted to select the USB driver, do the following:
   In the Windows **Device Manager** (**Control Panel**>**System and Security**>**System**), right-click the **CT440 USB Device** and select **Update driver**.
   You are prompted to select the appropriate driver.
3. To select the USB driver, browse your computer and select the following location:
   C:\Program Files (x86)\EXFO\CT440\USB Driver
   The CT440 can now communicate with your computer.

Contacting the Technical Support Group

To obtain after-sales service or technical support for this product, contact EXFO at one of the following numbers. The Technical Support Group is available to take your calls from Monday to Friday, 8:00 a.m. to 7:00 p.m. (Eastern Time in North America).

Technical Support Group
400 Godin Avenue
Quebec (Quebec) G1M 2K2
CANADA

1 866 683-0155 (USA and Canada)
Tel.: 1 418 683-5498
Fax: 1 418 683-9224
support@exfo.com

For detailed information about technical support, and for a list of other worldwide locations, visit the EXFO Web site at www.exfo.com.

If you have comments or suggestions about this user documentation, you can send them to customer.feedback.manual@exfo.com.

To accelerate the process, please have information such as the name and the serial number (see the product identification label), as well as a description of your problem, close at hand.

Transportation

Maintain a temperature range within specifications when transporting the unit. Transportation damage can occur from improper handling. The following steps are recommended to minimize the possibility of damage:

- Pack the unit in its original packing material when shipping.
- Avoid high humidity or large temperature fluctuations.
- Keep the unit out of direct sunlight.
- Avoid unnecessary shocks and vibrations.

For instructions on returning the CT440, please contact EXFO (see *Contacting the Technical Support Group* on page 89).

10 Installing/Updating the CT440 Library

This section explains how to install the CT440 library on your computer, and update it from a preceding version to the new one.

All features of the CT440 DLL are described in *Description of Functions* on page 97.

The CT440 DLL applies to all models of CT440.

Application

Information applies to the CT440 library v 1.1.x (with DSP version 2.00) and operating systems from Windows 7 to Windows 10.

Intended Readers

Users of this section must be familiar with:

- The use of a C compiler or the use of the LabVIEW software
- The use of the CT440 product

CT440 Library - Presentation

The CT440 library is provided with the CT440 software package.

When installed on your computer, the **Library x.xx** folder contains two folders:

- **PDL** folder, dedicated to the CT440 with PDL option
- **STD** folder, dedicated to the CT440 without PDL option

Each folder contains two versions of the library located in two different folders: one dedicated to 32-bit platforms and one dedicated to 64-bit platforms. Each folder contains the following files:

- **CT440_lib.dll** is the main DLL.
- **CT440_lib.h**/**CT440_lib-PDL.h** is the main DLL header file for CT440/CT440 with PDL option.
- **CT440_Types.h** is a support header file; it defines the integer types used.
It is recommended to use the integer types defined in this file.
- The **Labview** directory contains the corresponding LabVIEW library, with an example.
- **ftd2xx.dll**/**ftd2xx64.dll** is a DLL dependency (USB Driver).
- **Borland** and **MSVC** directories contains Lib files with the corresponding COFF format for both 32- and 64-bit MSCV; OMF format for Borland 32-bit: ELF format for Borland 64-bit.
- Examples (see *Program Examples* on page 157):
  - **CT440_testwrap.c**/**CT440-PDL_testwrap.c** are examples of the DLL use in C language.
  - **CT440_testwrap.py**/**CT440-PDL_testwrap.py** are examples of CT440/CT440 with PDL option control file in Python language.
  - In the **Labview** folder the **CT440_testwrap.vi**/**CT440-PDL_testwrap.vi** are examples of the DLL use in LabVIEW (see *Program Examples* on page 157).

Installing the Library

To install the CT440 library, you must install the CT440 software package, as explained in the following procedure.

To install the library:

1. Install the CT440 software package as described in *Installing/Updating the CT440 Software Package on Your Computer* on page 20.

   The CT440 library is installed in the following folder:
   C:\Program Files (x86)\EXFO\CT440\Library x.xx

2. Start the GUI software and make sure you can operate the CT440 and laser through the graphical user interface.

   If the new version requires an update of the DSP code of the unit, you are prompted to upgrade the CT440 DSP. In this case, click **Yes** to update the DSP.

3. Create your own project with your preferred IDE and Compiler.

4. In this project, include all files contained in the **Win32** or **Win64** folder. All DLL files must be in the same folder as your final executable/DLL.

Updating the CT440 Library to the New Version v. 1.1.x

If you are using programs written with a previous library of the CT440 library, you must make them compatible with the new version, as explained in the following procedure:

To update the library:

1. Install the last version of the software package on the PC as described in *Installing/Updating the CT440 Software Package on Your Computer* on page 20.

   The new version of the library is installed in the following folder:
   C:\Program Files (x86)\EXFO\CT440\Library

2. If you use LabVIEW, replace the LabVIEW library by the new one.

3. Replace the following existing files and directories by the new ones (located in the **Win32** or **Win64** folder, depending on your Windows platform):

   - **CT440_lib.h**/**CT440_lib-PDL.h**, **CT440_Types.h** and **CT440_lib.dll** files.
   - **Borland** and **MSVC** directories.
   - **ftd2xx.dll**/**ftd2xx64.dll** file.

4. In your existing programs, modify the following updated data type:

   Rename the existing **LS_TunicsT100s_HP** rLaserSource data type value into **LS_T100S_HP** (see *Data Types* on page 97).

11 Warranty

General Information

EXFO Inc. (EXFO) warrants this equipment against defects in material and workmanship for a period of 1 from the date of original shipment. EXFO also warrants that this equipment will meet applicable specifications under normal use.

During the warranty period, EXFO will, at its discretion, repair, replace, or issue credit for any defective product, as well as verify and adjust the product free of charge should the equipment need to be repaired or if the original calibration is erroneous. If the equipment is sent back for verification of calibration during the warranty period and found to meet all published specifications, EXFO will charge standard calibration fees.

IMPORTANT

The warranty can become null and void if:

- **unit has been tampered with, repaired, or worked upon by unauthorized individuals or non-EXFO personnel.**
- **warranty sticker has been removed.**
- **case screws, other than those specified in this guide, have been removed.**
- **case has been opened, other than as explained in this guide.**
- **unit serial number has been altered, erased, or removed.**
- **unit has been misused, neglected, or damaged by accident.**

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL EXFO BE LIABLE FOR SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

Liability

EXFO shall not be liable for damages resulting from the use of the product, nor shall be responsible for any failure in the performance of other items to which the product is connected or the operation of any system of which the product may be a part.

EXFO shall not be liable for damages resulting from improper usage or unauthorized modification of the product, its accompanying accessories and software.

Exclusions

EXFO reserves the right to make changes in the design or construction of any of its products at any time without incurring obligation to make any changes whatsoever on units purchased. Accessories, including but not limited to fuses, pilot lamps, batteries and universal interfaces (EUI) used with EXFO products are not covered by this warranty.

This warranty excludes failure resulting from: improper use or installation, normal wear and tear, accident, abuse, neglect, fire, water, lightning or other acts of nature, causes external to the product or other factors beyond the control of EXFO.

IMPORTANT

In the case of products equipped with optical connectors, EXFO will charge a fee for replacing connectors that were damaged due to misuse or bad cleaning.

Certification

EXFO certifies that this equipment met its published specifications at the time of shipment from the factory.

Service and Repairs

EXFO commits to providing product service and repair for five years following the date of purchase.

To send any equipment for service or repair:

1. Call one of EXFO's authorized service centers (see *EXFO Service Centers Worldwide* on page 96). Support personnel will determine if the equipment requires service, repair, or calibration.
2. If equipment must be returned to EXFO or an authorized service center, support personnel will issue a Return Merchandise Authorization (RMA) number and provide an address for return.
3. If possible, back up your data before sending the unit for repair.
4. Pack the equipment in its original shipping material. Be sure to include a statement or report fully detailing the defect and the conditions under which it was observed.
5. Return the equipment, prepaid, to the address given to you by support personnel. Be sure to write the RMA number on the shipping slip. *EXFO will refuse and return any package that does not bear an RMA number.*

Note: *A test setup fee will apply to any returned unit that, after test, is found to meet the applicable specifications.*

After repair, the equipment will be returned with a repair report. If the equipment is not under warranty, you will be invoiced for the cost appearing on this report. EXFO will pay return-to-customer shipping costs for equipment under warranty. Shipping insurance is at your expense.

Routine recalibration is not included in any of the warranty plans. Since calibrations/verifications are not covered by the basic or extended warranties, you may elect to purchase FlexCare Calibration/Verification Packages for a definite period of time. Contact an authorized service center (see *EXFO Service Centers Worldwide* on page 96).

EXFO Service Centers Worldwide

If your product requires servicing, contact your nearest authorized service center.

EXFO Headquarters Service Center
400 Godin Avenue
Quebec (Quebec) G1M 2K2
CANADA

1 866 683-0155 (USA and Canada)
Tel.: 1 418 683-5498
Fax: 1 418 683-9224
support@exfo.com

EXFO Europe Service Center
Winchester House, School Lane
Chandlers Ford, Hampshire S053 4DG
ENGLAND

Tel.: +44 2380 246800
Fax: +44 2380 246801
support.europe@exfo.com

EXFO Telecom Equipment (Shenzhen) Ltd.
3rd Floor, Building C,
FuNing Hi-Tech Industrial Park, No. 71-3,
Xintian Avenue,
Fuhai, Bao'An District,
Shenzhen, China, 518103

Tel: +86 (755) 2955 3100
Fax: +86 (755) 2955 3101
support.asia@exfo.com

To view EXFO's network of partner-operated Certified Service Centers nearest you, please consult EXFO's corporate website for the complete list of service partners:
http://www.exfo.com/support/services/instrument-services/exfo-service-centers.

A Description of Functions

This section describes all functions of the CT440 Library.

Data Types

The following table describes all specific data types defined for the CT440 library.

Data Type	Description and Possible Values
rLaserSource	Type of laser: ➤ LS_TunicsPlus ➤ LS_TunicsPurity ➤ LS_TunicsReference ➤ LS_T100S_HP (for TUNICS T100S and T100S-HP) ➤ LS_TunicsT100r ➤ LS_JdsuSws ➤ LS_Agilent
rLaserInput	Laser input number on the CT440 front panel: ➤ LI_1 ➤ LI_2 (not applicable to models with only one input port) ➤ LI_3 (not applicable to models with only one input port) ➤ LI_4 (not applicable to models with only one input port)
rDetector	Detector number on the CT440 front and rear panels: ➤ DE_1 ➤ DE_2 ➤ DE_3 ➤ DE_4 ➤ DE_5 (analog input of an external detector connected to the **Analog In** BNC connector on the rear panel)
rEnable	State: ➤ DISABLE ➤ ENABLE
rUnit	Units: ➤ Unit_mW ➤ Unit_dBm

Initialization Functions

CT440_Init

Applicability	All models of CT440.
Description	This function initializes the DLL for connection to a CT440 and returns a handle. If the DSP version of the CT440 is not compatible with the DLL in use, a pop-up window prompts you to automatically upgrade the DSP firmware.
Declaration	uint64_t CT440_Init(int32_t *iError);
Parameter	**iError** Initialized variable that stores the error code (-1001) produced in case the DSP version is not compatible with the CT440 library version. Type: Input/Output Data type: int32
Return value	Handle used in subsequent functions. ➤ 0: the initialization failed. ➤ > 0: the initialization succeeded. Data type: unsigned int64

Example	int32_t iError = 0;
	uint64_t uiHandle;
	uiHandle = CT440_Init(&iError);

CT440_CheckConnected

Applicability	All models of CT440.
Description	This function verifies if the CT440 is connected to the computer.
Declaration	int32_t CT440_CheckConnected(uint64_t uiHandle);
Parameter	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64
Return value	➤ 1: a CT440 is connected. ➤ 0: no CT440 is connected. Data type: int32
Example	int32_t isCT440_connected; isCT440_connected = CT440_CheckConnected(uiHandle);

CT440_Close

Applicability	All models of CT440.
Description	This function closes the connection between your application and the CT440. It also releases all memory allocated by **CT440_Init**.
Declaration	int32_t CT440_Close(uint64_t uiHandle);
Parameter	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64
Return value	➤ 1: the closing operation succeeded. ➤ -1: the closing operation failed. Data type: int32
Example	CT440_Close(uiHandle);

Configuration Functions

CT440_SetLaser

Applicability	All models of CT440.
Description	This function configures the parameters of the laser connected to the CT440. In the GUI, this function corresponds to the **Laser Settings** area in the **Scan Parameters** window.
Declaration	int32_t CT440_SetLaser(uint64_t uiHandle, rLaserInput eLaser, rEnable eEnable, int32_t iGPIBInterfaceID, int32_t iGPIBAdress, rLaserSource eLaserType, double dMinWavelength, double dMaxWavelength, int32_t Speed);
Parameters	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64 **eLaser** Laser input number. Possible values: see *Data Types* on page 97. Type: Input Data type: rLaserInput **eEnable** Enables/Disables the laser output. Possible values: see *Data Types* on page 97. Type: Input Data type: rEnable

CT440_SetLaser

Parameters

iGPIBInterfaceID

GPIB interface ID of laser GPIB controller. Refer to your GPIB controller firmware setup to set the correct ID number.

Possible values: 0 to 100

Type: Input

Data type: int32

iGPIBAdress

GPIB address of the laser.

Possible values: 1 to 30

Type: Input

Data type: int32

eLaserType

Laser type.

Possible values: see *Data Types* on page 97.

Type: Input

Data type: rLaserSource

dMinWavelength

Laser minimum wavelength in nm.

Possible values: minimum of the wavelength range of the laser.

Type: Input

Data type: double

dMaxWavelength

Laser maximum wavelength in nm.

Possible values: maximum of the wavelength range of the laser.

Type: Input

Data type: double

Speed

Speed of laser in nm/s.

Possible values: from 10 to 100, limited to laser speed specifications.

Type: Input

Data type: int32

Return value

- 0: the laser setting operation succeeded.
- -1: the laser setting operation failed.

Data type: int32

Example

CT440_SetLaser(uiHandle,LI_1,ENABLE,0,12,LS_T100S_HP,1480.0,1600.0,100);

CT440_CmdLaser

Applicability

All models of CT440.

Description

This function enables you to control a laser connected to the computer via GPIB. It sets the wavelength, power and state (enable/disable).

Declaration

```
int32_t CT440_CmdLaser(uint64_t uiHandle,
    rLaserInput eLaser,
    rEnable eEnable,
    double dWavelength,
    double dPower);
```

Parameters

uiHandle

Handle returned from **CT440_Init**

Type: Input

Data type: unsigned int64

eEnable

Enables/Disables the laser output.

Possible values: see *Data Types* on page 97.

Type: Input

Data type: rEnable

eEnable

Enables/Disables the laser output.

Possible values: see *Data Types* on page 97.

Type: Input

Data type: rEnable

dWavelength

Laser wavelength to set in nm.

Possible values: depend on the laser's wavelength range.

Type: Input

Data type: double

dPower

Laser power to set in mW.

Possible values: depend on the laser's power specifications.

Type: Input

Data type: double

Return value

- 0: the operation succeeded.
- -1: the operation failed.

Data type: int32

Example

```
CT440_CmdLaser(uiHandle,LI_1,ENABLE,1500.0, 1.0);
```

CT440_SwitchInput

Applicability	CT440 models with twoor more TLS input ports.
Description	This function selects the CT440 input port, which enables the use of the laser connected to this port.
Declaration	int32_t CT440_SwitchInput(uint64_t uiHandle, rLaserInput eLaser);
Parameters	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64 **eLaser** Laser input number. Possible values: *Data Types* on page 97 Type: Input Data type: rLaserInput
Return value	➤ 0: the operation succeeded. ➤ -1: the operation failed. Data type: int32
Example	CT440_SwitchInput(uiHandle,1);

CT440_SetScan

Applicability	All models of CT440.
Description	This function sets the scan parameters. In the GUI, this function corresponds to the **Scanning Range** settings in the **Scan Parameters** window.
Declaration	int32_t CT440_SetScan(uint64_t uiHandle, double dLaserPower, double dMinWavelength, double dMaxWavelength, uint32_t * uiResolution);
Parameters	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64 **dLaserPower** Laser power for the scan in mW, between 1 and 10 mW. Possible values: depend on the laser's power specifications. Type: Input Data type: double **dMinWavelength** Laser minimum wavelength in nm. Possible values: minimum of the wavelength range of the laser. Type: Input Data type: double **dMaxWavelength** Laser maximum wavelength in nm. Possible values: maximum of the wavelength range of the laser. Type: Input Data type: double **uiResolution** Pointer over an initialized variable to store the sampling resolution in pm. An automatic adjustment of resolution may occur due to the limited number of points. In this case, the pointer returns the new resolution. Possible values: ➤ On CT440 without PDL option: 1 to 250 ➤ On CT440 with PDL option: 5 to 250 For resolution < 5 pm, the PDL measurement is not guaranteed. Type: Input/ouput Data type: unsigned int32*

CT440_SetScan

Return value

- 0: the operation succeeded.
- -1: the operation failed.

Data type: int32

Example

```
uint32_t *uiResolution = 0;
uiResolution = (uint32_t *) calloc(1, sizeof(uint32_t));
*uiResolution = 5;
CT440_SetScan(uiHandle, 1.0, 1500.0, 1600.0, uiResolution);
free(uiResolution);
```

CT440_SetDetectorArray

Applicability

All models of CT440.

Description

This function enables the CT440 detectors and the **Analog In** BNC port so that data can be read from these ports.

Detector 1 is always enabled.

The number of enabled detectors impacts the number of points available for measurements (see functions *CT440_ScanGetWavelengthSyncArray* on page 122, *CT440_ScanGetWavelengthResampledArray* on page 124, *CT440_ScanGetPowerSyncArray* on page 126, *CT440_ScanGetPowerResampledArray* on page 128, *CT440_ScanGetDetectorArray* on page 130, *CT440_ScanGetDetectorResampledArray* on page 133,

In the GUI, this function corresponds to the **Source** selection setting in the **Trace X Parameters** window.

Declaration

```
int32_t CT440_SetDetectorArray(uint64_t uiHandle,
rEnable eDect2,
rEnable eDect3,
rEnable eDect4,
rEnable eExt);
```

CT440_SetDetectorArray

Parameters	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64 **eDect2** Enables/Disables the detector 2. Possible values: see *Data Types* on page 97. Type: Input Data type: rEnable **eDect3** Enables/Disables the detector 3. Possible values: see *Data Types* on page 97. Type: Input Data type: rEnable **eDect4** Enables/Disables the detector 4. Possible values: see *Data Types* on page 97. Type: Input Data type: rEnable **eExt** Enables/Disables the **Analog In** BNC connector (located on the rear panel of the instrument). Possible values: see *Data Types* on page 97. Type: Input Data type: rEnable
Return value	➤ 0: the operation succeeded. ➤ -1: the operation failed. Data type: int32
Example	CT440_SetDetectorArray(uiHandle,DISABLE,DISABLE,DISABLE,DISABLE);

CT440_PolState

Applicability	CT440 with PDL option only.
Description	This function sets the state of polarization of the polarization state generator in the CT440 with PDL option. For 4-states method PDL measurement, you must provide the states 0; 1; 2; 5 in that order to be able to use the *CT440_CalcPDL4OneDET* on page 147 for PDL calculation.
Declaration	int32_t CT440_Polstate(uint64_t uiHandle, int iState);
Parameters	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64 **eState** State of polarization: Possible values: ➤ 0: (101010) LVP Linearly vertical polarized ➤ 1: (101111) LHP Linearly horizontal polarized ➤ 2: (101000) L+45 Linear +45° polarized ➤ 3: (101011) L-45 Linear -45° polarized ➤ 4: (110101) RCP Right circularly polarized ➤ 5: (000101) LCP Left circularly polarized Type: Input Data type: int
Return value	➤ 0: the operation succeeded. ➤ -1: the operation failed. Data type: int32
Example	CT440_Polstate(uiHandle, 0);

CT440_SetBNC

Applicability

All models of CT440.

On CT440 with PDL option, PDL measurement is not guaranteed if you use the BNC C interface.

Description

This function configures the CT440 BNC analog port labeled C (located on the rear panel of the instrument) during the scan.

This function enables you to get the measured voltage converted in dBm or mW, according to the entered parameters.

If this function is not called, the C detector can still be read; in this case the returned values represent the voltage at the port (see functions *CT440_ScanGetDetectorArray* on page 130 and *CT440_ScanGetDetectorResampledArray*).

In the GUI, this function corresponds to the **Analog In BNC** settings in the **Referencing** window.

Declaration

int32_t CT440_SetBNC(uint64_t uiHandle,
rEnable eEnable,
double dAlpha,
double dBeta,
rUnit eUnit);

Parameters

uiHandle

Handle returned from **CT440_Init**

Type: Input

Data type: unsigned int64

eEnable

Enables/Disables the laser output.

Possible values: see *Data Types* on page 97.

Type: Input

Data type: rEnable

dAlpha

Conversion factor (slope) in mW/V or dBm
(P = dBeta + dAlpha x V)
Possible values: depend on the external power meter or detector used.
Type: Input
Data type: double

CT440_SetBNC

	dBetadAlpha Optical power (offset) Beta parameter in mW or dBm (P = dBeta + dAlpha x V) Possible values: depend on the external power meter or detector used. Type: Input Data type: double **eUnit** Units: Possible values: Possible values: see *Data Types* on page 97. Type: Input Data type: rUnit
Return value	➤ 0: the operation succeeded. ➤ -1: the operation failed. Data type: int32
Example	CT440_SetBNC(uiHandle,ENABLE,1,0,Unit_mW);

CT440_SetExternalSynchronization

Applicability	All models of CT440. On CT440 with PDL option, you cannot use this function to perform a direct PDL measurement. PDL measurements use resampled data, not raw data.
Description	This function configures the CT440 external synchronization output (**Trigger Out**BNC connector located on the rear panel of the instrument). The CT440 generates a pulse each time a measurement occurs. For more details on this function, see *Synchronizing the CT440 with External Measurements* on page 44. In the GUI, this function is always enabled.
Declaration	in32_t CT440_SetExternalSynchronization (uint64_t uiHandle, rEnable eEnable);
Parameters	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64 **eEnable** Enables/Disables the laser output. Possible values: see *Data Types* on page 97. Type: Input Data type: rEnable
Return value	➤ 0: the operation succeeded. ➤ -1: the operation failed. Data type: int32
Example	CT440_SetExternalSynchronization(uiHandle,ENABLE);

CT440_SetExternalSynchronizationIN

Applicability

All models of CT440.

Description

This function configures the CT440 to run a scan triggered by the connected tunable laser (**Trigger In** BNC connector located on the rear panel of the instrument).

For more details, see *Setting up a Triggered Scan* on page 42.

In the GUI, this function corresponds to the **Single Trig** or **Continuous Trig** scanning modes in the **Scan Parameters** window.

On the T100S-HP, the λ BNC output must be activated as a trigger (for more details, see *T100S-HP User Manual*).

Declaration

int32_t CT440_SetExternalSynchronizationIN

(uint64_t uiHandle,

rEnable eEnable);

Parameters

uiHandle

Handle returned from **CT440_Init**

Type: Input

Data type: unsigned int64

eEnable

Enables/Disables the laser output.

Possible values: see *Data Types* on page 97.

Type: Input

Data type: rEnable

If Enable, the CT440 waits for an external trigger on the **Trigger In** BNC port to start measurements.

Return value

- 0: the operation succeeded.
- -1: the operation failed.

Data type: int32

Example

CT440_SetExternalSynchronizationIN(uiHandle,ENABLE);

CT440_UpdateWavelengthReference

Applicability	All models of CT440.
Description	This function modifies the reference wavelength by adding an offset to the factory wavelength calibration. In the GUI, this function corresponds to the **Wavelength Referencing** area in the **Referencing** window.
Declaration	int32_t CT440_UpdateWavelengthReference(uint64_t uiHandle, double RefWavelength, double MeasuredWavelength);
Parameters	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64 **RefWavelength** Wavelength value (in nm) of the reference (laser or gas cell). Type: Input Data type: double **MeasuredWavelength** Wavelength value (in nm) measured by the CT440. Type: Input Data type: double
Return value	➤ 0: the operation succeeded. ➤ -1: the operation failed. Data type: int32
Example	CT440_UpdateWavelengthReference(uiHandle, 1560.0, 1560.2);

CT440_MeasureDark

Applicability	All models of CT440.
Description	This function measures the power on the selected detector and stores it for power correction. The measured power is automatically taken into account for correction in the next power measurement. In the GUI, this function is identical to the **Zero Detector X** buttons in the **Referencing** window.
Declaration	int32_t CT440_MeasureDark (uint64_t uiHandle, rDetector eDetector);
Parameters	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64 **eDetector** Front panel detector number. Possible values: DE_1; DE_2; DE_3; DE_4. Type: Input Data type: rDetector
Return value	➤ 0: the operation succeeded. ➤ -1: the operation failed because of invalid uiHandle ➤ -2: the operation failed because of missing calibration file ➤ -3: the operation failed because of too much power on is measured on the detector Data type: int32
Example	CT440_MeasureDark (uiHandle,DE_1);

CT440_ResetDark

Applicability	All models of CT440.
Description	This function removes the detector dark current correction.
Declaration	int32_t CT440_ResetDark (uint64_t uiHandle, rDetector eDetector);
Parameters	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64 **eDetector** Front panel detector number. Possible values: DE_1; DE_2; DE_3; DE_4. Type: Input Data type: rDetector
Return value	➤ 0: the operation succeeded. ➤ -1: the operation failed. Data type: int32
Example	CT440_ResetDark (uiHandle,DE_1);

CT440_ResetCalibration

Applicability	All models of CT440.
Description	This function resets to default all referencing modifications done on the wavelength referencing and on detector referencing. In the GUI, this function is identical to the **Reset Calibration** button in the **Referencing** window.
Declaration	int32_t CT440_ResetCalibration (uint64_t uiHandle);
Parameter	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64
Return value	➤ 0: the operation succeeded. ➤ -1: the operation failed. Data type: int32
Example	CT440_ResetCalibration(uiHandle);

CT440_UpdateCalibration (Deprecated)

Applicability	CT440 without PDL option only, for legacy compatibility with CT400.
Description	This function references a single CT440 detector. It must be called after a scan has been performed on the same detector. Before sending the command, connect the CT440 output port directly to the selected detector with an SMF jumper.
Declaration	int32_t CT440_UpdateCalibration(uint64_t uiHandle, rDetector eDetector);
Parameters	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64 **eDetector** Detector number. Possible values: see *Data Types* on page 97. Type: Input Data type: rDetector
Return value	➤ 0: the operation succeeded. ➤ -1: the operation failed. Data type: int32
Example	CT440_UpdateCalibration(uiHandle,DE_1);

Measurement Control Functions

CT440_ScanStart

Applicability	All models of CT440.
Description	This function starts a scan. On CT440 with PDL option, one scan is performed at only one polarization state. For PDL measurement, you need to combine this function with the CT440_PolState function (page 107) to record all 4 or 6 states of polarization and be able to measure the PDL. If the CT440_SetExternalSynchronizationIN function is used (see page 111), the CT440 waits for a trigger signal from the laser on the **Trigger In** BNC port to start a scan. In the GUI, this function corresponds to the **Scan** button (only for measurement of Transfer Function).
Declaration	int32_t CT440_ScanStart(uint64_t uiHandle);
Parameter	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64
Return value	➤ 0: the operation succeeded. ➤ -1: the operation failed. Data type: int32
Example	CT440_ScanStart(uiHandle);

	CT440_ScanAbort
Applicability	All models of CT440.
Description	This function aborts a scan. In the GUI, this function corresponds to the **Abort** button when a start has been started.
Declaration	int32_t CT440_ScanAbort(uint64_t uiHandle);
Parameter	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64
Return value	➤ 0: the operation succeeded. ➤ -1: the operation failed. Data type: int32
Example	CT440_ScanAbort(uiHandle);

CT440_ScanWaitEnd

Applicability	All models of CT440.
Description	This function waits for the scan to finish and returns errors or warnings. The list of these messages is available in *Troubleshooting* on page 83.
Declaration	int32_t CT440_ScanWaitEnd (uint64_t uiHandle,char tcError[1024]);
Parameters	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64 **tcError[1024]** Initialized array that stores the description of the error. Type: Input/Output Data type: char[1024]
Return value	➤ > 0: indicates the error/warning number. ➤ 0: the operation succeeded. Data type: int32

Example	int32_t iErrorMsg;
	char tcError[1024];
	iErrorMsg = CT440_ScanWaitEnd(uiHandle, tcError);
	if (iErrorMsg !=0)
	printf("Warning: %s\n", tcError);

CT440_ScanGetProgress

Applicability
All models of CT440.

Description
This function returns the completion state of the scan in progress.

Declaration
```
int32_t CT440_ScanGetProgress(uint64_t uiHandle,
rLaserInput * activeLaser,
int32_t * allLasersProgress,
int32_t * activeLaserProgress,
int32_t * status,
char tcError[1024]);
```

Parameters

uiHandle

Handle returned from **CT440_Init**

Type: Input

Data type: unsigned int64

activeLaser

Pointer over an initialized variable to return the number of the laser currently scanning.

Type: Input/Output

Data type: rLaserInput

allLasersProgress

Pointer over an initialized variable to return the percentage of completion of all the scanning lasers.

Type: Input/Output

Data type: int32

activeLaserProgress

Pointer over an initialized variable to return the percentage of completion of the current scanning laser.

Type: Input/Output

Data type: int32

status

Pointer over an initialized variable to return the state of the scan in progress:

- 0: the scan is not started.
- 1: the laser is scanning.
- 2: the scan is being aborted.
- 3: data is being retrieved.
- 4: the scan has been aborted.
- 5: the scan is finished.

Type: Input/Output

Data type: int32

CT440_ScanGetProgress

tcError[1024]
Initialized array that stores the description of the error.
Type: Input/Output
Data type: char|1024]

Return value

- 0: the operation succeeded.
- -1: the operation failed.

Data type: int32

Example

```
rLaserInput * activeLaser = (rLaserInput *) calloc(1,
sizeof(rLaserInput));
int32_t * allLasersProgress = (int32_t *) calloc(1, sizeof(int32_t));
int32_t * activeLaserProgress = (int32_t *) calloc(1, sizeof(int32_t));
int32_t * status = (int32_t *) calloc(1, sizeof(int32_t));
char tcError[1024]);

CT440_ScanGetProgress(uiHandle, activeLaser, allLasersProgress,
activeLaserProgress, status, tcError);

free(activeLaser);
free(allLasersProgress):
free(activeLaserProgress);
free(status);
```

Data Handling Functions

CT440_ScanGetWavelengthSyncArray

Applicability

All models of CT440.

On CT440 with PDL option, you cannot use this function to directly calculate PDL; you must use the *CT440_ScanGetWavelengthResampledArray* on page 124.

Description

This function performs the following:

- Gets the total number of measured wavelength points. The step between points corresponds to the native resolution or a multiple of native resolution.
  For more details on native resolution, see *Measurement Principle* on page 3.
- Fills the input array with the wavelengths for which a data point has been measured.

Declaration

int32_t CT440_ScanGetWavelengthSyncArray
(uint64_t uiHandle,

double *dArray,

int32_t iArraySize);

Parameters

uiHandle

Handle returned from **CT440_Init**

Type: Input

Data type: unsigned int64

dArray

Pointer over an initialized array to return the wavelengths for which a data point has been measured.

Type: Input/Output

Data type: double*

iArraySize

Size of the array. The number of detectors used (defined with *CT440_SetDetectorArray* on page 105) limits the available number of points. Recommended values are:

- For 1 detector used: up to 260,000
- For 2 detectors used: up to 219,500
- For 3 detectors used: up to 164,400
- For 4 detectors used: up to 131,100
- For 5 detectors used: up to 110,500 (4 optical detectors + BNC C detector)

Type: Input

Data type: int32

CT440_ScanGetWavelengthSyncArray

Return value

- > 0: indicates the available number of data points in dArray and the corresponding data values.
- -1: the operation failed.

Data type: int32

Example

int32_t iArraySize = CT440_GetNbDataPoints(uiHandle);

double *dWavelengthSync=(double*)calloc(iArraySize,sizeof(double));

ScanGetWavelengthSyncArray(uiHandle,dWavelengthSync,iArraySize);

free(dWavelengthSync);

The result of the operation is the array dWavelengthSync [0 to iArraySize - 1] containing all the measured wavelength values.

CT440_ScanGetWavelengthResampledArray

Applicability All models of CT440.

Description This function performs the following:

- ➤ Gets the total number of wavelength points produced by the CT440, spaced by the uiResolution parameter (see *CT440_SetScan* on page 104). The step between points corresponds to the resolution set in *CT440_SetScan* on page 104. For more details on re-sampled data points, see *Measurement Principle* on page 3.
- ➤ Fills the input array with the re-sampled wavelength in each point.

Declaration

int32_t CT440_ScanGetWavelengthResampledArray

(uint64_t uiHandle,

double *dArray,

int32_t iArraySize);

Parameters

uiHandle

Handle returned from **CT440_Init**

Type: Input

Data type: unsigned int64

dArray

Pointer over an initialized array to return the re-sampled wavelength in each point.

Type: Input/Output

Data type: double*

iArraySize

Size of the array. The number of detectors used (defined with *CT440_SetDetectorArray* on page 105) limits the available number of points. Recommended values are:

- ➤ For 1 detector used: up to 260,000
- ➤ For 2 detectors used: up to 219,500
- ➤ For 3 detectors used: up to 164,400
- ➤ For 4 detectors used: up to 131,100
- ➤ For 5 detectors used: up to 110,500 (4 optical detectors + BNC C detector)

Type: Input

Data type: int32

CT440_ScanGetWavelengthResampledArray

Return value

- > 0: indicates the available number of (resampled) data points in dArray and the corresponding data values.
- -1: the operation failed.

Data type: int32

Example

```
int32_t iArraySize = CT440_GetNbDataPointsResampled(uiHandle);
double *dWavelength=(double*)calloc(iArraySize,sizeof(double));
ScanGetWavelengthResampledArray(uiHandle,dWavelength,
iArraySize);
free(dWavelength);
```

The result of the operation is the array dWavelength [0 to iArraySize - 1] containing all the re-sampled wavelength values.

CT440_ScanGetPowerSyncArray

Applicability

All models of CT440.

On CT440 with PDL option, you cannot use this function to directly calculate PDL; you must use *CT440_ScanGetPowerResampledArray* on page 128.

Description

This function performs the following:

- Gets the total number of output power values (measured at the output port of the CT440) associated with the wavelength values produced by the CT440.
  The step between wavelength points corresponds to the native resolution or a multiple of native resolution.
  For more details on native resolution, see *Measurement Principle* on page 3.
- Fills the input array with the measured values.

Declaration

int32_t CT440_ScanGetPowerSyncArray (uint64_t uiHandle,

double *dArray,

int32_t iArraySize);

Parameters

uiHandle

Handle returned from **CT440_Init**

Type: Input

Data type: unsigned int64

dArray

Pointer over an initialized array to return the measured output power values.

Type: Input/Output

Data type: double*

iArraySize

Size of the array. The number of detectors used (defined with *CT440_SetDetectorArray* on page 105) limits the available number of points. Recommended values are:

- For 1 detector used: up to 260,000
- For 2 detectors used: up to 219,500
- For 3 detectors used: up to 164,400
- For 4 detectors used: up to 131,100
- For 5 detectors used: up to 110,500 (4 optical detectors + BNC C detector)

Type: Input
Data type: int32

CT440_ScanGetPowerSyncArray

Return value

- > 0: indicates the available number of measured points in dArray and the corresponding data values.
- -1: the operation failed.

Data type: int32

Example

```
int32_t iArraySize = CT440_GetNbDataPoints(uiHandle);
double *dPowerSync=(double*)calloc(iArraySize,sizeof(double));
ScanGetPowerSyncArray(uiHandle,dPowerSync,iArraySize);
free(dPowerSync);
```

The result of the operation is the array dPowerSync [0 to iArraySize - 1] containing the measured output power values.

CT440_ScanGetPowerResampledArray

Applicability

All models of CT440.

Description

This function performs the following:

- Gets the total number of output power values (measured at the output port of the CT440) associated with the wavelength values produced by the CT440.
  The step between wavelength points corresponds to the resolution set in the *CT440_SetScan* on page 104.
  For more details on re-sampled data points, see *Measurement Principle* on page 3.
- Fills the input array with the re-sampled output power in each point.

Declaration

int32_t CT440_ScanGetPowerResampledArray (uint64_t uiHandle,
double *dArray,
int32_t iArraySize);

Parameters

uiHandle

Handle returned from **CT440_Init**

Type: Input

Data type: unsigned int64

dArray

Pointer over an initialized array to return the re-sampled output power values.

Type: Input/Output

Data type: double*

iArraySize

Size of the array. The number of detectors used (defined with *CT440_SetDetectorArray* on page 105) limits the available number of points. Recommended values are:

- For 1 detector used: up to 260,000
- For 2 detectors used: up to 219,500
- For 3 detectors used: up to 164,400
- For 4 detectors used: up to 131,100
- For 5 detectors used: up to 110,500 (4 optical detectors + BNC C detector)

Type: Input
Data type: int32

CT440_ScanGetPowerResampledArray

Return value

- > 0: indicates the available number of measured points in dArray and the corresponding data values.
- -1: the operation failed.

Data type: int32

Example

```
int32_t iArraySize = CT440_GetNbDataPointsResampled(uiHandle);
double *dPowerSync=(double*)calloc(iArraySize,sizeof(double));
ScanGetPowerResampledArray(uiHandle,dPowerSync,iArraySize);
free(dPowerSync);
```

The result of the operation is the array dPowerSync [0 to iArraySize - 1] containing the re-sampled output power values.

CT440_ScanGetDetectorArray

Applicability	All models of CT440. On CT440 with PDL option, you cannot use this function to directly calculate PDL; you must use *CT440_ScanGetDetectorResampledArray* on page 133.
Description	This function performs the following: ➤ Gets the total number of measured transfer function points on a selected detector. The step between points corresponds to the native resolution. ➤ Fills the input array with the measured transfer function in each point. This array is useful for direct use of recorded data; this is the computed transfer function, not the input power on the CT440 detectors.
Declaration	int32_t CT440_ScanGetDetectorArray(uint64_t uiHandle, rDetector eDetector, double *dArray, int32_t iArraySize);

CT440_ScanGetDetectorArray

Parameters

uiHandle

Handle returned from **CT440_Init**

Type: Input

Data type: unsigned int64

eDetector

Detector number.

Possible values: see *Data Types* on page 97.

Type: Input

Data type: rDetector

dArray

Pointer over an initialized array to return all the measured transfer function values.

Type: Input/Output

Data type: double*

iArraySize

Size of the array. The number of detectors used (defined with *CT440_SetDetectorArray* on page 105) limits the available number of points. Recommended values are:

- For 1 detector used: up to 260,000
- For 2 detectors used: up to 219,500
- For 3 detectors used: up to 164,400
- For 4 detectors used: up to 131,100
- For 5 detectors used: up to 110,500 (4 optical detectors + BNC C detector)

Type: Input

Data type: int32

CT440_ScanGetDetectorArray

Return value

- > 0: indicates the available number of measured points in dArray and the corresponding data values.
- -1: the operation failed.

Data type: int32

If the eDetector parameter is set to DE_5 and the *CT440_SetBNC* on page 108 is set to DISABLE, the value returned by the CT440_ScanGetDetectorArray function is the voltage measured at the **Analog In** BNC port.

Example

```
int32_t iArraySize = CT440_GetNbDataPoints(uiHandle);
double *dPowerdet =(double*)calloc(iArraySize,sizeof(double));
ScanGetDetectorArray(uiHandle,DE_1,dPowerdet,iArraySize);
free(dPowerdet);
```

The result of the operation is the array dPowerdet [0 to iArraySize - 1] containing all the measured transfer function values.

CT440_ScanGetDetectorResampledArray

Applicability

All models of CT440.

Description

This function performs the following:

- Returns the points corresponding to the transfer function (or to one state of PDL) on a selected detector associated with the wavelength points produced by the CT440.
  The step between points corresponds to the resolution set in *CT440_SetScan* on page 104.
  For more details on re-sampled data points, see *Measurement Principle* on page 3.
- Fills the input array with the re-sampled transfer function (or state of PDL) in each point.

Declaration

int32_t CT440_ScanGetDetectorResampledArray(uint64_t uiHandle,

rDetector eDetector,

double *dArray,

int32_t iArraySize);

CT440_ScanGetDetectorResampledArray

Parameters

uiHandle

Handle returned from **CT440_Init**

Type: Input

Data type: unsigned int64

eDetector

Detector number.

Possible values: see *Data Types* on page 97.

Type: Input

Data type: rDetector

dArray

Pointer over an initialized array to return all the re-sampled measured transfer function values.

Type: Input/Output

Data type: double*

iArraySize

Size of the array. The number of detectors used (defined with *CT440_SetDetectorArray* on page 105) limits the available number of points. Recommended values are:

- For 1 detector used: up to 260,000
- For 2 detectors used: up to 219,500
- For 3 detectors used: up to 164,400
- For 4 detectors used: up to 131,100
- For 5 detectors used: up to 110,500 (4 optical detectors + BNC C detector)

Type: Input

Data type: int32

CT440_ScanGetDetectorResampledArray

Return value

- > 0: indicates the available number of measured points in dArray and the corresponding data values.
- -1: the operation failed.

Data type: int32

If the eDetector parameter is set to DE_5 and the *CT440_SetBNC* on page 108 is set to DISABLE, the value returned by the CT440_ScanGetDetectorResampledArray function is the voltage measured at the **Analog In** BNC port.

Example

```
int32_t iArraySize = CT440_GetNbDataPointsResampled(uiHandle);
double *dPowerdet=(double*)calloc(iArraySize,sizeof(double));
ScanGetDetectorResampledArray(uiHandle,DE_1,dPowerdet,
iArraySize);
free(dPowerdet);
```

The result of the operation is the array dPowerdet [0 to iArraySize - 1] containing all the re-sampled transfer function values.

CT440_ScanSaveWavelengthSyncFile

Applicability	All models of CT440. On CT440 with PDL option, you cannot use this function to directly calculate PDL; you must use the *CT440_ScanSaveWavelengthResampledFile* on page 137.
Description	This function saves the wavelength points measured by the CT440 in a text file. The step between points corresponds to the native resolution.
Declaration	int32_t CT440_ScanSaveWavelengthSyncFile(uint64_t uiHandle, char *pcPath);
Parameters	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64 **pcPath** Path to the file to write (absolute or relative path). Type: Input/Output Possible file extension: txt Data type: char*
Return value	➤ 0: the operation succeeded. ➤ -1: the operation failed. Data type: int32
Example	CT440_ScanSaveWavelengthSyncFile(uiHandle,"D:\\measurements\\wavelength.txt");

CT440_ScanSaveWavelengthResampledFile

Applicability	All models of CT440.
Description	This function saves in a text file the wavelength values measured by the CT440 spaced by the uiResolution parameter (see *CT440_SetScan* on page 104). The step between values corresponds to the resolution set in *CT440_SetScan* on page 104. For more details on re-sampled data points, see *Measurement Principle* on page 3.
Declaration	int32_t CT440_ScanSaveWavelengthResampledFile(uint64_t uiHandle, char *pcPath);
Parameters	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64 **pcPath** Path to the file to write (absolute or relative path). Type: Input/Output Possible file extension: txt Data type: char*
Return value	➤ 0: the operation succeeded. ➤ -1: the operation failed. Data type: int32
Example	CT440_ScanSaveWavelengthSyncFile(uiHandle,"D:\\measurements\\wavelength.txt");

	CT440_ScanSavePowerSyncFile
Applicability	All models of CT440. On CT440 with PDL option, you cannot use this function to directly calculate PDL; you must use the *CT440_ScanSavePowerResampledFile* on page 139.
Description	This function saves in a text file the output power and transfer function values measured on the enabled detector(s) associated with the recorded pulse number. Recorded values are those measured by the CT440 (at the native sampling resolution).
Declaration	int32_t CT440_ScanSavePowerSyncFile (uint64_t uiHandle, char *pcPath);
Parameters	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64 **pcPath** Path to the file to write (absolute or relative path). Type: Input/Output Possible file extension: txt Data type: char*
Return value	➤ 0: the operation succeeded. ➤ -1: the operation failed. Data type: int32
Example	CT440_ScanSavePowerSyncFile(uiHandle,"D:\\measurements\\powerout.txt");

CT440_ScanSavePowerResampledFile

Applicability All models of CT440.

Description This function saves in a text file the output power associated with the wavelength values measured by the CT440, spaced by the uiResolution parameter (see *CT440_SetScan* on page 104).
The step between points corresponds to the resolution set in *CT440_SetScan* on page 104).
For more details on re-sampled data points, see *Measurement Principle* on page 3.

It also saves the (re-sampled) transfer function measured on the enabled detectors.

Declaration int32_t CT440_ScanSavePowerSyncFile (uint64_t uiHandle,
char *pcPath);

Parameters

uiHandle

Handle returned from **CT440_Init**

Type: Input

Data type: unsigned int64

pcPath

Path to the file to write (absolute or relative path).

Type: Input/Output

Possible file extension: txt

Data type: char*

Return value

- 0: the operation succeeded.
- -1: the operation failed.

Data type: int32

Example CT440_ScanSavePowerResampledFile(uiHandle,"D:\\measurements\
\powerout_resampled.txt");

CT440_ScanSaveDetectorFile

Applicability	All models of CT440. On CT440 with PDL option, you cannot use this function to directly calculate PDL; you must use *CT440_ScanSaveDetectorResampledFile* on page 141 function.
Description	This function saves in a text file the transfer function values measured by the CT440 on a selected detector associated with the recorded pulse number.
Declaration	int32_t CT440_ScanSaveDetectorFile(uint64_t uiHandle, rDetector eDetector, char *pcPath);
Parameters	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64 **eDetector** Detector number. Possible values: see *Data Types* on page 97. Type: Input Data type: rDetector **pcPath** Path to the file to write (absolute or relative path). Type: Input/Output Possible file extension: txt Data type: char*
Return value	➤ 0: the operation succeeded. ➤ -1: the operation failed. Data type: int32
Example	CT440_ScanSaveDetectorFile(uiHandle,DE_1,"D:\\measurements\\PoutDet1.txt");

CT440_ScanSaveDetectorResampledFile

Applicability

All models of CT440.

Description

This function saves in a text file the transfer function (or one state of PDL) values on a selected detector associated with the wavelength values measured by the CT440 spaced by the uiResolution parameter (see *CT440_SetScan* on page 104).
The step between points corresponds to the resolution set in *CT440_SetScan* on page 104).
For more details on re-sampled data points, see *Measurement Principle* on page 3.

Declaration

int32_t CT440_ScanSaveDetectorResampledFile(uint64_t uiHandle,
rDetector eDetector,
char *pcPath);

Parameters

uiHandle

Handle returned from **CT440_Init**

Type: Input

Data type: unsigned int64

eDetector

Detector number.

Possible values: see *Data Types* on page 97.

Type: Input

Data type: rDetector

pcPath

Path to the file to write (absolute or relative path).

Type: Input/Output

Possible file extension: txt

Data type: char*

Return value

- 0: the operation succeeded.
- -1: the operation failed.

Data type: int32

Example

CT440_ScanSaveDetectorResampledFile(uiHandle,DE_1,"D:\\measurements\\PoutDet1_resampled.txt");

CT440_ReadPowerDetectors

Applicability

All models of CT440.

Description

This function reads the instantaneous optical power (in dB) measured at the Output port and on the four detectors, and reads the voltage (in V) on the **Analog In** BNC port.

In the GUI, this function corresponds to the **Power Monitoring** and **Voltage Monitoring** areas the **Referencing** window.

Declaration

int32_t CT440_ReadPowerDetectors(uint64_t uiHandle,

double *Pout,

double *P1,

double *P2,

double *P3,

double *P4,

double *Vext);

Parameters

uiHandle

Handle returned from **CT440_Init**

Type: Input

Data type: unsigned int64

Pout

Pointer over an initialized variable to store the power measured on the output port (in dB).

Type: Input/Output
Data type: double*

P1

Pointer over an initialized variable to store the power measured on detector 1 (in dB).

Type: Input/Output
Data type: double*

P2

Pointer over an initialized variable to store the power measured on detector 2 (in dB).

Type: Input/Output
Data type: double*

CT440_ReadPowerDetectors

P3

Pointer over an initialized variable to store the power measured on detector 3 (in dB).

Type: Input/Output
Data type: double*

P4

Pointer over an initialized variable to store the power measured on detector 4 (in dB).

Type: Input/Output
Data type: double*

Vext

Pointer over an initialized variable to store the voltage measured on the **Analog In** BNC port, located on the rear panel.

Type: Input/Output
Data type: double*

Return value

- 0: the operation succeeded.
- -1: the operation failed.

Data type: int32

Example

```
double Pout, P1, P2, P3, P4, Vext;
CT440_ReadPowerDetectors(uiHandle,&Pout,&P1,&P2,&P3,&P4,&Vext);
printf("P1:%f\n",P1);
printf("P2:%f\n",P2);
printf("P3:%f\n",P3);
printf("P4:%f\n",P4);
printf("Vext:%f\n",Vext);
```

CT440_GetNbDataPoints

Applicability	All models of CT440. On CT440 with PDL option, you cannot use this function to directly calculate PDL; you must use *CT440_GetNbDataPointsResampled* on page 146.
Description	This function returns: ➤ The number of measured data points after a scan has been performed by the CT440 ➤ The index value of the trigger pulse associated with the first measured data point. This index value corresponds to the total number of spurious pulses generated by the CT440 at the beginning of the scan of the laser, which must be discarded when performing triggered measurements. This operation avoids shifts between CT440's data and triggered measurement data.
Declaration	int32_t CT440_GetNbDataPoints (uint64_t uiHandle, int32_t *iDataPoints, int32_t *iDiscardPoints);

CT440_GetNbDataPoints

Parameters

uiHandle

Handle returned from **CT440_Init**

Type: Input

Data type: unsigned int64

iDataPoints

Pointer to a variable that stores the number of valid data points measured by the CT440.

Type: Input/Output
Data type: unsigned int32

iDiscardPoints

Pointer to a variable that stores the index of the trigger pulse associated with the first measured data point.

Type: Input/Output
Data type: unsigned int32

Return value

- 0: the operation succeeded.
- -1: the operation failed.

Data type: int32

Example

```
int32_t iDataPoints;
int32_t iDiscardPoints;
CT440_GetNbDataPoints(uiHandle, &iDataPoints, &iDiscardPoints);
printf("Number of measured points: %d\n", iDataPoints);
printf("Index value of the trigger pulse associated with the first measured data point: %d\n", iDiscardPoints);
```

CT440_GetNbDataPointsResampled

Applicability	All models of CT440.
Description	This function returns the number of valid (re-sampled) data points after a scan has been performed.
Declaration	int32_t CT440_GetNbDataPointsResampled (uint64_t uiHandle);
Parameter	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64
Return value	➤ >0: indicates the number of valid data points in the array. ➤ -1: the operation failed. Data type: int32
Example	int32_t iPointsNumber = CT440_GetNbDataPointsResampled(uiHandle);

CT440_CalcPDL4OneDET

Applicability

CT440 with PDL option only.

Description

Calculate IL and PDL on one detector.

You must provide Ref, WL and DET data for each polarization state in the correct order.

Declaration

```
int32_t CT440_CalcPDL4OneDET(uint64_t uiHandle,
int32_t iMethod,
int32_t iNbvalues,
double * dWLwithoutDUT,
double * dRefwithoutDUT,
double * dDETwithoutDUT,
double * dWLwithDUT,
double * dRefwithDUT,
double * dDETwithDUT,
double * dWLadjusted,
double * dIL,
double * dPDL,
int32_t * iTabsize);
```

Parameters

uiHandle

Handle returned from **CT440_Init**

Type: Input

Data type: unsigned int64

iMethod

Method of PDL used for the calculation.

Possible values:

- 0: 4-states method
  In this case, you must provide the polarization states 0; 1; 2; 5 in that order (see *CT440_PolState* on page 107).
- 1: 6-states method

Type: Input
Data type: int32

iNbvalues

Total number of data points in the Wavelength and Power tables.

Type: Input
Data type: int32

CT440_CalcPDL4OneDET

dWLwithoutDUT

Pointer over an array containing the wavelength for each state during the measurement without DUT.

Type: Input
Data type: double*

dRefwithoutDUT

Pointer over an array containing the reference power for each state during the measurement without DUT.

Type: Input
Data type: double*

dDETwithoutDUT

Pointer over an array containing the detector power for each state during the measurement without DUT.

Type: Input
Data type: double*

dWLwithDUT

Pointer over an array containing the wavelength for each state during the measurement with DUT.

Type: Input
Data type: double*

dRefwithDUT

Pointer over an array containing the reference power for each state during the measurement with DUT.

Type: Input
Data type: double*

dDETwithDUT

Pointer over an array containing the detector power for each state during the measurement with DUT

Type: Input
Data type: double*

dWLadjusted

Pointer over an array containing the wavelength for each point of IL and PDL calculation

Type: Input/Output
Data type: double*

dIL

Pointer over an array containing the calculated IL for each data points.

Type: Input/Output
Data type: double*

CT440_CalcPDL4OneDET

dPDL

Pointer over an array containing the calculated PDL for each data points.

Type: Input/Output

Data type: double*

iTabsize

Pointer over an initialized variable to store the size of **dIL**, **dPDL** and **dWLadjusted** arrays.

Type: Input/Output

Data type: int32*

Return value

- 0: the operation succeeded.
- -1: the operation failed.

Data type: int32

Example

See the *CT440-PDL_testwrap.c* source file provided on the USB key with the instrument.

CT440_GetNbLinesDetected

Applicability	CT440 with two or more input ports only.
Description	This function returns the number of spectral lines detected with heterodyne detection.
Declaration	int32_t CT440_GetNbLinesDetected (uint64_t uiHandle);
Parameter	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64
Return value	➤ ≥ 0: indicates the number of spectral lines detected. ➤ -1: the operation failed. Data type: int32
Example	int32_t iLinesDetected = CT440_GetNbLinesDetected(uiHandle);

CT440_ScanGetLinesDetectionArray

Applicability
CT440 with two or more input ports only.

Description
This function returns the values of spectral lines detected by heterodyne detection.

In the GUI, this function gets the results displayed in the **Line detection** tab.

Declaration
```
int32_t CT440_ScanGetLinesDetectionArray
(uint64_t uiHandle,
double *dArray,
int32_t iArraySize);
```

Parameters

uiHandle

Handle returned from **CT440_Init**

Type: Input

Data type: unsigned int64

dArray

Pointer over an initialized array.

Type: Input
Data type: double*

iArraySize

Size of the array.

Recommended value is the result of *CT440_GetNbLinesDetected* on page 150.

Type: Input
Data type: double*

Return value

- ≥ 0: indicates the number of spectral lines detected.
- -1: the operation failed.

Data type: int32

Example
```
int32_t iLinesDetected;
double *dLinesValues = 0;
iLinesDetected = CT440_GetNbLinesDetected(uiHandle);
dLinesValues = (double *) calloc(iLinesDetected, sizeof(double));
CT440_ScanGetLinesDetectionArray(uiHandle, dLinesValues,
iLinesDetected);
for(i = 0; i < iLinesDetected; i++)
 {
  printf("Spectral line #%d : %f\n", i+1, dLinesValues[i]);
  }
free(dLinesValues);
```

Instrument Information Functions

CT440_GetNbInputs

Applicability	All models of CT440.
Description	This function returns the number of available TLS inputs on the connected CT440 model.
Declaration	int32_t CT440_GetNbInputs(uint64_t uiHandle);
Parameter	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64
Return value	➤ ≥ 0: indicates the number of available inputs on the unit. ➤ -1: the operation failed.
Example	int32_t iNbofInputs = CT440_GetNbInputs(uiHandle);

CT440_GetNbDetectors

Applicability	All models of CT440.
Description	This function returns the number of available optical power detectors on the connected CT440 model.
Declaration	int32_t CT440_GetNbDetectors(uint64_t uiHandle);
Parameter	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64
Return value	➤ ≥ 0: indicates the number of available detector ports on the unit. ➤ -1: the operation failed.
Example	int32_t iNbofDetectors = CT440_GetNbDetectors(uiHandle);

CT440_GetCT440Type

Applicability All models of CT440.

Description This function returns the type of CT440 connected to your computer.

Declaration int32_t CT440_GetCT440Type(uint64_t uiHandle);

Parameter **uiHandle**

Handle returned from **CT440_Init**

Type: Input

Data type: unsigned int64

Return value

- 0: the CT440 model type is SMF.
- 1: the CT440 model type is PM13.
- 2: the CT440 model type is PM15.
- -1: the operation failed.

For more details on the operating wavelength range of each model type, see *Technical Specifications* on page 7.

Example

```
int32_t CT440Type =
CT440_GetCT440Type(uiHandle);
```

CT440_GetCT440Model

Applicability All models of CT440.

Description This function returns the model of the instrument connected to your computer.

Declaration int32_t CT440_GetCT440Model(uint64_t uiHandle);

Parameter **uiHandle**

Handle returned from **CT440_Init**

Type: Input

Data type: unsigned int64

Return value

- 0: the connected instrument is a CT440 with PDL option.
- 1: the connected instrument is a CT440 without PDL option.
- -1: the operation failed.

Example

```
int32_t CT440Model =
CT440_GetCT440Model(uiHandle);
```

CT440_GetCT440SN

Applicability	All models of CT440.
Description	This function returns the serial number of the CT440 connected to your computer.
Declaration	int32_t CT440_GetCT440SN(uint64_t uiHandle,char SN[50]);
Parameters	**uiHandle** Handle returned from **CT440_Init** Type: Input Data type: unsigned int64 **SN[50]** Allocated memory for storing the serial number. Type: Input/Output Data type: char[50]
Return value	➤ > 0: the operation succeeded. ➤ -1: the operation failed.
Example	char SN[50]; CT440_GetCT440SN(uiHandle, SN); printf("Serial number : %s \n", SN);

CT440_GetCT440DSPver

Applicability
All models of CT440.

Description
This function returns the DSP firmware version of the CT440 connected to your computer.

Declaration
int32_t CT440_CT440_GetCT440DSPver(uint64_t uiHandle, int32_t * iDSPversion);

Parameters

uiHandle

Handle returned from **CT440_Init**

Type: Input

Data type: unsigned int64

iDSPversion

Pointer to a variable that stores the version of the DSP firmware.

Type: Input/Output

Data type: int32*

Return value

- 0: the operation succeeded.
- -1: the operation failed.

Data type: int32

Example

```
int32_t *iDSPversion = 0;
  iDSPversion = (int32_t *) calloc(1, sizeof(int32_t));
  CT440_GetCT440DSPver(uiHandle, iDSPversion);
  printf("DSP firmware version : %d ", *iDSPversion);
  free(iDSPversion);
```

B Program Examples

EXFO provides an example on how to use the CT440_lib.dll in C, Python and LabVIEW programming languages. An example is available for each platform (Win32 and Win64).

- CT440_testwrap.c/CT440-PDL_testwrap.c are examples of the DLL use in C language.
- It has been edited, compiled and tested using the C++ Builder XE7.
- CT440_testwrap.py/CT440-PDL_testwrap.py are examples of CT440/CT440-PDL control file in Python language.
- It has been edited, compiled and tested using the IDLE and Python v. 2.7.13 for Win32 and v. 3.4.2 for Win64.
- In the Labview folder the CT440_testwrap.vi/CT440-PDL_testwrap.vi are examples of the DLL use in LabVIEW (see section Program Examples, p. 51).
- It has been edited and tested using the LabVIEW 2013. The example is provided in LabVIEW 2013 for both Win32 and Win64 platforms.
- The dll wrappers are provided with the LabVIEW example projects.

Example Description

The provided examples perform the following operations:

1. It initializes the DLL library and verifies if the communication between the computer and the CT440 has been established.
   - If the communication is established, the configuration of the CT440 is carried out.
   - If the communication is not established, the program ends by closing the communication with the DLL.
2. The configuration detects the number of available inputs and detectors of the CT440, the type of CT440 and sets the following:
   - the sampling resolution of the measurement to be made,
   - the laser type and laser parameters (e.g. lower and upper wavelengths, speed of scan, GPIB address etc.),
   - the wavelength scan range
   - detector of the CT440 in active state
   - in case of CT440 with PDL option: the PDL method.
3. A popup windows prompts the user to connect TLS and patchcord to perform the detector(s) referencing.
4. Scans are performed over the wavelength range previously set in the configuration section of the program, and awaits for the scan to finish.

   If an error occurred during this process, the program displays the error or warning message generated by the CT440.
5. A popup windows prompts the user to connect the DUT for measurements.
6. Once the scans are finished, the CT440 retrieves IL and/or PDL data.
   The measured wavelength, optical power and corresponding IL data are assigned to the corresponding output arrays.

IL and/or PDL are calculated and depending on the language used:

➤ LabVIEW: results are displayed on graph and in a table.

➤ C and Python: results are saved in a .xls file in the current folder.

7. The communication between the CT440 and the computer is closed and the memory allocated by the dll is released.

Index

CHINESE REGULATION ON RESTRICTION OF HAZARDOUS SUBSTANCES (RoHS)
中国关于危害物质限制的规定
NAMES AND CONTENTS OF THE TOXIC OR HAZARDOUS SUBSTANCES OR ELEMENTS CONTAINED IN THIS EXFO PRODUCT
包含在本 EXFO 产品中的有毒有害物质或元素的名称及含量

Part Name 部件名称	Lead 铅 （Pb）	Mercury 汞 （Hg）	Cadmium 镉 （Cd）	Hexavalent Chromium 六价铬 （Cr(VI)	Polybrominated biphenyls 多溴联苯 （PBB）	Polybrominated diphenyl ethers 多溴二苯醚 （PBDE）
Enclosure 外壳	O	O	O	O	O	O
Electronic and electrical sub-assembly 电子和电气组件	X	O	X	O	X	X
Optical sub-assembly[a] 光学组件 [a]	X	O	O	O	O	O
Mechanical sub-assembly[a] 机械组件 [a]	O	O	O	O	O	O

Note:
注：
This table is prepared in accordance with the provisions of SJ/T 11364.
本表依据 SJ/T 11364 的规定编制。
O: Indicates that said hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement of GB/T 26572.
O: 表示该有害物质在该部件所有均质材料中的含量均在 GB/T 26572 标准规定的限量要求以下。
X: indicates that said hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement of GB/T 26572. Due to the limitations in current technologies, parts with the “X” mark cannot eliminate hazardous substances.
X: 表示该有害物质至少在该部件的某一均质材料中的含量超出 GB/T 26572 标准规定的限量要求。
标记 “X” 的部件，皆因全球技术发展水平限制而无法实现有害物质的替代。
a. If applicable.
如果适用。

MARKING REQUIREMENTS
标注要求

Product 产品	Environmental protection uses period (years) 环境保护使用期限 （年）	Logo 标志
This EXFO product 本 EXFO 产品	10	
Battery[a] 电池 [a]	5	

a. If applicable.
如果适用。

www.EXFO.com · info@exfo.com

CORPORATE HEADQUARTERS	400 Godin Avenue	Quebec (Quebec) G1M 2K2 CANADA Tel.: 1 418 683-0211 · Fax: 1 418 683-2170
TOLL-FREE	(USA and Canada)	1 800 663-3936