



T100S-HP

High Power Tunable Laser



User Guide

About This Manual

Subject This manual explains how to install, set-up and use the T100S-HP tunable external cavity laser. It also explains how to perform basic maintenance operations. The remote control of the T100S-HP is described in *T100S-HP Programming Guide*.

Application This document applies to T100S-HP version 6.06 and later versions.

Intended Readers Users of this manual must be familiar with:

- Fiber optic technology and laser safety
- The RS-232 C and/or IEEE-488.1 interfaces used to operate the T100S-HP in the remote modes.

Date 29 November 2018

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Typographical Conventions

bold	Identifies interface objects such as menu names, labels, buttons and icons.
<i>italic</i>	Identifies references to other sections or other guides.
<code>monospace</code>	Identifies portions of program codes, command lines, or messages displayed in command windows.

Symbols



Important

Identifies important information to which you must pay particular attention.



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 component damage. Do not proceed unless you understand and meet the required conditions.

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Product Warranty and Limitation of Warranty

For detailed information about the sales terms and conditions, visit the EXFO web site at www.exfo.com/how-to-buy/sales-terms-conditions

Contact Information

To obtain after-sales service or technical support for this product, contact EXFO at one of the following numbers.

Technical Support Group

400 Godin Avenue
Quebec (Quebec) G1M 2K2
CANADA

Tel. USA and Canada: 1 866 683-0155
Fax: 1 418 683-9224
E-mail: 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/support

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.

Table of Contents

About This Manual	3
Table of Contents	5
Important Safety Information for Your Product	7
1. Product Presentation	11
1.1 Product Features.....	11
1.2 Technical Specifications	12
1.3 Product Overview	15
1.3.1 Description of the Front Panel	15
1.3.2 Description of the Rear Panel.....	18
2. Installing and Connecting the Product	21
2.1 Unpacking and Installing the Product.....	21
2.2 Connecting the T100S-HP to a Power Source	22
2.3 Connecting External Optical Devices to the product	22
2.4 Installing the Remote Interlock	23
3. Turning on/off and Initializing the Product	25
3.1 Initializing the Laser.....	25
3.2 Enabling/Disabling the Laser Output.....	26
3.3 Shutting Down the Product	26
4. Setting Up the Emission Wavelength or Frequency	27
4.1 Changing the Emission Wavelength or Frequency	27
4.2 Setting a Predefined Increment/Decrement Step.....	28
4.3 Using the Fine Scanning Mode (Fine Tuning)	28
4.4 Implementing Step-by-Step Wavelength Scanning.....	29
4.5 Implementing Continuous Wavelength Sweep (hop-free)	31
4.5.1 Implementing Wavelength Sweep	31
4.5.2 Setting the Sweep Speed.....	32
4.6 Turning On/Off Backlash Suppression of the Micrometer Screw	32
4.7 Turning On/Off Coherence Control.....	32
5. Changing the Optical Output Power and Diode Current	33
5.1 Changing the Optical Output Power	33
5.2 Switching Between Constant-Power and Constant-Current Modes.....	34
5.3 Disabling/Enabling Active Cavity Control.....	35
5.4 Changing the Laser Diode Current.....	36
6. Calibrating the Product	37
6.1 Performing Power Calibration.....	37
6.2 Performing Internal Wavelength Referencing	38

7. Enabling Active Wavelength Monitoring	39
7.1 Setting Up the Product for Active Wavelength Monitoring	39
7.2 Performing Wavelength Monitoring.....	40
8. Using the Auxiliary Inputs and Outputs	43
8.1 Implementing External Modulation.....	43
8.1.1 Implementing Low Frequency Intensity Modulation	43
8.1.2 Implementing High Frequency Intensity Modulation.....	46
8.1.3 Wavelength Modulation.....	48
8.2 Output Signals.....	49
8.2.1 Available TTL Output Signals	49
8.2.2 Monitoring Outputs	49
8.2.3 Activating/Deactivating the λ Output as a Trigger	49
9. Verifying Performances	51
9.1 Preparing the Product for Testing	51
9.2 Verifying the Absolute Wavelength Accuracy	52
9.3 Verifying Wavelength Range and Output Power	52
9.4 Verifying Side Mode Suppression.....	53
9.5 Verifying Wavelength and Power Calibration.....	53
10. Performing Basic Maintenance Operations.....	55
10.1 Cleaning and Caring for Optical Connectors and Fibers	55
10.2 Cleaning the Product	56
10.3 Replacing the Line Fuses.....	56
10.4 Packaging for Shipment	57
11. Error and Warning Messages.....	59
Certification and Compliance	61
List of Tables	63
List of Figures.....	65
Index.....	67


Important Safety Information for Your Product

Before you start working with your device, you need to first read the important safety information provided in this section. This section provides information that may supplement or add safety information to the user guides of your product. Keep this information close at hand.

You can obtain a copy of the complete user guide for your product at the following link: www.EXFO.com










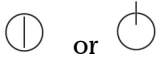

Important

- If you see the  symbol on your unit, make sure that you refer to the instructions provided in this safety notice. Ensure that you understand and meet the required conditions before using your product.
- 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.

Product Safety

Safety Symbols on Your Product

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

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

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

- The use of voltages higher than those indicated on the label affixed to your unit may damage the unit.
- 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.
- If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.
- Use only accessories designed for your unit and approved by EXFO. For a complete list of accessories available for your unit, see its technical specifications or contact EXFO.
- 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 fire risk.
- Unless otherwise specified, all interfaces are intended for connection to Safety Extra Low Voltage (SELV) circuits only.
- To avoid electrical shock, do not operate the unit if any part of the outer surface (covers, panels, etc.) is damaged.
- Operation of any electrical instrument around flammable gases or fumes constitutes a major safety hazard.
- 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 are 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.




Caution

- Where applicable, the operation and storage temperatures, as well as the altitude and relative humidity values of some modules may differ from those specified for your platform. In this case, always ensure that you comply with the most restrictive conditions (either module or platform).
- Position the unit so that the air can circulate freely around it.

Optical Safety

Safety Symbols on Your Product

Symbol	Meaning
	This symbol on your product indicates that the unit is equipped with a laser source, or that it can be used with instrument equipped with a laser source. These instruments include but are not limited to, modules and external optical units.

Optical Safety Instructions

Your instrument is in compliance with standards IEC 60825-1: 2007 and 2014.

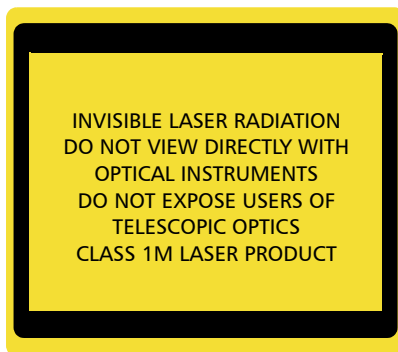


Warning

- (IEC 60825-1: 2007) Viewing the laser output with certain optical instruments designed for use at a distance (for example, telescopes and binoculars) may pose an eye hazard.
- (IEC 60825-1: 2014) Viewing the laser output with telescopic optical instruments (for example, telescopes and binoculars) may pose an eye hazard and thus the user should not direct the beam into an area where such instruments are likely to be used.
- 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.

The following labels indicate that the product contains a Class 1M source:



Pout max: / Psortie max. : ≤ 42 mW (on 1240-1400 nm); 100 mW (on 1400-1680 nm)

Complies with standards 21 CFR 1040.10, except for deviations pursuant to Laser Notice No. 50, dated June 24, 2007.

1. Product Presentation

1.1 Product Features

The T100S-HP is a high-performance, self-aligned external cavity laser. It is a general-purpose instrument designed for fiber-optic system testing and precise WDM component testing, as well as for research and development in the field of optical communications.

The following table lists the T100S-HP main features.

Feature	Description
Wide, fast, and 100%-continuous tunability	Extremely smooth scans over 100 nm obtained in 1 second, with a high resolution of 1 picometer. A digitally-controlled analog fine-tuning extending the resolution beyond the 1-picometer step to the sub-MHz level.
Active cavity control	The proprietary active cavity control provides the means for full optical communications systems and components characterizations. It ensures true mode-hop-free operations over the entire tuning range along with remarkable wavelength accuracy.
Internal wavelength referencing	The T100S-HP features its own internal referencing system to ensure highly accurate and repeatable measurements.
Active wavelength monitoring	This feature turns the T100S-HP into a high-precision tunable laser for DWDM component characterization.
Full-featured wavelength sweeper mode	True swept-wavelength function with adjustable sweep speed setting over the user-defined wavelength range (within the system's specified wavelength range).
Mode-hop free	A wide range guaranteed to be free of any mode hopping to ensure a smooth and accurate wavelength sweep for reliable testing of narrow-band components.
SSE-free operation	A unique optical design to yield intra-cavity filtering of SSE coming out of the diode. More than 90 dB of dynamic range for a pure, high-power single-mode laser line.
High output power	+10 dBm delivered by the <i>Essential</i> models. +8 dBm delivered by the <i>Extended Range</i> models. See section <i>Technical Specifications</i> , p. 12.
Outstanding long-term stability	Self-aligned optical layout, single-moving-part design and construction with low CTE materials to ensure a high level of long-term stability.
Intuitive and user-friendly controls	Optimized keyboard and display for intuitive and easy-to-implement laboratory operations. Dual parameter input (keyboard or multi-speed rotary control).

Feature	Description
Multiple modulation capability	Easy direct analog and digital modulation of the laser: <ul style="list-style-type: none"> • Low frequency modulation • High frequency modulation. • Coherence control.
Easy system integration	A fully integrated system featuring computer interfaces, on-board software, and analog inputs/outputs to allow all operations to be performed in remote mode and to make integration into a test set-up easy.

Table 1: T100S-HP – Main Features

1.2 Technical Specifications

The following table lists the technical specifications of all T100S-HP models.

		Essential Models		Extended Range Models			
		O	CL	O+	ES	SCL	CLU
Wavelength range (nm)		1260–1360	1500–1630	1240–1380	1350–1510	1440–1640	1500–1680
Output power	Over full wavelength range	≥ +10 dBm		≥ +8 dBm			
	Peak	≥ +13 dBm					
Signal to source spontaneous emission ratio ^{*1}		≥ 90 dB (100 dB typical)					
Side mode suppression ratio ^{*2}		≥ 45 dB					
Stability ^{*3}	Wavelength	±5 pm/h (±3 pm/h ; ±5 pm/24h typical)					
	Output Power	±0.01 dB/h (±0.025 dB/24h typical)					
Relative intensity noise ^{*4}		< -140 dB/Hz					
Spectral width (FWHM)		> 100 MHz (coherence control on) 400 kHz typical (coherence control off)					
Absolute wavelength accuracy ^{*5}		±20 pm					
Wavelength setting repeatability		5 pm typical					
Wavelength setting resolution		1 pm (0.1 pm in fine tuning mode)					
Fine tuning mode range		±25 pm (±2 GHz)					
Tuning speed in step mode		Approximately 1 s for 100 nm step					
Mode hop free range ^{*6}		Full wavelength range					
Continuous sweep speed		Adjustable from 1 to 100 nm/s					
Power flatness during sweep		±0.25 dB typical					
Power repeatability sweep to sweep ^{*7}		±0.05 dB typical					
Low frequency modulation		DC to 8 MHz (sinusoidal), DC to 1 MHz (TTL)					
High frequency modulation		30 kHz to 200 MHz					
Output fiber type		SMF or PMF (option)					
Output connector		FC / APC					

		Essential Models		Extended Range Models			
		O	CL	O+	ES	SCL	CLU
Communication interfaces ^{*8}		RS-232C and GPIB (IEEE-488.1)					
Temperature / Humidity range		+15 °C to +30 °C (+60 °F to +85 °F) / <80% (non-condensing)					
Electrical Specifications	Power supply	100-240 V ~ ; 50/60 Hz					
	Maximum input current	5 A rms					
	Maximum power consumption	300 W					
	Fuse type	2x T4AL250V, 5 x 20 mm (0.2 x 0.79 in) Equipment has double fuse in both Line and Neutral conductors.					
Laser safety classification		Class 1M					
Laser type		External cavity laser diode					
Laser output		Single mode optical fiber					
Laser Output divergence (full angle at 1/e²)		0.18 rad					
Dimensions (W x H x D)		448 x 370 x 133 mm (17.64 x 14.6 x 5.2 in)					
Weight		12.5 kg (27.5 lb)					

All specifications are given after 60 minutes warm-up and apply for wavelengths not equal to any absorption line.

*1: Measured over a 0.1 nm bandwidth ± 1 nm from the signal.

*2: For output power ≥ 0 dBm.

*3: Over one hour at constant temperature.

*4: RIN within the range 100 MHz–3 GHz measured at +8 dBm output power with RBW = 30 kHz.

*5: O and CL at 10 dBm / Others at 8 dBm, ± 40 pm all at 0 dBm.

*6: Validated at 0 and +10 dBm for essential and 0 and +8 dBm for extended range models.

*7: Over 100 wavelength scans at constant temperature.

*8: GPIB tested & validated with National Instruments GPIB Board.

Table 2: Technical Specifications

Environmental Specifications

Equipment Type	Test and measurement
Overvoltage category	II
Pollution degree	2
Temperature	Operation: +10 °C to +35 °C (+50 °F to +95 °F) Storage: -10 °C to +50 °C (+14 °F to +122 °F)
Maximum relative humidity	< 80 % (non-condensing)
Altitude (maximum operating)	2000 m (6562 ft)

Table 3: Environmental Specifications

Valid Ranges for Parameter Settings

		Essential Models		Extended Range models			
		O	CL	O+	ES	SCL	CLU
Laser diode current level (I)		See the <i>Acceptance Test Report</i> delivered with the product					
Beam output power (P)		0.2-50 mW					
Wavelength scan steps (nm)	Step-mode	0.001-150					
	Swept-mode	continuous					
Time at each scan step (Pause timer)		0.1-25 s					

Table 4: Valid Range for Parameter Settings

Available Accessories and Replaceable Parts

For information about accessories and replaceable parts, contact your EXFO sales representative.

Name	Description
Fuse	see <i>Technical Specifications, p. 12</i>
PM optical fiber cable	Single-mode polarization maintaining cable
Optical fiber cable	Single-mode cable
Power key	Front panel key-lock
Rack-mount handles	2 rack-mount handles
Carrying case (3U)	Field carrying case (3U)

Table 5: Available Accessories and Replaceable Parts

1.3 Product Overview

The T100S-HP Tunable External Cavity Laser is delivered with the following standard accessories:

- A power supply cord
- An FC/PC-FC/APC adapter cable
- A safety-lock key
- A USB key containing the user documentation and available software

For more information on replaceable parts, see section *Available Accessories and Replaceable Parts*, p. 14.

This section provides an overview of the operating interfaces of all T100S-HP functions.

1.3.1 Description of the Front Panel

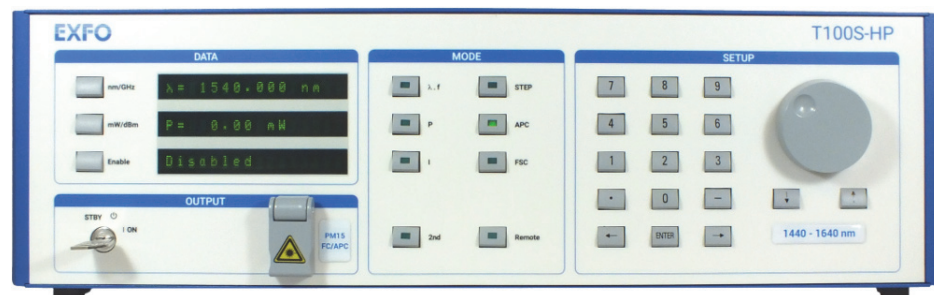


Figure 1: Front Panel

DATA Area

Description

The DATA area displays the three main operating parameters:

- Emission wavelength (λ) or optical frequency (f)
- Output power (P)
- Laser diode current (I)

This area is also used to display system status messages.

Function Keys

Function Key	Purpose
nm/GHz	Displays either the wavelength in nanometer (nm) or the corresponding optical frequency in gigahertz (GHz).
mW/dBm	Displays the optical output power either in dBm or mW.
Enable	Enables the optical output. <ul style="list-style-type: none"> • If the optical output is disabled, the message <code>Disabled...</code> is displayed. • If the optical output is enabled the current of the diode is displayed in milliamperes (mA).

Table 6: DATA Area – Function Keys

MODE Area**Description**

The MODE area allows you to access and change the parameters that you want to configure.

It consists of 8 keys that light up when the corresponding function is active.

Function Keys

Key	Description
$\lambda.f$	Edits the current value of the emission wavelength λ or the optical frequency f ., and enables the entry of a new value (see section <i>Changing the Emission Wavelength or Frequency</i> , p. 27).
P	<ul style="list-style-type: none"> Edits the current value of the output power P, and allows the entry of a new value (see section <i>Changing the Optical Output Power and Diode Current</i>, p. 33). Switches to the constant-power mode (see section <i>Switching Between Constant-Power and Constant-Current Modes</i>, p. 34).
I	<ul style="list-style-type: none"> Edits the current value of the diode current I, and allows the entry of a new value. Switches to the constant-current mode (see section <i>Switching Between Constant-Power and Constant-Current Modes</i>, p. 34).
STEP	Changes the wavelength increment (STEP) value (see section <i>Setting a Predefined Increment/Decrement Step</i> , p. 28). It is also possible to increase or decrease the wavelength STEP-by-STEP, at any time, by pressing the ← or → keys on the keypad.
APC	Automatic Power Control. Switches between constant-current (APC light off) and constant-power (APC light on) modes. See section <i>Switching Between Constant-Power and Constant-Current Modes</i> , p. 34.
FSC	Enables/Disables the Fine SCanning mode. (see section <i>Using the Fine Scanning Mode (Fine Tuning)</i> , p. 28).
2nd	Enables you to access advanced functions.
$\lambda.f$	To set the motor-speed for swept-mode wavelength scanning (see section <i>Setting the Sweep Speed</i> , p. 32).
P	To perform power calibration (see section <i>Performing Power Calibration</i> , p. 37).
I	To perform system auto-calibration (see section <i>Performing Internal Wavelength Referencing</i> , p. 38).
APC	To disable/enable active cavity control (see section <i>Disabling/Enabling Active Cavity Control</i> , p. 35).
dBm/mW	To turn on active wavelength monitoring (see section <i>Enabling Active Wavelength Monitoring</i> , p. 39).

Key	Description	
2nd	STEP	To activate wavelength step-mode (see section <i>Implementing Step-by-Step Wavelength Scanning</i> , p. 29) or sweep-mode scanning (see section <i>Implementing Continuous Wavelength Sweep (hop-free)</i> , p. 31).
	1	To disable/enable backlash suppression of the micrometer screw (see section <i>Turning On/Off Backlash Suppression of the Micrometer Screw</i> , p. 32).
	2	To display the software version.
	Remote	To change the GPIB address and to activate/deactivate the RS-232 remote mode: see <i>T100S-HP Programming Guide</i> .
	FSC	To enable the coherence control function (see section <i>Turning On/Off Coherence Control</i> , p. 32).
Remote	Switches between remote mode and manual mode (see <i>T100S-HP Programming Guide</i>).	

Table 7: MODE Area – Function Keys

SETUP Area**Description**

The SETUP area is used to enter or change the values of the system operating parameters.

Keys

Key	Purpose
Numeric keypad	Enters a numeric value
← →	Corrects a typing error.
ENTER	Validates the selection.
.	Enters a decimal point.
-	Enters a negative value.
Rotary knob	Adjusts parameter values.
↑ ↓	Changes the basic increment/decrement applied by the rotary knob.

Table 8: SETUP Area – Keys

OUTPUT Area

- **STBY/ON:** key-lock switch. The product can only be started if the key-lock switch is in the ON position.
- **FC/APC:** connector type, protected by a cover bearing the laser warning symbol.

Laser Warning Labels:

The warning symbol indicates the location of the laser source. For more details, see section *Optical Safety*, p. 9.

1.3.2 Description of the Rear Panel

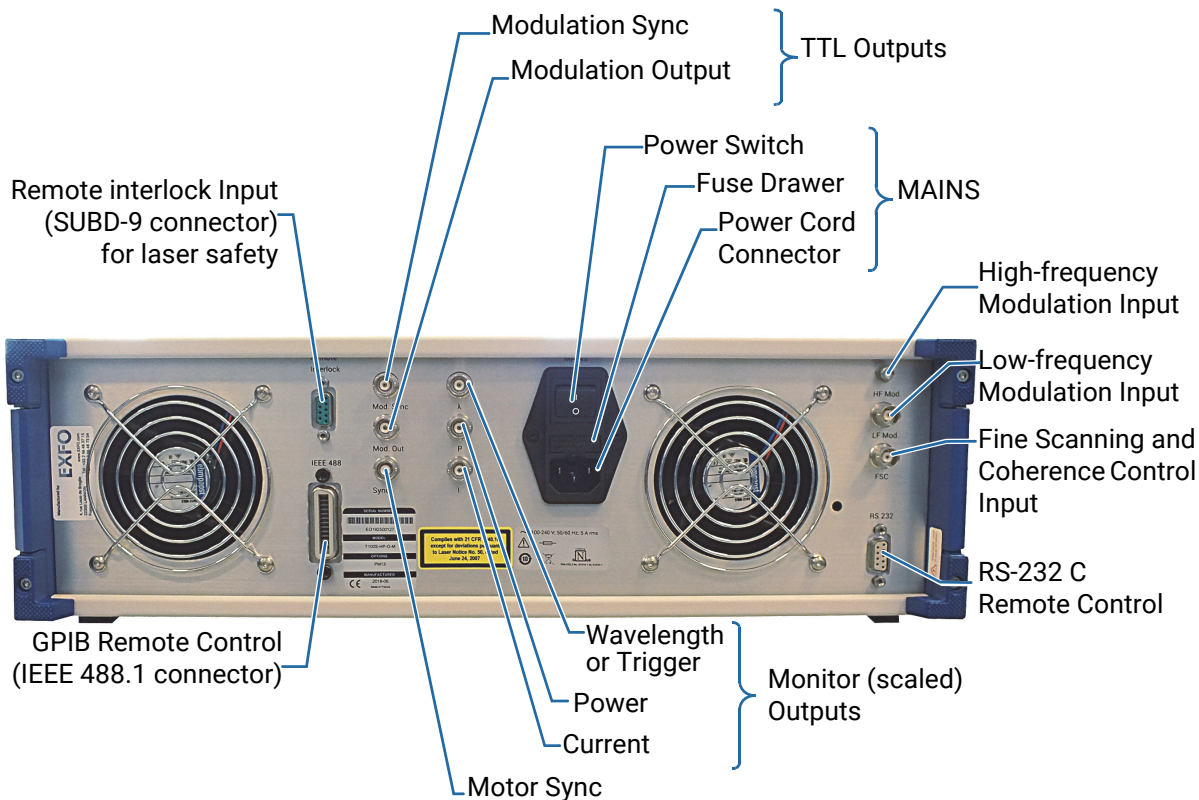


Figure 2: Rear Panel

MAINS

The MAINS module includes:

- The mains power switch
- The power cord connection
- The fuse drawer

Monitor (Scaled) Outputs

- **Sync:** BNC connector for motor Sync.
- **λ :** BNC connector for wavelength monitoring.
You can also use this output connector as a trigger, as explained in section *Activating/Deactivating the λ Output as a Trigger*, p. 49.
- **P:** BNC connector for power monitoring.
- **I:** BNC connector for current monitoring.

TTL Outputs

- **Mod. Sync:** BNC connector for modulation sync (TTL output).
- **Mod. Out:** BNC connector for modulation output (TTL output).

For a detailed description on particular connectors, see section *Using the Auxiliary Inputs and Outputs*, p. 43.

Inputs

- **HF Mod:** SMA connector for high-frequency modulation input.
- **LF Mod:** BNC connector for low-frequency modulation input.
- **FSC:** BNC connector for fine scanning and coherence control.
- **Remote Interlock:** SUBD-9 connector for laser safety (safety interlock is mandatory for Class 3B and 4 laser products. Note that T100S-HP lasers are Class 1M).

For a detailed description on particular connectors, see section *Using the Auxiliary Inputs and Outputs*, p. 43.

Remote Interfaces

- RS-232 C remote control (SUBD-9 connector).
- GPIB remote control (IEEE-488.1 connector).

Remote commands are available in *T100S-HP Programming Guide*.

Labels

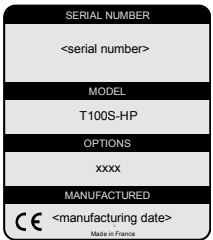

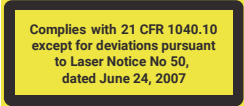
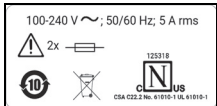



Label	Description
	Identification of the Product Indicates serial number, model number, options (if any), and date of manufacture.
	Manufacturer Identification Contact information of the manufacturer.
	Class 1M Laser Product The product is a class 1M laser product. For more details, see section <i>Optical Safety</i> , p. 9.
	Power and Compliance <ul style="list-style-type: none"> •  indicates an injury hazard. It appears on a location that requires special instructions for proper use: see section <i>Connecting the T100S-HP to a Power Source</i>, p. 22. • \sim : see section <i>Safety Symbols on Your Product</i>, p. 7. •  : the fuse types are described in section <i>Technical Specifications</i>, p. 12. • Compliances: see section <i>Certification and Compliance</i>, p. 61.
	Warranty Seal The product cover must not be open, otherwise the warranty is not valid anymore.

Table 9: Rear Panel Labels

2. Installing and Connecting the Product

2.1 Unpacking and Installing the Product

Subject

When used as a stand-alone bench-top product, this product is designed so that the feet leave enough room under the product to enable proper ventilation. The apertures (under the product) and the fan (behind the product) are used for the inside ventilation.



Caution

- Make sure there is sufficient clearance below and at the back of the product to ensure proper ventilation. The apertures (under the product) and the fan (behind the product) are used for the inside ventilation.
- If you plan to rack-mount this product, make sure to allow at least a 15-mm (0.6 inches) gap between two products.
- The T100S-HP is not designed for outdoor use. To avoid the possibility of injury, do not expose the product to rain or excessive moisture. Do not operate the product in the presence of flammable gases or fumes.

Procedure

1. Pull out the product from its packaging: hold it by its two retractable handles and keep it horizontal.



Important

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

2. Set the product on a flat stable surface free of excessive vibration.
3. Keep the original shipping container, for use in case the product needs to be returned to EXFO for repair or servicing.
4. Allow the flow of air from the cooling fan to circulate freely around the product and remove any equipment or paper that could block the air-flow.
5. On the rear panel (see *Figure 2, p. 18*), make sure the power switch is set to **0**.
6. On the front panel, in the OUTPUT area, make sure the key-lock switch is in **STBY** position before applying power.
7. Place the T100S-HP in the wanted operating position as illustrated in *Figure 3, p. 21*. To tilt the T100S-HP upward, deploy the two retractable legs located below it.



Figure 3: Possible operating positions (bench-top)

2.2 Connecting the T100S-HP to a Power Source

Before Starting



Warning

- Make sure the product power source does not apply more than 265 Volts RMS between the supply conductors or between either of the supply conductors and the ground.
- To avoid the possibility of injury, make sure the socket outlet in which the power supply cord will be plugged is equipped with a protective ground contact, and that the electrical installation fulfills the local safety requirements.
- The T100S-HP has a chassis connected to ground via the power supply cable. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Procedure

1. Make sure the power adapter is not plugged to the wall socket.
2. Make sure the power switch is set to **0**.
3. Connect one end of the power supply cable to the rear panel of the product and plug the other end to the proper voltage mains supply point. The T100S-HP is equipped with a self-regulating power supply that adapts to both AC 110V and 230V voltages, and 50 Hz or 60 Hz frequencies.

2.3 Connecting External Optical Devices to the product

Subject

You can connect external optical components and instruments to the T100S-HP.



Caution

Keeping fiber-optic connectors clean at all times is essential to achieve optimum system performance. Refer to the cleaning instructions in section *Cleaning and Caring for Optical Connectors and Fibers*, p. 55. The standard output connector is a FC/APC connector. Never connect another type of connector to the optical output.

Before Starting



Warning

- The use of optical instruments with this product will increase eye hazard. Do not under any circumstances look directly into the fiber end of an optical cable attached to the optical output while the device is in use for this may cause permanent eye damage and possible loss of eyesight. Note that the laser radiation is not visible to the human eye, therefore, protective cap must always be replaced on the laser output connector after use to avoid involuntary exposure to laser radiation.
- Disable the laser output before connecting or disconnecting a fiber optic cable on the product.

Procedure

1. Make sure fiber-optic connectors are clean.
2. On the front panel, in the OUTPUT area, remove the protective cap and connect external optical components and instruments to the T100S-HP via the FC/APC fiber-optic connector.

**Caution**

- To avoid damage to the laser output, always use a FC/APC type connector. To connect other types of connectors such as FC/PC, make sure to use the appropriate FC/APC converter.
- To help protect the laser output, leave a fiber-optic cable connected to the product while making connections to other devices. When the laser output is not connected, always install the protective cap.

2.4 Installing the Remote Interlock

Subject

The T100S-HP is equipped with a Remote Interlock connector at the rear-panel. You can connect an external remote interlock switch to the Remote Interlock SUBD-9 connector located on the rear panel. Remote interlock sets the system current and power to 0 mA and 0 mW, respectively.

Before Starting**Important**

Make sure that the external switch is electrically isolated from other circuits, including earth ground.

Procedure

- To connect the remote interlock switch, use a connector that meets the following pin assignment:
 - Pins 1-2: Shorted
 - Pins 6-7: Connect to external switch

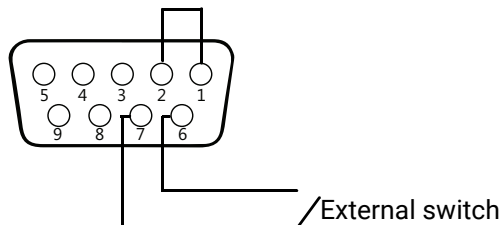


Figure 4: Remote Interlock SUBD-9 Connector

- Opening the interlock switch disables the laser output.
- To turn on the laser output, close the interlock switch and press the **Enable** key.

When the system resumes from remote interlock mode into active state, we suggest that you run a new system auto-calibration procedure (see section *Performing Internal Wavelength Referencing*, p. 38) since the present system calibration data is still based on the previous system operating conditions.

3. Turning on/off and Initializing the Product

3.1 Initializing the Laser

Before Starting



Caution

If the T100S-HP has previously been shut down (see section *Shutting Down the Product*, p. 26), you must wait at least thirty seconds before initializing the laser again.



Warning

While the system initializes the laser, it performs the internal wavelength referencing just after the initialization routine: the T100S-HP produces a laser beam, even if the system is in **Disable** mode.

To avoid eye damage, do not look into the laser output or into the end of an optical cable. Even though the laser radiation is not visible, the intense infrared light can cause eye damage.

Procedure

1. Make sure the key-lock switch on the front panel is in **STBY** position.
2. Set the rear panel **MAINS** power switch to the **I** position to turn on the product.
3. Turn the front panel key to the right to set it to **ON**.



Caution

Do not switch the product off before the system is fully initialized.

- The product performs the initialization routine, the message `Initializing` appears.

The T100S-HP performs self-checks during initialization sequence. Under **MODE**, the LED of the APC key is lit. Power setting is set to zero before the laser is powered up.

- The message `Referencing...` appears to indicate that the system is performing its self-calibration (internal wavelength referencing). This message clears once the laser is initialized and ready for operation.

For optimum system performance, we recommend you to let the T100S-HP perform its self-calibration routine when turning on the system.

4. To skip the self-calibration step (skip `Referencing`): while the message `Initializing...` is displayed, press the **0** key.

Once the initialization routine is complete, the laser output is ready to be enabled:

- The cavity laser is tuned on its central emission wavelength (depending on the model).
- In the **DATA** area:
 - The first display shows the wavelength (λ)
 - The second display shows the output power (P)
 - The third display shows the message `Disabled`.

3.2 Enabling/Disabling the Laser Output

Subject For laser safety reasons, the T100S-HP laser output is not immediately enabled after system turn-on and initialization.
After the initialization routine, the T100S-HP is in Disabled mode, as shown on the third display (DATA area).



Important

For laser safety reasons the T100S-HP features a Remote Interlock connector at the rear-panel that can connect to an external remote interlock switch. When the interlock switch is open, the laser output is turned off. To enable the laser output, the interlock switch must be closed (see section *Installing the Remote Interlock*, p. 23).

Procedure

1. To enable the laser output: in the DATA area, press the **Enable** key.
On the third display, the message `Disabled` is replaced with diode current I.
The **Enable** LED is lit to indicate that the T100S-HP is emitting a laser output.
2. To disable the laser output: in the DATA area, press the **Enable** key again and check that the **Enable** key LED is off.
On the third display, the message `Disabled` appears.

3.3 Shutting Down the Product

Subject The following procedure explains how to shut down the product. Do not turn on and off the system repeatedly and too rapidly.



Warning

Do not unplug the fiber-optic cable from the laser output connector while the laser is still enabled. Exposure to the laser beam is potentially harmful.

Procedure

1. In the DATA area, press the **Enable** key to disable the laser output and make sure the message `Disabled` appears on the third display.
2. On the front panel, in the OUTPUT area turn the key-lock switch counterclockwise to the STBY position.
The message `Parking...` displays and the optical head is automatically moved to its parking position.
3. Wait a few seconds until complete system shutdown.



Caution

During system shutdown, DO NOT TURN OFF the system with the rear panel O/I switch. The optical head must be parked when transporting the product.

4. If you want to move the product, or if it is not going to be used for a long period of time, set the MAINS power switch on the rear panel to the **O** position.



Caution

Before transporting the product, make sure the system is completely turned off.

5. If you want to initialize the laser again, wait at least 30 seconds.

4. Setting Up the Emission Wavelength or Frequency

4.1 Changing the Emission Wavelength or Frequency

Subject To change the emission wavelength/frequency, you can use the numeric keypad or the rotary knob.

- Procedure**
1. In the **MODE** area, press the **λ.f** key.
The corresponding LED indicator is lit and the current parameter value is displayed. When the = sign flashes, you can modify the value.
 2. In the **DATA** area, press the **nm/GHz** key to display the value you want to modify (wavelength or frequency).
 3. Do one of the following:
 - Using the numeric keypad, enter the wanted value. If you make a mistake while entering the value, use the arrow keys ← and → to correct your entry.
 - Turn the rotary knob until the wanted value is reached: turn right to increase the value or left to decrease the value.
To modify the basic increment/decrement applied by the rotary knob, press the ↑ and ↓ arrow keys to set the scroll step in pm or nm.
The required output power may not be reached even at the maximum allowable current. If this occurs, the T100S-HP automatically limits the current to its maximum value and the message "**Lim**" appears at the right end of the displayed power, as shown in this example:
P = 10 mW Lim



Important

As the parameter is changed in real time, the backlash suppression feature applied to the tuning micrometer screw is not activated when you change a value with the rotary knob (see section *Turning On/Off Backlash Suppression of the Micrometer Screw*, p. 32).

4. Make sure the value you entered is valid, as specified in section *Valid Ranges for Parameter Settings*, p. 14.
5. In the **SETUP** area, press the **ENTER** key.

4.2 Setting a Predefined Increment/Decrement Step

Subject The following procedure explains how to change the wavelength increment (STEP) value.

Procedure

1. In the MODE area, press the **STEP** key.
2. Using the numeric keypad, enter the wanted wavelength or frequency step.
Example for wavelength (nm): 0.5
3. Make sure the value you entered is valid, as specified in section *Valid Ranges for Parameter Settings, p. 14*.
The required output power may not be reached even at the maximum allowable current. If this occurs, the T100S-HP automatically limits the current to its maximum value and the message "**Lim**" appears
4. In the SETUP area, press the **ENTER** key.
5. Increase or decrease the wavelength by pressing the ← or → arrow keys in the SETUP area.

4.3 Using the Fine Scanning Mode (Fine Tuning)

Subject The Fine Scanning Mode performs a complete and virtually continuous sweep of the wavelength on a ± 2 GHz range. It enables you to fine tune wavelength with a 0.1 pm resolution. You first need to set the desired emission wavelength (resolution 1 pm) and then adjust the value with the FSC function key (0.1 pm resolution), as described below.

Procedure

1. To enable the Fine Scanning mode: in the MODE area, press the **FSC** function key.
2. Adjust the wavelength with the rotary knob over a limited range of about ± 20 pm.
The wavelength offset selected with the rotary knob is displayed in the DATA area in nm (d λ) or GHz (df).
3. To exit the Fine Scanning mode, press the **FSC** function key again.

4.4 Implementing Step-by-Step Wavelength Scanning

Subject

Wavelength scanning enables the T100S-HP tunable laser to broadcast on a different wavelength at each time interval. It incrementally scans the entire wavelength scanning range that you specified.

The following flowchart illustrates the wavelength scan process:

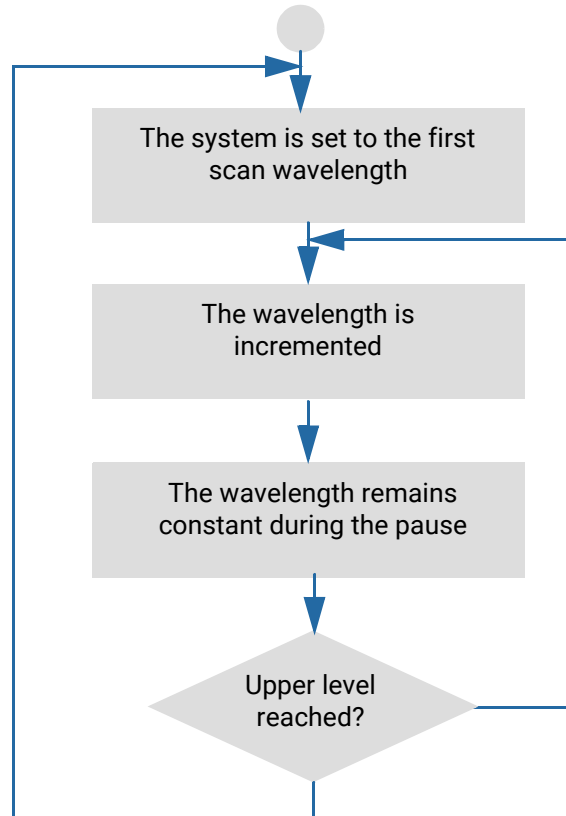


Figure 5: Wavelength scanning process

Starting from the first wavelength (i.e. the lower wavelength limit that you set), the emission wavelength increases incrementally (you set the wavelength increment stored in the STEP parameter) up to the last wavelength value (upper wavelength limit that you set).

During each scan interval, the T100S-HP laser broadcast at a set wavelength for the duration specified by the Pause Timer parameter that you set.

Before Starting

Before activating the wavelength scanning, you must set the optical output power of the T100S-HP laser, as described in section *Changing the Optical Output Power and Diode Current*, p. 33.

Operating parameters cannot be changed while the wavelength scanning is in progress. Make sure the power output level you set can be achieved within the maximum current limits over the entire scanning range. If the desired power output cannot be reached due to current limitations, the **Lim** message is displayed to indicate that the system no longer operates at constant power.

Procedure

1. Press the **2nd + STEP** keys to activate the scan mode.
2. Press **Enter** to validate.
The **DATA** area display prompts you to enter the lower wavelength scan limit while the current setting is displayed.
3. Enter the lower wavelength scan limit and press **Enter** (for valid scan limits, see section *Technical Specifications, p. 12*).
The **DATA** area display prompts you to enter the upper wavelength scan limit while the current setting is displayed.
4. Enter the upper wavelength scan limit and press **Enter** (for valid scan limits, see section *Technical Specifications, p. 12*).
The **DATA** area display prompts you to enter the scan STEP while the current setting is displayed.
5. Enter the scan STEP and press **Enter**.
To know the valid range for scan STEP values, see section *Valid Ranges for Parameter Settings, p. 14*).
The **DATA** area display prompts you to enter the Pause Timer between two scan steps while the current setting is displayed.
6. Enter the Pause Timer and press **Enter**. Possible values for Pause Timer range from 0.1 to 25 seconds.
Scanning begins. The wavelength scanning process repeats continuously until you press the **STEP** key to suspend or stop the scan.
7. To suspend the current wavelength scan, press the **STEP** key.
The **DATA** area display prompts you to `stop scan 1/0?`.
8. To stop the scan, press the numeric keys **1 + Enter**.
Scanning stops and the emission wavelength remains set to the value applied at the time the scan was suspended.
9. To resume scanning, press numeric keys **0 + Enter**.

4.5 Implementing Continuous Wavelength Sweep (hop-free)

The T100S-HP allows you to perform truly continuous, mode-hop-free scans in swept-mode over the entire operational wavelength range.

4.5.1 Implementing Wavelength Sweep

Procedure

1. Press the **2nd + STEP** keys to activate the scan mode.
The **DATA** area display prompts you to enter the lower wavelength scan limit while the current setting is displayed.
2. Enter the lower wavelength scan limit and press **Enter** (for valid scan limits, see section *Technical Specifications*, p. 12).
The **DATA** area display prompts you to enter the upper wavelength scan limit while the current setting is displayed.
3. Enter the upper wavelength scan limit and press **Enter** (for valid scan limits, see section *Technical Specifications*, p. 12).
The **DATA** area display prompts you to enter the scan STEP while the current setting is displayed.
4. Enter **0** as scan STEP parameter and press **Enter**.
The **DATA** area display prompts you to enter the Pause Timer. The PAUSE TIMER is the dwell time at the upper wavelength of the sweep range before the T100S-HP tunable laser returns to the lower wavelength to restart a new sweep cycle.
5. When prompted, enter the PAUSE TIMER parameter, and press **Enter**. Possible values for Pause Timer range from 0.1 to 25 seconds.
The wavelength sweep (hop-free) is activated, sweep begins.
6. To suspend the current wavelength sweep, press the **STEP** key.
You are then prompted to `stop scan 1/0?`.
7. To stop the scan press the numeric keys **1 + Enter**.
Sweep stops and the emission wavelength remains set to the value applied at the time the scan was suspended.
8. To resume scanning, press numeric keys **0 + Enter**.
 - In manual operating mode, the wavelength sweeping process repeats continuously until you press the **STEP** key to suspend or stop the sweep.
 - In remote operating mode (see *T100S-HP Programming Guide*), the system performs a single sweep path over the wavelength sweeping range and stops when the wavelength reaches the upper wavelength limit.

4.5.2 Setting the Sweep Speed

Subject You can set the sweeping process to scan from a lower to an upper wavelength value, at a user-specified speed. When the T100S-HP has reached the upper wavelength limit, it returns to the initial wavelength value at maximum speed (i.e. 100 nm/s), and starts again the scanning process at the defined speed.

- Procedure**
1. Press **2nd + λ.f** keys to display the current sweep speed setting.
 2. Enter the new sweep speed directly in nm/s unit.

The sweeping speed is user-selectable within the speed range of 1 to 100 nm/s. You may choose any speed value within this range. However, operational speeds that the motor can move are: [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 20, 22, 25, 29, 33, 40, 50, 67, 100] (nm/s). Therefore, the speed you select is rounded-up to nearest value of operational speed.

For example, if you select a 70 nm/s sweep speed on the T100S-HP front panel, your setting is automatically corrected by the system to match the nearest operational value, i.e. 67 nm/s.

3. Press **Enter** to confirm the change.

4.6 Turning On/Off Backlash Suppression of the Micrometer Screw

Subject The T100S-HP firmware systematically implements an on-board procedure to eliminate the effect of backlash on the tuning micrometer screw. By default, backlash suppression is activated.

- Procedure**
- To disable the backlash suppression mode, press the **2nd + 1** function keys. A dot is displayed at the right end of the wavelength.
Example: $\lambda = 1555.000 \text{ nm} \cdot$
 - To enable the backlash suppression mode, press the **2nd + 1** function keys again.

4.7 Turning On/Off Coherence Control

Subject The Coherence Control function adds noise to the laser optical frequency output producing an apparent broadening of the linewidth. Coherence control is particularly useful to reduce the impact of parasitic interferences in the user setup. This function can also be accessed by using the FSC input on rear panel (see section *Using the Auxiliary Inputs and Outputs*, p. 43).

- Procedure**
- To activate the coherence control feature, press the **2nd + FSC** function key. The **FSC** key LED blinks, which means that the function is activated.
 - To deactivate the coherence control feature, press the **2nd + FSC** function key again.

5. Changing the Optical Output Power and Diode Current

5.1 Changing the Optical Output Power

Subject The optical output power is displayed in the DATA area, at the right of the **mW/dBm** key.

Procedure

1. In the MODE area, press the **P** key.

The corresponding LED indicator is lit and the current parameter value is displayed. When the = sign flashes, you can modify the value.

2. Do one of the following:

- Using the numeric keypad, enter the wanted value. If you make a mistake while entering the value, use the arrow keys ← and → to correct your entry.
- Turn the rotary knob until the wanted value is reached: turn right to increase the value or left to decrease the value.

To modify the basic increment/decrement applied by the rotary knob, press the ↑ and ↓ arrow keys to set the scroll step at either 0.1 mW or 0.01 mW.

The possible output power values range from 0.2 to 10 mW for the standard-power T100S-HP model.

The required output power may not be reached even at the maximum allowable current. If this occurs, the T100S-HP automatically limits the current to its maximum value and the message "**Lim**" appears at the right end of the displayed power, as shown in this example:

```
P = 12 mW Lim
```

3. Depending on which output power model you are using, make sure to enter values within the valid parameter range of your T100S-HP model, as specified in section *Valid Ranges for Parameter Settings*, p. 14.
4. In the SETUP area, press the **ENTER** key.

5.2 Switching Between Constant-Power and Constant-Current Modes

Subject

- The **constant-current mode** enables you to change the wavelength/frequency of the laser while maintaining the diode current level.
- The **constant-power mode** enables you to change the wavelength/frequency of the laser while maintaining the output power level. In this mode, the diode current is automatically adjusted through a feedback loop.

The **APC** function key allows you to toggle between the constant-current and the constant-power modes.

Procedure

- To activate the constant-power mode, press the APC function key to turn **on** the APC key LED:

The active mode is **constant-power**: the laser-diode current is controlled to ensure an optical power output equal to the **P** parameter.

By pressing the **P** function key, the system switches automatically to the constant-power mode.

In this mode, the required power cannot be obtained, even with the maximum allowable current. In this case:

- The current is limited to its maximum value.
 - The optical power is lower than the user-set power value.
 - The **Lim** message is displayed to the right of the current and power values.
- To activate the constant-current mode, press the APC function key to turn **off** the APC key LED:

The active mode is **constant-current**: the diode current level is determined by the **I** parameter.

By pressing the **I** function key, the system switches automatically to the constant-current mode.

5.3 Disabling/Enabling Active Cavity Control

Subject

The T100S-HP is equipped with on-board active cavity control.

When you turn on the T100S-HP after the initialization routine is complete, the system switches automatically to APC (constant power) mode with active cavity control (the APC LED is on).

Active Cavity Control Requirements

Active cavity control is enabled if the following requirements are both met:

- APC (constant power) mode (APC LED on)
- Power > 0.8 mW

System Status

System status is summarized in the following table:

APC LED	Constant Power Mode	Active Cavity Control
On	Yes	Yes
Blinking	Yes	No
Off	No	No

Table 10: Active Cavity Control - System Status

Procedure

- To disable active cavity control, press the **2nd + APC** key combination.

The **APC LED** blinks.

If you press the **APC** key and the APC LED goes off, this indicates that the system has switched in constant current mode. When entering constant current mode, the active cavity control becomes disabled, and the system restores the operating parameters that were in effect at the time the T100S-HP last left the constant current mode.

- To enable active cavity control, press the **2nd + APC** command keys again.

If the APC LED starts blinking while the T100S-HP is in APC mode with active cavity control on, this may indicate that the laser power output (P) is set to a value lower than the 0.8 mW threshold.

5.4 Changing the Laser Diode Current

Subject The laser diode current is displayed in the DATA area, at the right of the I key. To change the laser diode current, proceed as follows:

Procedure

1. In the MODE area, press the I function key.
The corresponding LED indicator is lit and the current parameter value is displayed. When the = sign flashes, you can modify the value.
2. Do one of the following:
 - Using the numeric keypad, enter the wanted value. If you make a mistake while entering the value, use the arrow keys ← and → to correct your entry.
 - Turn the rotary knob until the wanted value is reached: turn right to increase the value or left to decrease the value.
To modify the basic increment/decrement applied by the rotary knob, press the ↑ and ↓ arrow keys to set the scroll step at either 1 mA or 0.1 mA.
3. In the SETUP area, press the **ENTER** key.

6. Calibrating the Product

6.1 Performing Power Calibration

Subject The power calibration procedure calibrates the laser output power. The procedure requires the use of an optical power meter.



Caution

This procedure corrects the factory-set calibration data.

- Do not perform this procedure unless you actually intend to correct this data.
- Do not perform these procedures unless you have calibrated sources.

Procedure

1. Connect the laser output of the product to a power meter, (see section *Connecting External Optical Devices to the product*, p. 22).
2. Enable the laser output (see section *Enabling/Disabling the Laser Output*, p. 26).
3. Press the **2nd + P** function keys to activate the power calibration procedure.
The tunable laser moves to a short wavelength within the tuning range and displays the power level corresponding to the current calibration data.
4. Measure the power level at the first wavelength on the power meter.
5. Enter the reading at the prompt **P =**.
The tunable laser moves to a long wavelength within the tuning range and displays the power level corresponding to the current calibration data.
6. Measure the power level at the second wavelength.
7. Enter the reading at the prompt **P =**.
The power calibration is now complete and the instructions reference the new power calibration data.

6.2 Performing Internal Wavelength Referencing

Subject

The T100S-HP internal referencing system ensures optimum calibration of the laser source as soon as the system starts.

We recommend you to perform an auto-calibration after the first half hour of system warm-up or use.



Important

When the system is subject to substantial changes of operating environmental conditions such as a sharp change in room temperature or mechanical vibrations, you must run a new system auto-calibration procedure, as specified below.

The T100S-HP automatically performs a self-calibration procedure (also called Internal Referencing) during the initialization routine: see section *Initializing the Laser*, p. 25.

In addition to the self-calibration performed at start-up only, you can instruct the system to perform a new auto-calibration at any time, as explained in the following procedure.



Warning

While the system performs an auto-calibration, the T100S-HP produces a laser beam, even if the system is in **Disable** mode.

To avoid eye damage, do not look into the laser output or into the end of an optical cable. Even though the laser radiation is not visible, the intense infrared light can cause eye damage.

Before Starting

Make sure the Remote Interlock switch is closed: for laser safety reasons the T100S-HP features a Remote Interlock connector at the rear-panel that can connect to an external remote interlock switch. When the interlock switch is open, the laser output is turned off. Remote interlock sets the system current and power to 0 mA and 0 mW, respectively. Therefore, as long as the system is in remote interlock mode, it cannot perform any self-calibration or internal referencing.

Procedure

1. Press the **2nd + I** function keys to start auto-calibration.
2. The T100S-HP performs its internal referencing routine and the message `Referencing...` appears.
 - After calibration is complete, the T100S-HP restores the initial wavelength value in effect at the time auto-calibration was performed.
 - If auto-calibration has failed, the following message appears: `Referencing error. Press Enter.`

Press the **Enter** key to cancel the calibration. The system current internal wavelength referencing remains unchanged.

7. Enabling Active Wavelength Monitoring

When associated with an external optical wavelength meter, the T100S-HP tunable laser can implement active wavelength monitoring to achieve high-precision wavelength tuning (± 2 pm, typically or within the wavemeter's accuracy).

7.1 Setting Up the Product for Active Wavelength Monitoring

Subject This section outlines the product setup and system requirements.

Before Starting The wavemeter used must meet the following hardware and configuration requirements:

- Serial port command set: based on the SCPI (Standard Commands for Programming Instruments) syntax.
- Serial interface configuration:
 - RS-232: ON
 - Baud rate: 9600
 - Handshaking: None

Depending on the wavemeter you are using, configuration can be achieved either via soft-panel controls or by hardware setting via a back-panel dip-switch. For details on how to configure your wavemeter, please refer to the user's manual provided by the manufacturer.

As an example, with a Burleigh-EXFO wavemeter, use a DB9 male-male straight-through serial cable to connect the T100S-HP RS-232 C port to the wavemeter serial port.

Please contact your EXFO representative for a list of compatible wavemeters.

- Procedure**
1. To setup the measurement, connect the T100S-HP output to the wavemeter via the low output port of an optical coupler.

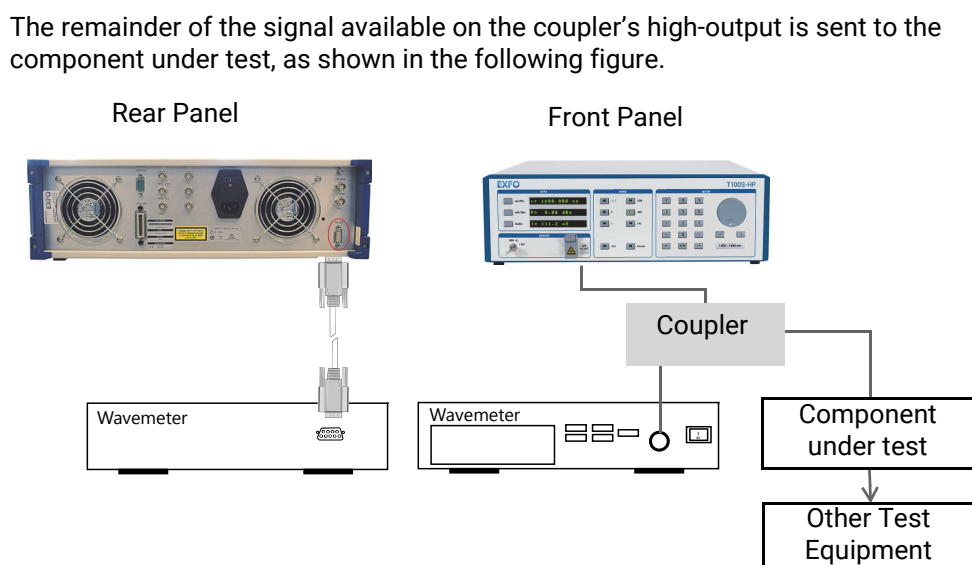


Figure 6: Instrument Setup for Wavelength Monitoring

2. Connect a communication link between the T100S-HP tunable laser source and the wavemeter via the RS-232 C interface: make sure the RS-232 C cable connection meets the following pin assignment on the T100S-HP SubD-9 connector:
 - Pin 2: RX (data received by T100S-HP on pin 2)
 - Pin 3: TX (messages sent out by T100S-HP via pin 3)
 - Pin 5: GND (the ground is through pin 5)

7.2 Performing Wavelength Monitoring

Wavelength Monitoring Scheme

The wavelength monitoring scheme consists in a loop-back to the tunable laser of the wavemeter actual reading, and self-alignment of the tunable laser by iteration process to achieve the user-defined target wavelength within the wavemeter's accuracy. In order to achieve the user-defined target wavelength within the wavemeter accuracy, the following wavelength monitoring scheme is implemented:

- The wavemeter actual reading loops back to the tunable laser
- An iteration process self-aligns the tunable laser.

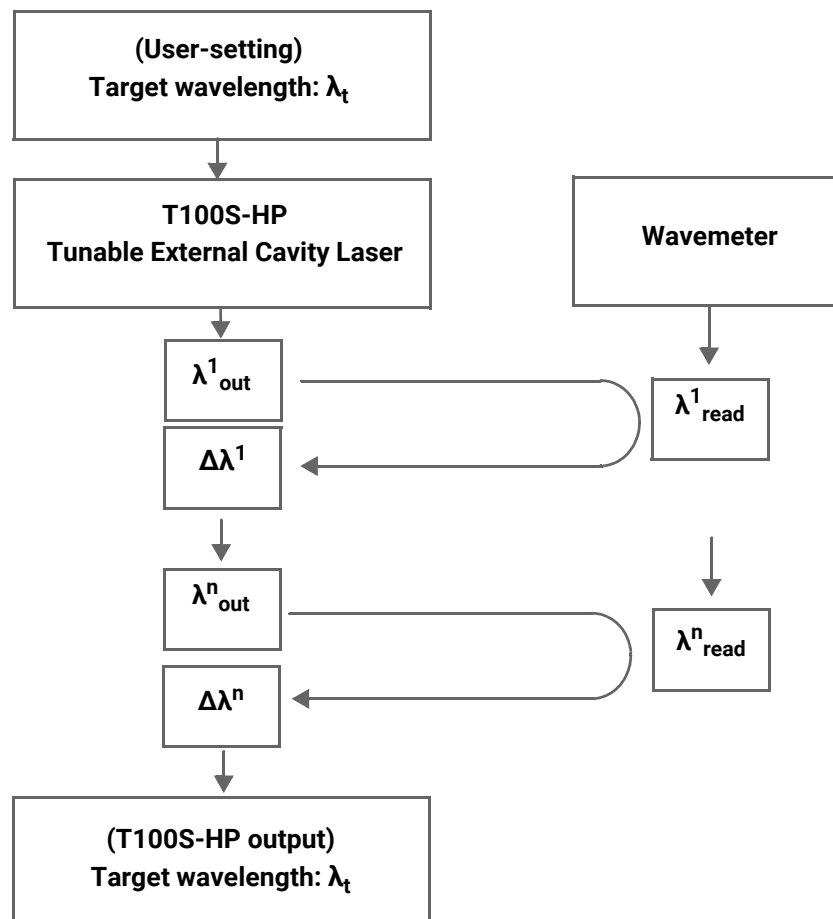


Figure 7: Wavelength Monitoring Scheme

Depending on the performance of the wavemeter you are using, the average iteration time to reach the target wavelength may range from 1.5 s to 2 s.

The following procedure explains how to perform wavelength monitoring of the T100S-HP using a wavemeter.

Procedure

1. Configure the wavemeter remote interface with the following parameters:
 - Remote: [On]
 - RS-232: [On]
 - Baud: [9600]
 - Handshaking: [None]
2. Connect the T100S-HP DB9 serial port to the wavemeter serial port.
3. As the tunable laser acts as the controller device for the wavemeter, press the **2nd+Remote** function keys at the T100S-HP front-panel and select:
RS-232 IN: [OFF]
4. Start the Feedback function by pressing the **2nd+mW/dBm** keys.
5. Enter the wavelength setting at the T100S-HP front-panel.
 - The T100S-HP executes the wavelength monitoring scheme (see *Figure 7, p. 40*) so that the output signal wavelength closely matches the wavelength setting. The message `Moving...` is displayed at the front-panel indicator until the output wavelength has reached the target value and has stabilized within wavemeter accuracy.

To compensate for possible disturbance such as accidental vibrations, shocks, temperature drifts, and possible malfunction of the wavemeter, the T100S-HP performs the wavelength monitoring scheme with a 4-second periodicity.
 - The T100S-HP front-panel display shows the tunable laser operating wavelength, alternating with the `λ FEEDBACK:ON` message to indicate that the "active wavelength monitoring" is currently on.

If the active wavelength monitoring does not work properly, the `λ FEEDBACK:ERR` message appears, alternating with the tunable laser operating wavelength.
6. To turn off the active wavelength monitoring, press the **2nd+mW/dBm** again.
The message `FEEDBACK:OFF` displays once then goes off.

8. Using the Auxiliary Inputs and Outputs

The auxiliary input and output connectors are located on the rear panel of the T100S-HP, as described in section *Description of the Rear Panel*, p. 18.

8.1 Implementing External Modulation

8.1.1 Implementing Low Frequency Intensity Modulation

Subject You can implement low frequency intensity modulation of the output beam:

- in the constant-current mode:
 - from DC to 8 MHz for sinusoidal signals
 - from DC to 1 MHz for TTL signals
- in the APC (constant-power) mode:
 - from 30 kHz to 8 MHz for sinusoidal signals
 - from 30 kHz to 1 MHz for TTL signals

Modulation of the diode current is obtained by applying a signal anywhere between **0 and 5 volts** on the BNC connector labeled **LF Mod**.

Before Starting



Important

Before implementing external modulation via **LF Mod**, input connector, make sure the system's active cavity control is disabled (see section *Disabling/Enabling Active Cavity Control*, p. 35).

Procedure

1. Connect an external modulation source to the **LF Mod**. BNC connector, as shown in *Figure 8*, p. 44.
 - The output impedance of your waveform generator must match the 50 Ω input impedance of the T100S-HP **LF Mod**. BNC connector.

- Make sure to use a 50 Ω BNC cord to connect the T100S-HP and the waveform generator.

T100S-HP Laser Diode Source

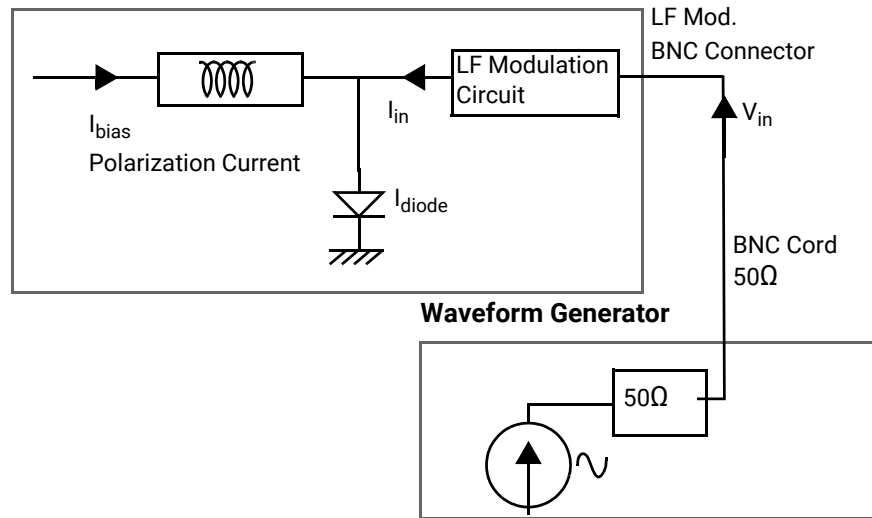


Figure 8: Low frequency modulation setup

2. Set the operating current I_{bias} of the T100S-HP in constant-current mode. The relationship between the diode output current I_{diode} and the input voltage V_{in} is then given by:

$$\text{Formula: } I_{diode} = I_{bias} - 2 \times \frac{V_{in}}{R}$$

Where:

- V_{in} is the input voltage applied to the LF Mod. BNC input connector (V_{in} must always be positive and less than 5 V)
- I_{diode} is the total diode current
- I_{bias} is the polarization current of your T100S-HP
- R is the 50 Ω resistor of the LF modulation circuit

With a maximum allowed voltage input of 5 volts, the maximum input current you can add to the T100S-HP laser diode is 100 mA.

Resulting LF-Modulated Diode Current

The laser diode of your T100S-HP is characterized by its saturation current (I_{max}) and the cutoff current (I_{cutoff}).

To perform a diode intensity modulation under optimum conditions, you must ensure at all times that the resulting modulated diode current obeys the following condition: $I_{cutoff} \leq I_{diode} \leq I_{max}$

The following figure shows a behavioral representation the resulting modulated diode current.

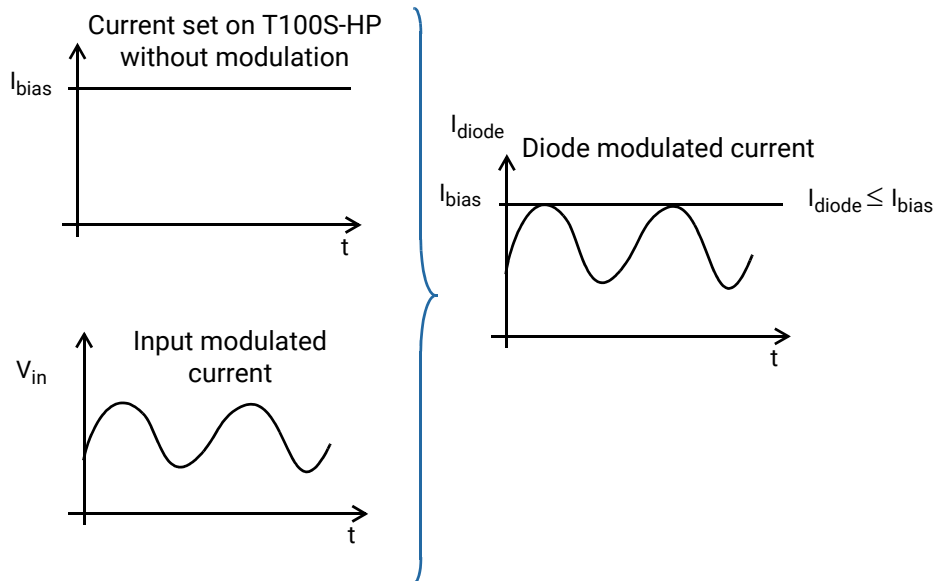


Figure 9: Resulting LF-modulated diode current

In the APC mode, the output power is controlled in order to remain constant. In principle this is not compatible with a modulation of the output power.

However, if the frequency of the modulation signal is well above the intrinsic frequency (≈ 1 kHz) of the APC loop, the average power is monitored, and remains constant.

Modulation is possible in the APC mode at frequencies above 30 kHz. If a lower frequency is used, interaction between modulation signal and APC circuit will cause unpredictable modifications of the output power waveform.

8.1.2 Implementing High Frequency Intensity Modulation

Subject

The **HF Mod** input allows you to increase the total diode current by applying voltage to the **HF Mod** SMA connector.

A valid high frequency modulation signal applied to the SMA port can range from 30 KHz up to 200 MHz.

Before Starting



Important

Before implementing external modulation via **HF Mod** input connector, make sure the system's active cavity control is disabled (see section *Disabling/Enabling Active Cavity Control*, p. 35).

Procedure

1. Connect an external high frequency modulation source to the **HF Mod**. SMA connector, as shown in the following *Figure 10*, p. 46.

Make sure to use a 50 Ω coaxial cord to connect your HF generator to the 50 input SMA connector.

T100S-HP Laser Diode Source

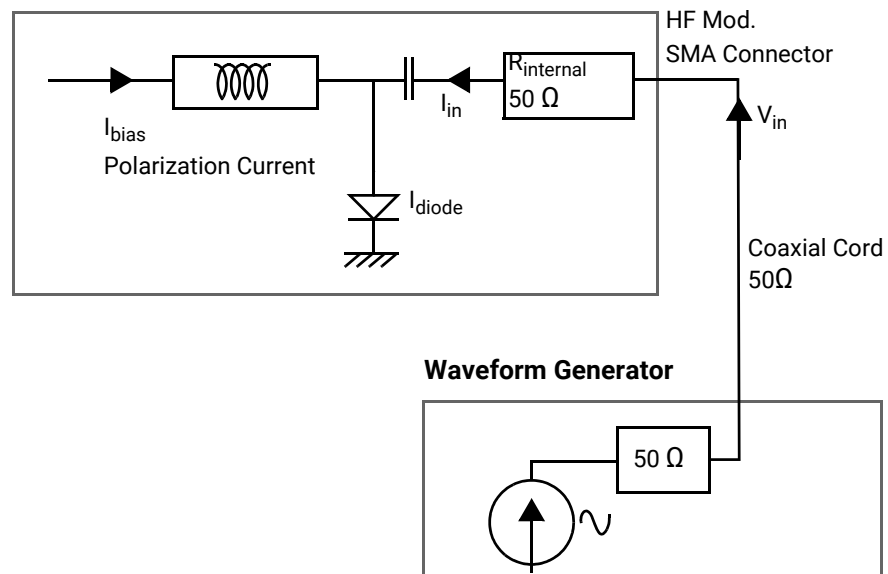


Figure 10: High frequency modulation setup

2. Use High Frequency Modulation:



Warning

Since the **HF Mod** SMA input is directly connected to the laser diode chip via a 50 Ω resistor, you must ensure that the input voltage on the **HF Mod** connector is such that the following conditions are always met, to avoid the destruction of the diode:

- The diode laser is forward biased.
- The current flowing through the diode is lower than the maximum admissible current (I_{max}) indicated in the system acceptance test report.

The relationship between the voltage at the **HF Mod** input and the current added to the diode is given by:

$$I_{in} = V_{in}/R_{internal}$$

where:

- I_{in} is the added current
- V_{in} is the voltage applied to the **HF Mod** input
- $R_{internal}$ is the 50 Ω internal resistor of your T100S-HP

By modulating this extra current, the optical power output can be modulated within a frequency range from 30 kHz to 200 MHz. The low-frequency cutoff is 30 kHz. The modulation bandwidth is greater than 200 MHz, and this **HF Mod** input can also be used for mode-locked operation.

The best way to fulfill the above conditions is to measure the system bias current (I_b) through the voltage on the current monitor output, and to compute the total current using the following formula:

$$I_{diode} = I_{bias} + \frac{V_{in}}{R_{internal}}$$

Where:

- I_{diode} is the total current through the diode
- I_{bias} is the bias current
- V_{in} is the voltage applied to the **HF Mod** input
- $R_{internal}$ is the 50 Ω T100S-HP internal resistor

Resulting HF-Modulated Diode Current

You must monitor V_{in} to ensure that the total current remains positive and lower than the maximum admissible current, as shown in the following figure:

$$0 < I_{diode} < I_{max}$$

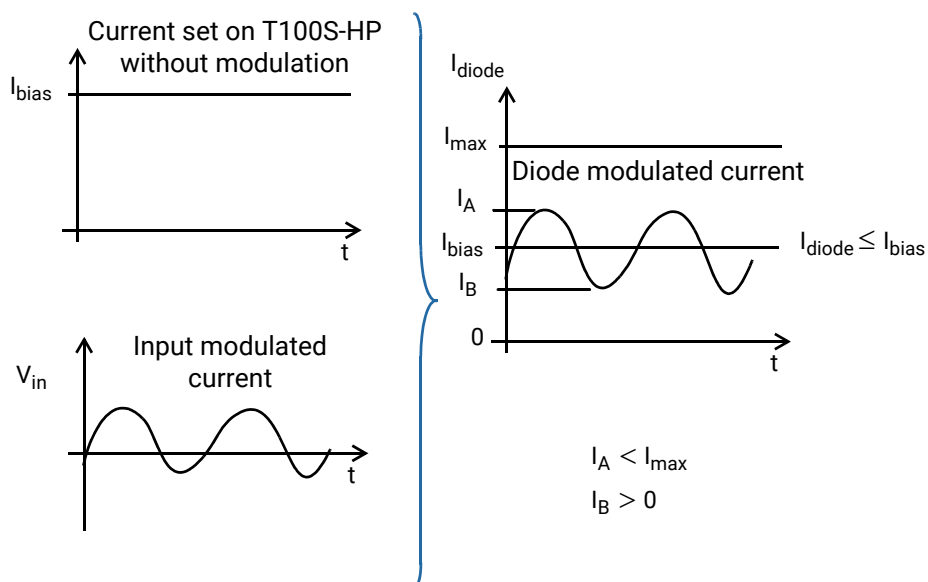


Figure 11: Resulting HF-modulated diode current

If the voltage applied to the **HF Mod** input is an AC signal with no DC component, and whose peak-to-peak amplitude is V_{pp} , the above condition becomes:

$$V_{pp} < 2 \times R_{internal} (I_{max} - I_{bias})$$

$$V_{pp} < 2 \times R_{internal} (I_{bias})$$

V_{pp} must be lower than the lowest of these two values.

The T100S-HP constantly monitors the average optical output power and regulates the system bias current to keep the system output power constant. If a DC or low frequency (below 30 kHz) voltage is applied to the **HF Mod** input, there is no modulation on the output power, as the system automatically compensates by adjusting the bias current to cancel this modulation. However, if the frequency of the signal applied to the **HF Mod** input is well above the power control loop cutoff frequency (30 kHz), the output signal modulation will match that of the input signal, around an average power determined by the settings of the system. For that reason, you must implement a modulation frequency above 30 kHz.

8.1.3 Wavelength Modulation

Before Starting



Important

Before implementing external modulation via **FSC** input connector, make sure the system's active cavity control is disabled (see section *Disabling/Enabling Active Cavity Control*, p. 35).

Wavelength Fine Scanning

The T100S-HP has a wavelength fine tuning capability that can be used to adjust the wavelength very precisely, or to serve the optical frequency.

This function is available via the FSC connector on the rear panel.

When voltage is applied to the FSC connector, the optical frequency shifts -300 MHz/V for every volt applied.

The maximum input voltage allowed on FSC is ± 10 volts.

FSC input also allows wavelength modulation by applying a modulation signal whose frequency is lower than 450 Hz.

Coherence Control

When a "noise" signal is directly fed into the FSC input via the **2nd + FSC** function to modulate the optical frequency, this induces an apparent broadening of the laser linewidth leading to a reduction of the coherence length.

This can be useful to eliminate parasitic interferometers in the user setup. This modulation is limited to low frequency (DC to 450 Hz typ.). When this function is active, the LED on the FSC key is blinking.

8.2 Output Signals

8.2.1 Available TTL Output Signals

A 7.2 kHz TTL modulation signal is provided on the following BNC connectors (see section *Description of the Rear Panel*, p. 18):

- **Mod Out:** internal modulation signal
- **Mod Sync:** synchronization signal

8.2.2 Monitoring Outputs

Output connectors located on the rear panel enable continuous monitoring of:

- Actual values of current (**I** output),
- Actual values of power (**P** output),
- Actual values of wavelength (**λ** output)
- Detection of motor displacement (**Sync.** output).

These monitor outputs use BNC connectors.

Signal levels are as follows:

Monitor Output	Description	Reading
I output	Current monitoring	10 mV/mA
P output	Power monitoring	0.1 mV/μW
λ output as analog	Wavelength monitoring	0.3-4.8 V from λ min to λ max linear
λ output as trigger	Trigger	TTL
Sync.	Motor monitoring	<ul style="list-style-type: none"> • 5 V: motor moving • 0 V: motor idle

Table 11: Monitor Output - Signal Levels

8.2.3 Activating/Deactivating the λ Output as a Trigger

Subject

You can switch the λ output to a trigger (TTL) that is high when the T100S-HP is scanning (only in positive direction ignoring return and backlash).

Procedure

1. Press the **2nd + 3** keys.
The **DATA** area display prompts you to activate the BNC connector as a trigger.
2. Press **1** to activate the λ BNC connector as trigger.
3. Press **Enter** to validate.
You can now use the λ BNC connector as a trigger.
4. To switch the λ BNC connector back as the wavelength output:
 - a. Press the **2nd + 3** keys
 - b. Press **0** to deactivate the λ BNC connector as trigger.
 - c. Press **Enter** to validate.

9. Verifying Performances

Use the procedures in this section to verify the following warranted specifications of the T100S-HP:

- Absolute wavelength accuracy
- Wavelength range and output power
- Tuning repeatability
- Side mode suppression
- Return loss

The recommended calibration interval is one year.



Warning

- The use of optical instruments with this product will increase eye hazard. Do not under any circumstances look directly into the fiber end of an optical cable attached to the optical output while the device is in use for this may cause permanent eye damage and possible loss of eyesight. Note that the laser radiation is not visible to the human eye, therefore, protective cap must always be replaced on the laser output connector after use to avoid involuntary exposure to laser radiation.
- Disable the laser output before connecting or disconnecting a fiber optic cable on the product.

9.1 Preparing the Product for Testing

Equipment Required

The following table lists the equipment required to carry out the performance verification procedures. The type and amount of connectors needed may vary according to the particular equipment you use as well as the distance between the test equipment and the T100S-HP tunable laser under test.

Description	Minimum Requirements
Optical power meter	Wavelength range: 1240 nm to 1680 nm
Optical Spectrum Analyzer (OSA)	Wavelength range: 1240 nm to 1680 nm
Wavemeter	Wavelength range: 1240 nm to 1680 nm
Jumper	FC/APC to FC/PC
Inline optical adapter	FC to FC

Table 12: Test Equipment

Procedure

1. Warm up the T100S-HP tunable laser under test and the test equipment for 2 hours at an ambient temperature (between 20° and 30° C).
2. Initialize the system as described in section *Initializing the Laser*, p. 25.
3. Connect the laser output as described in section *Connecting External Optical Devices to the product*, p. 22.
4. Enable the laser output as described in section *Enabling/Disabling the Laser Output*, p. 26.

9.2 Verifying the Absolute Wavelength Accuracy

Subject The following procedure verifies that the wavelength settings agree with the measured wavelengths over the entire specification range.
If these values do not match the absolute wavelength specification, you may calibrate the lower and upper wavelength setting limits by using an external wavemeter, as described below.

- Procedure**
1. Connect the laser to the wavemeter.
 2. Set the output power to 0 dBm using the front-panel power controls: (Press P > 0 > ENTER).
 3. Set the wavelength of the tunable laser to the lower limit of the wavelength range according to the T100S-HP model (see section *Technical Specifications*, p. 12).
 4. Enable the laser output and verify the wavelength at the lower limit ± 0.04 nm.
 5. Repeat the check for each increment of 5 nm from the lower limit to the upper limit listed in section *Technical Specifications*, p. 12.
 6. Verify that the measured wavelength is no greater than ± 0.04 nm away from each wavelength setting.

9.3 Verifying Wavelength Range and Output Power

Subject The following procedure verifies that the laser output can achieve the rated power at the specified limits of the wavelength range.
If the power settings do not exactly match the measured power, you may calibrate the power settings from the front panel, as follows.

- Procedure**
1. Disable the laser output.
 2. Connect the laser to the optical power meter.
 3. Set the wavelength of the tunable laser and the power meter to the lower limit of the wavelength range listed in section *Technical Specifications*, p. 12.
 4. Enable the laser output and adjust the power setting as necessary to verify that the laser can achieve the rated output power at the lower limit of the wavelength range.
 5. Set the wavelength of the tunable laser and the power meter to the upper limit of the wavelength range listed in section *Technical Specifications*, p. 12.
 6. Enable the laser output and adjust the power setting as necessary to verify that the laser can achieve the rated output power at the upper limit of the wavelength range.

9.4 Verifying Side Mode Suppression

Subject The following procedure verifies the suppression of any wave emissions that are more than 1 nm away from the selected wavelength.
This procedure requires the use of an optical spectrum analyzer.

- Procedure**
1. Connect the laser output to the optical spectrum analyzer.
 2. Set the laser wavelength at mid-range of the wavelength specification range listed in section *Technical Specifications*, p. 12.
 3. Set the laser output power to 0 dBm
 4. Configure the optical spectrum analyzer as follows:

Control	Setting
Center wavelength	Same as laser wavelength
Span	20 nm
Resolution	0.1 nm
Reference level	0 dBm
Level scale	10 dB/div
Scan	Repeat

5. Verify that at wavelength deviations larger than 1 nm from the centered wavelength of the laser peak, the power level of any residual emissions is lower than -45 dB down from the peak level.

9.5 Verifying Wavelength and Power Calibration

Subject During the course of the performance verification it is possible that the settings for wavelength and power may not agree with the measured values. If this occurs, you may calibrate wavelength and power settings from the front panel.
To perform the wavelength and power calibration procedures, refer to section *Calibrating the Product*, p. 37.
If the performance does not meet warranted specifications, a complete calibration of the product may be required.
Some calibration steps require the adjustment of internal components including the laser head.
Therefore, a complete calibration must be performed by authorized EXFO staff only.

10. Performing Basic Maintenance Operations

User maintenance of the T100S-HP is limited to the following:

- Cleaning optical connectors for optimum power
- Checking the performance of optical connections and cables
- User calibration (see section *Calibrating the Product*, p. 37)
- Replacing the line fuse



Warning

- To avoid personal injury, do not operate this equipment without the protective cover of the chassis. Do not make any service or maintenance of any kind to the system.
- Do not make any service or maintenance repairs of any kind to the T100S-HP laser head. You must not remove the protective cover of the T100S-HP laser head.

Refer servicing to authorized EXFO personnel only.

10.1 Cleaning and Caring for Optical Connectors and Fibers

Subject



Caution

To optimize the performance of the system and to prevent loss of optical power or damage to the optical connectors, keep the connectors clean at all times.

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

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

Do not over stress or sharply bend optical fiber beyond tolerances specified by the manufacturer.

Handle optical fiber with appropriate care and keep optical connectors free of outside contaminant to preserve optical-signal integrity.

Use the following items to clean the optical connectors:

- clean compressed air
- fiber-optic cleaning swabs
- isopropyl alcohol

Cleaning kits for optical connectors are available from many fiber optic suppliers.

Procedure

1. Hold the can of compressed air upright and spray the can into the air to purge any propellant.
2. Spray the clean compressed air on the connectors to remove any loose particles or moisture.

3. Moisten a clean optical swab with isopropyl alcohol and lightly swab the surfaces of the connectors.
4. Spray the clean compressed air on the connectors again to remove any loose particles or isopropyl alcohol.
5. To clean the internal connector, unscrew the plug, slightly pull it towards you, and clean the internal connector. Then put everything back in place. This operation must be made carefully in order not to damage the internal connector near the fiber cable.

10.2 Cleaning the Product

Subject



Caution

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

The following procedure explains how to clean the T100S-HP product.

Procedure

1. Unplug the power cord from the mains supply before cleaning.
2. Clean the case with a slightly damp cloth with an isopropyl alcohol liquid.

10.3 Replacing the Line Fuses

Before Starting

- Unplug the power cord.
- Make sure you have the following material:
 - Appropriate power fuse (see section *Technical Specifications*, p. 12).



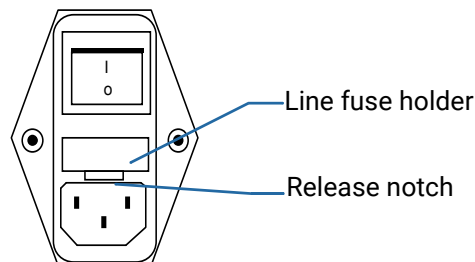
Warning

To avoid fire hazard, only use the correct fuse type, voltage and current ratings (see section *Technical Specifications*, p. 12).

- Small flat-blade screwdriver.

Procedure

1. Insert a small flat-blade screwdriver into the notch just inside the power cord socket of the line filter.



2. Use the notch to pull the fuse holder straight out to remove the fuse.
3. Replace the defective fuse in the fuse holder and snap the fuse holder back into its housing.

10.4 Packaging for Shipment

If you need to return the T100S-HP to EXFO for servicing or calibration, use the original packaging.

For instructions on returning the instrument, please contact EXFO (see section *Contact Information*, p. 4).

11. Error and Warning Messages

Message	Possible Cause	Troubleshooting
WARNING: User calib. Err press "enter"	The user power calibration is not correct (see section <i>Performing Power Calibration</i> , p. 37).	As the user calibration is not valid, the T100S-HP implements the default power calibration value instead.
ERROR: No factory calib. Turn Power off	No factory calibration.	Turn off the system and check the integrity of electrical connections. If this error message shows continuously, please contact the EXFO customer support service (see section <i>Contact Information</i> , p. 4).
VALUE error Press Enter.	The system parameter you are trying to configure is outside the valid range (see section <i>Valid Ranges for Parameter Settings</i> , p. 14).	Press Enter . All changes are discarded and the previous parameter value is restored.
Limit Switch Turn Power off	Mechanical problem.	Turn off the system and immediately contact the EXFO customer support service (see section <i>Contact Information</i> , p. 4).
EEPROM error Turn Power off	Electrical problem.	Turn off the system and contact the EXFO customer support service (see section <i>Contact Information</i> , p. 4).
Referencing Error 1 or 2 Press Enter	The system's internal wavelength referencing operation has failed.	Press Enter to restore the current system settings.
Referencing Warning 1 or 2 Press Enter		Internal wavelength referencing remains unchanged.

Message	Possible Cause	Troubleshooting
λ FEEDBACK:ERR	Active wavelength monitoring does not work properly. Possible causes are:	Press Enter to restore the current system settings. Internal wavelength referencing remains unchanged.
	<ul style="list-style-type: none"> No communication between the T100S-HP tunable laser and the wavemeter. 	<ul style="list-style-type: none"> Check the RS-232 serial connection between the two devices.
	<ul style="list-style-type: none"> The wavemeter may not be compatible with the SCPI command set. 	<ul style="list-style-type: none"> Please contact a EXFO representative for a list of compatible wavemeters.
	<ul style="list-style-type: none"> The wavemeter remote interface may not be configured properly. 	<ul style="list-style-type: none"> Configure the wavemeter serial port with the following parameters: <ul style="list-style-type: none"> RS-232 → ON Baud rate → 9600 Handshaking →None
	<ul style="list-style-type: none"> No optical signal. 	<ul style="list-style-type: none"> Press the Enable key to turn on the laser output
	<ul style="list-style-type: none"> Wavemeter malfunction. 	
DEFAULT Laser Head Overheating	The temperature of the room is too high, the laser is disabled	Switch off the product and make sure the temperature room is lower than 30°C before starting again the product.

Table 13: Error and Warning Messages

Certification and Compliance

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 guide, 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 European Declaration of Conformity is available at www.EXFO.com/en/resources/legal-documentation

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 procedures and contact information, visit the EXFO website at www.EXFO.com/recycle.

China Table of Toxic and Hazardous Substances

CHINESE REGULATION ON RESTRICTION OF HAZARDOUS SUBSTANCES (RoHS)

中国关于有害物质限制的规定

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	0	0	0	0	0	0
Electronic and electrical sub-assembly 电子和电气组 件	X	0	X	0	X	X
Optical sub-assembly ^a 光学组件 ^a	X	0	0	0	0	0
Mechanical sub-assembly ^a 机械组件 ^a	0	0	0	0	0	0

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。

List of Tables

Table 1: T100S-HP – Main Features	12
Table 2: Technical Specifications	13
Table 3: Environmental Specifications	13
Table 4: Valid Range for Parameter Settings	14
Table 5: Available Accessories and Replaceable Parts	14
Table 6: DATA Area – Function Keys	15
Table 7: MODE Area – Function Keys	17
Table 8: SETUP Area – Keys	17
Table 9: Rear Panel Labels	19
Table 10: Active Cavity Control - System Status	35
Table 11: Monitor Output - Signal Levels	49
Table 12: Test Equipment	51
Table 13: Error and Warning Messages	60

List of Figures

Figure 1: Front Panel	15
Figure 2: Rear Panel	18
Figure 3: Possible operating positions (bench-top)	21
Figure 4: Remote Interlock SUBD-9 Connector	23
Figure 5: Wavelength scanning process	29
Figure 6: Instrument Setup for Wavelength Monitoring	39
Figure 7: Wavelength Monitoring Scheme	40
Figure 8: Low frequency modulation setup	44
Figure 9: Resulting LF-modulated diode current	45
Figure 10: High frequency modulation setup	46
Figure 11: Resulting HF-modulated diode current	47

Symbols

- key	17
. key	17

Numerics

2nd + 1	32
2nd + 3	49
2nd + APC	35
2nd + FSC	32
2nd + I	38
2nd + P	37
2nd + STEP	30, 31
2nd key	16
2nd+mW/dBm	41

A

Absolute wavelength accuracy	52
Accessories	14
Active Cavity Control	
Disable/Enable	16, 35
Feature	11
Operating requirements	35
Active wavelength monitoring	39
Preparation	39
Use	40
APC	
Key	16
LED	35
Use	34
Arrow keys	17
Auto-calibration	16, 38

B

Backlash suppression	32
BNC connectors	18

C

Calibration	
Interval	51
Power calibration	37
Wavelength calibration	38
Cleaning	55
Coherence Control	
Enable/Disable	32
Input	48
Connections to instruments	22
Constant-current mode	34
Constant-power mode	34
Current change	36

Current Saturation	47
--------------------------	----

D

DATA area	15
Decrement step	28
Diode current	
Change	36
Cutoff current	44
Saturation current	44

E

Enable key	15
ENTER key	17
Environmental Specifications	13
Error messages	59
External instruments	22
External modulation	43

F

FC/APC	17
Features	11
Feedback function	39
Fine Scanning Mode	16, 28
Fine tuning	28
Front Panel	15
FSC	
Connector	19, 48
Input	19
Key	16
LED	32
Use	28
Wavelength modulation input	48
FSC input	48
FSC use	28
Fuse replacement	56

G

GPIO Connector	19
----------------------	----

H

HF Mod input	19
High Frequency Modulation	46
Hop-free	31

I

I key	16
I output	18, 49
IEEE-488.1 Connector	19
Increment step	28

Initialization	25
Initializing...	25
Inputs	19, 43
Installation	21
Internal modulation	49
Internal Wavelength Referencing	11, 38
L	
Laser	
Disabling	26
Enable	15
Enabling	26
Initialization	25
Shutting down	26
LF Mod input	19
Lim	27, 33
Line fuse	56
Linewidth	48
Low Frequency Modulation	43
M	
MAINS	18
Maintenance	55
Message	
Error	59
Warning	59
Micrometer screw	32
Mod. Out	18, 49
Mod. Sync.	18, 49
MODE area	16
Modulation	
High Frequency	46
Internal Modulation	49
Low Frequency	43
Synchronization Signal	49
Wavelength Modulation	48
Monitor outputs	18, 49
Motor Sync.	49
mW/dBm key	15
N	
nm/GHz key	15
Numeric keypad	17
O	
Operating mode	
Constant-current mode	16
Constant-power mode	16
Manual mode	17
Optical connectors	55
OUTPUT area	17
Output power	
Change	33
Verification	52
Outputs	49
P	
P key	16
P output	18, 49
Package	57
Panel	
Front	15
Rear	18
Parking	26
Pause Timer	14, 29
Performance verification	51
Power	33
Power calibration	37
R	
Rear Panel	18
Remote Interlock	19, 23
Remote key	17
Replaceable Parts	14
Resolution	11
RS-232C Connector	19
S	
Saturation current	47
Scan	
Fine scanning mode	16, 28
Interval	29
Pause Timer	14, 29
Scan step	14
Step-Mode	29
Stop scan	30, 31
Scanning process	29
Self-calibration	38
SETUP area	17
Shutting down	26
Side mode suppression	53
Specifications	12
SSE-noise-free operation	11
Standard Accessories	14
STBY/ON	17
STEP key	16
Step modification	28
Step-Mode Wavelength Scanning	29
Stop scan	30
SUBD-9 connector	19, 23
Sweep	31
Sync. output	18, 49
Synchronization signal	49
T	
Technical Specifications	12
Test preparation	51
Trigger	49
TTL outputs	18, 49
U	
Units	15

V		
Valid range	14	
Verification	51	
W		
Warning messages	59	
Wavelength		
Change	27	
Modulation	48	
		Monitoring
		Range verification
		Sweep
		Wavemeter use
		λ
		λ output
		λ.f key

