THORLABS

LFLTM
Tm-Doped Fiber Laser

Operating Manual

Table of Contents

Chapter 1 Warning Symbol Definitions

Note: Throughout this manual, references to temperature are with respect to °C.

Below is a list of warning symbols you may encounter in this manual or on your device.

Symbol	Description
	Direct Current
	Alternating Current
	Both Direct and Alternating Current
	Earth Ground Terminal
	Protective Conductor Terminal
	Frame or Chassis Terminal
	Equipotentiality
	On (Supply)
	Off (Supply)
	In Position of a Bi-Stable Push Control
	Out Position of a Bi-Stable Push Control
	Caution: Risk of Electric Shock
	Caution: Hot Surface
	Caution: Risk of Danger
	Warning: Visible or Invisible Laser Radiation
	Caution: Spinning Blades May Cause Harm

Chapter 2 Safety

All statements regarding safety of operation and technical data in this instruction manual will only apply when the unit is operated correctly.

SHOCK WARNING

To avoid electrical shock, before powering unit, make sure that the protective conductor of the 3-conductor power cord is correctly connected to the protective earth contact of the socket outlet. Improper grounding can cause electric shock resulting in severe injury or even death. Do not operate without cover installed.

CAUTION

Do not directly look into the fiber key slot. Use a viewing card to safely determine fiber laser output.

WARNING

Avoid Exposure – Invisible Radiation Emitted from Apertures

The unit is supplied North American and European line cords. For all other applications use an IEC 320 compatible line cord fitted with a plug appropriate for your particular AC wall socket.

Make sure that the line voltage rating marked on the rear panel agrees with your local supply and that the appropriate fuses are installed. Changing of the mains fuse can be done by the user (see 4.1 Setting the AC Line Voltage). With the exception of the mains fuses, there are no user serviceable parts in this product.

Do not operate in wet or damp conditions. Do not obstruct the air-ventilation slots in the housing!

This device can only be returned when packed into the complete original packaging, including all foam-packing inserts. If necessary, ask for a replacement package.

Mobile telephones, cellular phones or other radio transmitters should not to be used within the range of three meters of this unit since the electromagnetic field intensity may exceed the maximum allowed disturbance values according to EN50082-1.

Chapter 3 Description

Thorlabs' LFLTM is a Tm-doped Fabry-Perot fiber laser source that provides single mode fiber output and simple laser operation for test and measurement applications. The fiber laser is built using Tm-doped fiber as the gain medium with two fiber Bragg gratings to select the laser wavelength. The LFLTM has an emission wavelength of 1900 nm with an output power >30 mW and a RMS spectral width of <0.2 nm.

The Tm-doped fiber also provides emission in a very broad range from 1800 nm to 2040 nm. Fiber lasers with a custom emission wavelength are available upon request and CW emission with power levels more than 5 mW can be achieved within this entire range. A typical plot showing the typical output power for different fiber laser configurations is provided in Chapter 10.

Laser emission is accessible from a single-mode fiber output with 2.0 mm narrow key FC/APC connector. An optical isolator integrated at the output minimizes the impact of back reflections into the laser cavity. The LFLTM also allows controlling the output power by adjusting the pump laser current level.

The fiber laser operates from an independent, high-precision, low-noise, constant-current source and temperature control unit. An LCD display allows the user to view the parameters for the fiber laser. The user can adjust the driving current of the pump laser to control the fiber laser output power. Each laser is shipped with test data that shows output power scaling as a function of the pump drive current.

This device includes a microcontroller to fully control the fiber laser pump current, temperature, and monitor the system for fault conditions. To prevent damage, the microcontroller will disable the output if the analog input exceeds the system limits.

For added safety, there is an interlock located on the rear panel that must be shorted in order for the output to be enabled. This can easily be configured to be triggered by lab doors to disable the fiber laser in unsafe conditions. The power switch is a key-lock system to prevent accidental or unwanted use. An enable button must be set to activate the unit with a green LED indicator to easily determine its current state. There is a 3 second delay before the fiber laser turns on, and the user is warned by the rapidly blinking LED.

The laser includes a universal power supply that is rated for 100 to 240 VAC without the need for selecting the line voltage. This unit is supplied with a US line cord as well as a standard European line cord. The fuse access is conveniently located on the rear panel.

3.1. Shipping List

The LFLTM consists of the following components:

- Benchtop Laser Source
- AC Power Cord
- 2 m USB Type A to Type B Cable
- Fiber Cleaning Card
- This Manual

Chapter 4 Setup

4.1. Setting the AC Line Voltage

The fiber laser has been shipped with a power supply rated for 100 to 240 VAC. There is no end user adjustment of the line voltage for 110 or 220 VAC. A region-specific power cord ships with the purchased unit.

4.2. Changing the Fuse

To change the power fuse, follow the following steps.

1. Remove the AC power cord if it is connected to the unit.
2. Locate the fuse tray directly below the AC power cord connection on the rear panel of the unit.
3. Carefully use a flat blade screwdriver to open the fuse tray.
4. Remove the existing fuse and install the appropriate 500 mA fuse. The replacement fuse must be a 5 mm x 20 mm, 250 VAC Type T Fuses (IEC 60127-2/III, low breaking capacity, slow blow)
5. Push the fuse tray back into place making sure that it snaps and seats correctly.
6. Connect the appropriate power cord into the AC receptacle and plug the unit in.

4.3. Initial Set-Up

1. Set the unit on a dry, level working surface.
2. Make sure the POWER key switch on the front of the unit is in the OFF position (key perpendicular to working surface).
3. Plug the female end of the AC line cord provided into the AC Input Receptacle on the rear of the unit. Plug the male end into a properly grounded AC socket.
4. Install the interlock pin; see page 8 for details.
5. Connect a FC/APC fiber optic cable to the laser output connector on the front panel of the unit. We recommend using Thorlabs SM2000 series fiber patch cables to achieve the best coupling efficiency, more quality, and transmission.

Chapter 5 Operation

5.1. Front and Back Panel Overview

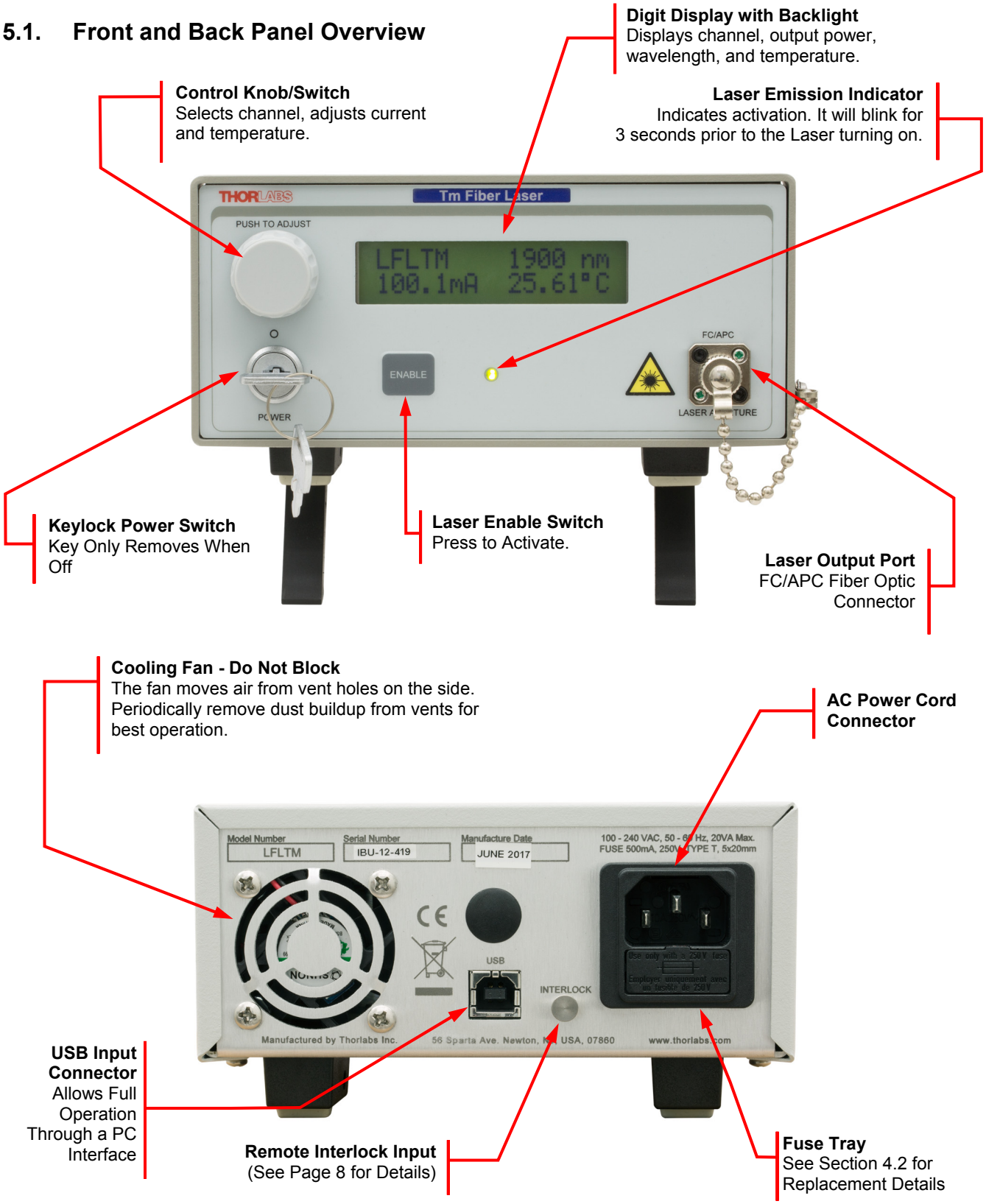


Figure 1 Front and Rear Panels of Laser Source

5.2. Turning On the Source

1. Please consult with your organization's laser safety officer regarding proper operation of the laser at your institution. Thorlabs recommends laser safety glasses with an OD of 5+ at the emission wavelength of the laser.
2. Turn the POWER key switch clockwise. The LCD display will scroll "Thorlabs" across the screen, followed by the software revision number.
3. Make sure the Interlock Input is short-circuited; see page 8 for detailed instructions.
4. Press and release the ENABLE switch to activate the fiber laser. There will be an approximately 3 second delay before the fiber laser powers up. During this time the ENABLE indicator will light up and blink rapidly.
5. Fiber laser power (mW) and thermo-electric cooler readings will be activated when the unit turns on. The temperature will typically require 1 to 2 minutes to stabilize.

5.3. Viewing Information

The LFLTM uses a single four quadrant LCD to display and access information. At any time, display variables can be adjusted by simply rotating the control knob located to the left of the display. The following information will be available:

- Top left – Indicates device type (LFLTM).
- Top Right – Indicates the nominal wavelength of the fiber laser internal to the LFLTM.
- Bottom Left – a current reading in (mA) will be indicated.
- Bottom Right – Indicates the actual temperature the pump is stabilized to and is displayed in °C. The system defaults to a temperature that is set at the factory. The temperature control is always active and may require 5 to 10 minutes to fully stabilize.

5.4. Adjusting the Fiber Laser Output Power and Temperature

Note: The adjustment knob utilizes an intelligent speed control. Adjusting the knob slowly will increment values at the maximum resolution while adjusting fast will make larger movements. This allows both a fine and course control.

1. The bottom left location will start blinking and will change to current, ex: xx.xx mA, when the control knob is pressed. Adjust the control knob until the desired current is achieved. Adjusting the knob clockwise will increase the pump diode drive current incrementally to the max operating current. Adjusting the knob counter clockwise will incrementally decrease the current. Please refer to the L-I plot provided in the data-sheet and shipped with the laser in order to determine how the output power scales with the drive current. On system shut down, the current setting will be remembered.

Note that there is a timeout on the display, after which the display will revert back to the viewing mode. This is to prevent accidental adjustment of the power.

2. Press the knob again to switch to temperature adjustment to change the temperature of the pump diode. The set point temperature will be displayed and will be blinking; for example, 25.00 °C. Adjust the control knob to increase or decrease the temperature set point. The temperature is set to a default value at the factory but can be adjusted over a range of 20.00 to 30.00 °C with a resolution of 0.01 °C. Please note that for optimal operation of the fiber laser and to maximize the output power, the pump diode temperature is set to a value at the factory, which is provided in the data-sheet shipped with the laser. Changing the diode temperature from this optimal value can significantly reduce the output power below its specified value.

Note, as above there is a timeout where the display will revert to the viewing display and lock out adjustment to the temperature.

3. Pressing the control knob again will exit the adjustment mode and revert back to the viewing mode, locking in the selected parameters. This can also be achieved by allowing the display to time out at any point in the process. The power display will adjust real-time to its new current setting and depending on the magnitude of the change in temperature set point, it will take anywhere from a few seconds to a few minutes for the system to settle into the new operating temperature.

5.5. Turning the Fiber Laser Off

- **Standby Mode** – By adjusting the control knob fully counterclockwise the current/power will adjust down to the threshold current and then to standby mode. The threshold current is a user settable point at which the internal laser diode can be set to operate within a desirable range. For convenience the system is set up to adjust from the threshold to the max current. In addition, when adjusting below the threshold, the current will be set to almost 0 mA. Since the system utilizes a constant current control, there will always be a minimum current to maintain the current control loop. The output emission is typically very low, or nonexistent. The fiber laser is still enabled and operating at the minimum possible current
- **Disable/Enable Mode** - The laser output should be turned off by pressing and releasing the ENABLE switch. The laser diode temperature will be maintained even when the laser is disabled.
- **Power Down** - When completely powering down an enabled unit, first press and release the ENABLE switch and then turn the POWER key switch counterclockwise, which will turn OFF the entire unit. Anytime the unit is turned OFF and then turned back ON, the fiber laser will be disabled until the ENABLE switch is pressed.

Chapter 6 Making the Safety Interlock Connections

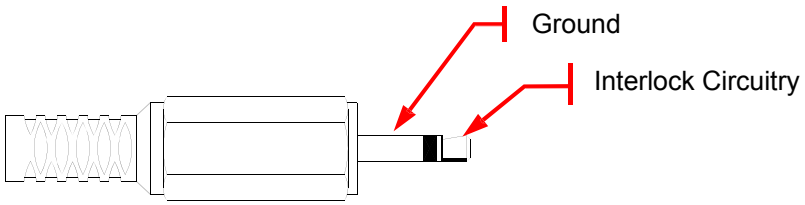
The LFLTM series laser source is equipped with a remote interlock connector located on the rear panel, see Figure 1, Page 5.

In order to enable the laser source, a short circuit must be applied across the terminals of the Remote Interlock connector. In practice this connection is made available to allow the user to connect a remote actuated switch to the connector (i.e. an open door indicator). The switch (which must be normally open) has to be closed in order for the unit to be enabled. Once the switch is in an open state the laser source will automatically shut down. If the switch returns to a closed condition the laser source must be re-enabled at the unit by pressing the ENABLE switch. All units shipped from Thorlabs are configured with a shorting device installed in the Interlock connector.

If you are not going to use this feature then you can leave the shorting device installed and the unit will operate normally as described in the procedures above. If you wish to make use of the Interlock feature you will need to acquire the appropriate connector mate and wire it your remote interlock switch. Next, remove the shorting device by pulling it out with a pair of needle nose pliers and install the connector into the interlock input.

To use the interlock feature, a Normally Open (N.O.) switch needs to be used. Closing the switch closes the circuit, which enables the laser. The interlock input only accepts a 2.5 mm mono phono jack. This connector is readily available at most electronics stores. The electrical specifications for the interlock input are shown in the following table.

Specification	Value
Type of Mating Connector	2.5 mm Mono Phono Jack
Open Circuit Voltage	Internal Pull Up to 5 VDC
Short Circuit Requirements	1.0 mA DC
Interlock Switch Requirements	Must be N.O. Dry Contacts Under No Circumstances Should any External Voltages be Applied to the Interlock Input



Chapter 7 Remote Communications

7.1. Installing the USB Drivers

Prior to running the command line interface, the USB drivers must be installed. The LFLTM must not be connected to the PC while installing the drivers. These drivers are provided on the included USB memory stick and can also be downloaded from the Thorlabs website (www.thorlabs.com). Run the executable file and follow the onscreen prompts to install the drivers. When this completes, attach the LFLTM to the PC and power it on. Your PC will then detect the new hardware and will prompt you when the installation is complete.

7.2. Command Line Interface

Once the USB drivers have been installed, the unit connected to the PC, and the power turned on, configure the terminal emulator as follows:

- Baud Rate = 115.2K Bits Per Second
- Data Bits = 8
- Parity = None
- Stop Bits = 1
- Flow Control = None

If the connection is correct you will see the following after pressing the “Enter” key.

Command error CMD_NOT_DEFINED

Followed immediately by the prompt:

<

The basic structure of the interface is a keyword followed by either an equals sign “=” or a question mark “?”. The “=” or “?” will determine if the string is a command or a query. All strings (commands and queries) must be terminated by a carriage return (CR) or pressing the ENTER key on the computer.

The command structure is as follows:

Keyword = argument (CR)

Where “keyword” defines the function and “argument” is a numerical value followed by a carriage return (CR). See listing below.

The query structure is a follows:

Keyword? (CR)

The “keyword” defines the function and the question mark (?) indicates a query. The string is terminated with a carriage return (CR). See listing below.

There are a few exceptions to this which are noted below, also noted are unique shortcut keys.

The prompt symbol “<” will appear on power up and after a command is accepted by the system indicating it is ready to receive another command line.

7.3. Keywords (Commands and Queries)

The following list shows all of the available commands and queries, and summarizes their functions:

Command	Syntax[1]	Description
Get ID	id?	Returns the model number and firmware version.
Get Commands	?	List the available commands
Set Target Temp.	target=*n*	Sets the target temperature in degrees Celsius.
Get Target Temp.	target?	Returns the target temperature.
Get Actual Temp.	temp?	Returns the actual temperature.
Set Current	current=*n*	Sets the current (*n*).
Get Current	current?	Returns the current.
Get Power	power?	If diode package contains a monitoring photodiode, returns the output power in mW.
Get Enable	enable?	Returns the current state of the Enable button.
Set Enable	enable=*n*	Sets the state of the Enable button (0: disabled, 1: enabled).
Get Specs	specs?	Returns the specifications.
Set Step	step=*n*	Sets the increment (*n*) used to adjust the temperature and current when the arrow keys are pressed.
Get Step	step?	Returns the increment used to adjust the temperature and current when the arrow keys are pressed.
Save Parameters	save	Saves target current and target temperature to EEPROM. Values are restored on device startup.
Get Status	statword?	Returns a string representation of an 8-bit number indicating the device's status. The right-most bit is '1' if the device is 'on' or 'pending on'. The other bits are unused.

If the keyword, format, or argument is incorrect or out of range, the unit will return an error string. The function is determined by the value set with the mode command in the above table.

In addition to the above commands there is also special functionality added to the arrow keys of the computer's keyboard.

- Up Arrow Key – Increments the current by *n*.
- Down Arrow Key – Decrements the current by *n*.
- Right Arrow Key – Increments the temperature by *n*.
- Left Arrow Key – Decrements the Temperature by *n*.

Where *n* is set by the command "Set Step".

[1] *All commands and queries are in lower case letters.*

Chapter 8 Troubleshooting

The following table describes some typical problems that may be encountered while using the LFLTM and possible solutions to these problems.

Problem	Solution
Unit does not turn on when switching the power switch to the ON position.	1. Make sure AC line cord is fully inserted into the AC Input receptacle and plugged into an outlet providing 100 to 240 VAC. 2. Fuse(s) may be open. Refer to Page 4 for information on replacing open fuses. If the problem persists, please return the unit to Thorlabs for evaluation.
Unit does not enable the Source when pressing the ENABLE keypad.	1. Make sure that the AC Line Cord is properly plugged in and Key Switch is turned to “ON” position 2. Check to make sure the interlock “jumper” is installed on the rear panel. See Page 8 for details.
Unit is enabled but there is no Output.	1. Check to make sure you are using the correct type of Fiber Patch Cord for the particular wavelength. 2. Disconnect the Fiber Patch Cord and check to see if there is Light Output from the FC/APC Connector. **Caution: Do Not Directly Look into the Fiber Key Slot.** Use a Viewing Card to safely determine fiber laser output.
I can’t connect to the LFLTM over the USB com port.	1. Make sure that the com port is configured correctly for the unit. Refer to page 9 for the correct com port settings. 2. The incorrect com port is selected on your terminal program or LFLTM application. 3. USB driver was not installed (see page 9).

Chapter 9 General Maintenance

Aside from the AC Input fuse there are no user serviceable parts in this product. If you suspect something has failed on the unit, please contact Thorlabs for advice on returning the unit for evaluation. Always clean fiber optic connectors that will be inserted into the system and install the dust cap whenever the source is not being used. Allowing dust and dirt into the fiber ports will degrade coupling efficiency and possibly damage the fiber patch cords, both inside and outside. If you suspect this to be true, Thorlabs can clean and inspect the fiber connections, and repair if necessary.

9.1. Cleaning

The unit can be cleaned using a soft, slightly damp cloth. Avoid using any solvents on or near the unit. Keep the vent holes located on the bottom of the unit and on the rear panel free of dust buildup. Restricted airflow will cause the temperature controls to operate inefficiently and in extreme cases, lose temperature control.

9.2. Connector Cleaning

Always clean the ferrule end of your fiber patch cable prior to inserting it into the output FC Adapter. Your benchtop source comes with a fiber-cleaning card. This should be used before inserting the fiber connector into the mating barrel.

Figure 2 Fiber Cleaning Card

To use the card, peel back and tear away one small blue strip. Holding the connector firmly, swipe the connector tip across the exposed cleaning strip. The connector tip should be flush to the card surface for FC/PC connectors and at a slight angle with the key straight up for FC/APC connectors.

Chapter 10 Specifications

Item #	LFLTM		
Parameter	**Min**	**Typical**	**Max**
Emission Wavelength	1898 nm	1900 nm	1902 nm
Instantaneous Linewidth (RMS)	-	-	200 pm
Drive Current	-	-	450 mA
Output Power at Max Drive Current[2]	30 mW	-	40 mW
Polarization	Random		
Power Stability (Ambient Temperature ±2 °C)	<±2% over 24 Hours (After 15 min Warm-Up)		
Relative Intensity Noise (RMS, 10 Hz - 1 MHz)[3]	<0.5%		
Output Fiber Type	SM2000		
Output Fiber Mode Field Diameter	13 ± 1 µm @ 1996 nm		
Output Fiber NA	0.11		
Output Fiber Connector	2.0 mm Narrow Key FC/APC		

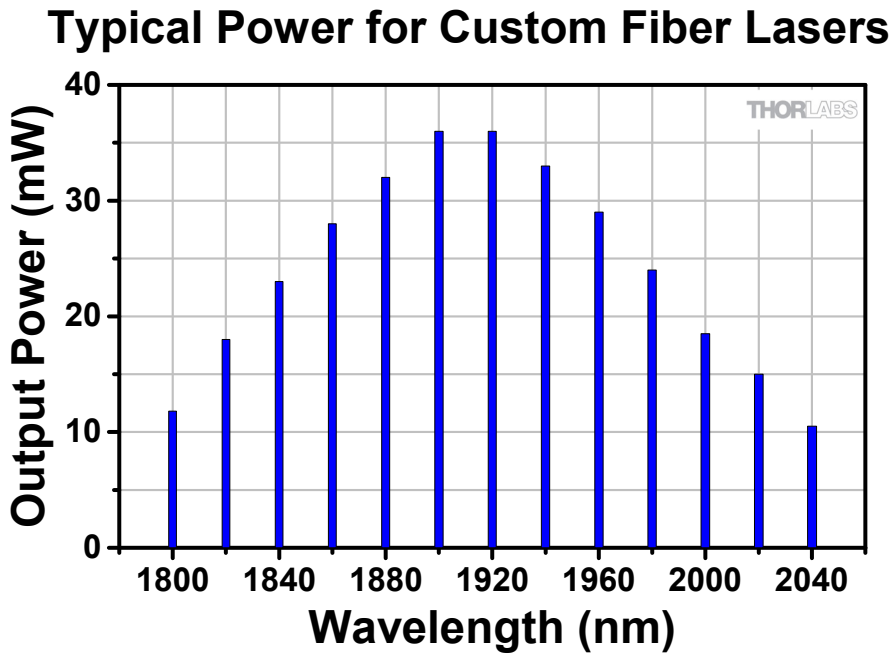


Figure 3 Selection of Possible Emission Wavelengths for Custom Fiber Lasers

[2] *The output power is specified for emission at 1900 nm measured with SM2000 delivery fiber.*

[3] *Multiple longitudinal modes exist within the linewidth of the laser that are separated by more than 100 MHz. The beating between these modes can create additional noise at frequencies >100 MHz.*

General Specifications	
AC Input	100 - 240 VAC, 50 - 60 Hz
Input Power	20 VA Max
Fuse Ratings	500 mA
Fuse Type	IEC60127-2/III (250 VA, Slow Blow Type 'T')
Fuse Size	5 mm x 20 mm
Dimensions (W x H x D)	5.77" x 11.43" x 2.60" (146.5 mm x 290.3 mm x 65.9 mm)
Weight	1.96 kg (4.32 lbs) 4.13 kg (9.1 lbs) Shipped Weight
Operating Temperature	15 to 35 °C
Storage Temperature	0 to 50 °C
Connections and Controls	
Interface Control	Optical Encoder with Pushbutton
Enable Select	Keypad Switch Enable with LED Indicator
Power On	Key Switch
Fiber Port	FC/APC, 2.0 mm Narrow Key
Display	LCD, 16x2, Alphanumeric Characters
Input Power Connection	IEC Connector
Interlock	2.5 mm Mono Phono Jack (See Chapter 6)
Communications	
Communications Port	USB 2.0 Compatible
Com Connection	USB Type B Connector
Required Cable	2 m USB Type A to Type B Cable (Replacement Item # USB-A-79)

Chapter 11 Mechanical Drawing

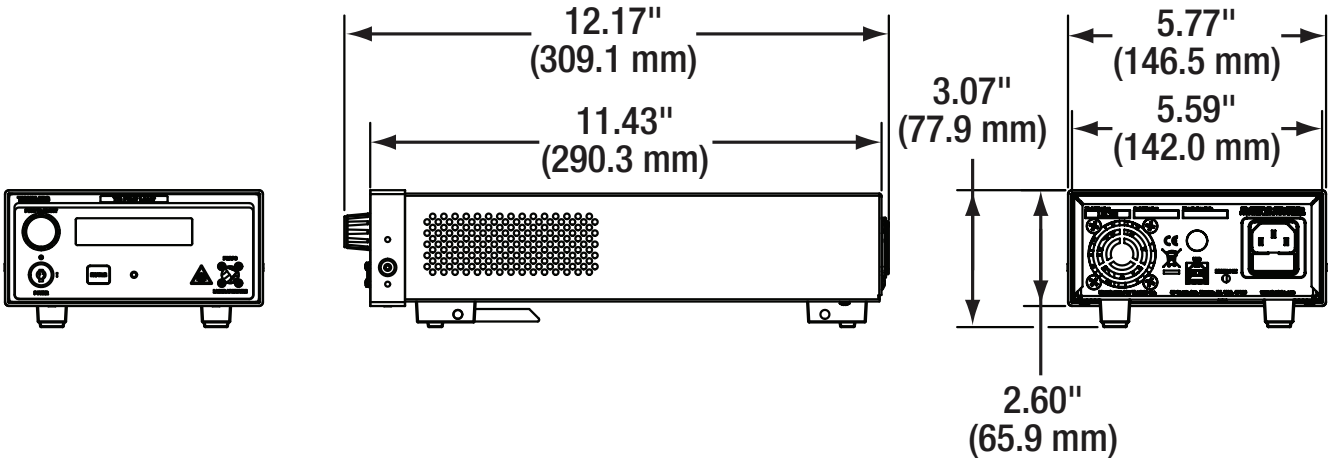
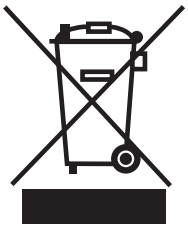


Figure 4 Mechanical Drawing

Chapter 12 Regulatory

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return “end of life” units without incurring disposal charges.

- This offer is valid for Thorlabs electrical and electronic equipment:
- Sold after August 13, 2005
- Marked correspondingly with the crossed out “wheelie bin” logo (see right)
- Sold to a company or institute within the EC
- Currently owned by a company or institute within the EC
- Still complete, not disassembled and not contaminated



Wheelie Bin Logo

As the WEEE directive applies to self-contained operational electrical and electronic products, this end of life take back service does not refer to other Thorlabs products, such as:

- Pure OEM products, that means assemblies to be built into a unit by the user (e. g. OEM laser driver cards)
- Components
- Mechanics and optics
- Left over parts of units disassembled by the user (PCB’s, housings etc.).

If you wish to return a Thorlabs unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.

Waste Treatment is Your Own Responsibility

If you do not return an “end of life” unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

Ecological Background

It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE directive is to enforce the recycling of WEEE. A controlled recycling of end of life products will thereby avoid negative impacts on the environment.

Chapter 13 Declaration of Conformity

EU Declaration of Conformity

in accordance with EN ISO 17050-1:2010

We: Thorlabs Inc.

Of: 56 Sparta Avenue, Newton, New Jersey, 07860, USA

in accordance with the following Directive(s):

2014/35/EU	Low Voltage Directive (LVD)
2014/30/EU	Electromagnetic Compatibility (EMC) Directive
2011/65/EU	Restriction of Use of Certain Hazardous Substances (RoHS)

hereby declare that:

Model: ***LFL2700, LFL2700-5, LFL2700-10 and LFLTM***

Equipment: ***2.7 um cw laser source***

is in conformity with the applicable requirements of the following documents:

EN 61010-1	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use.	2010
EN 61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2013
EN 60825-1	Safety of laser products	2014 3rd...
Title47 Part15(B)	FCC Telecommunication	2016

and which, issued under the sole responsibility of Thorlabs, is in conformity with Directive 2011/65/EU of the European Parliament and of the Council of 8th June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, for the reason stated below:

does not contain substances in excess of the maximum concentration values tolerated by weight in homogenous materials as listed in Annex II of the Directive

I hereby declare that the equipment named has been designed to comply with the relevant sections of the above referenced specifications, and complies with all applicable Essential Requirements of the Directives.

Signed: *On:* 02 June 2016

Name: Ann Strachan

Position: Compliance Manager *EDC - LFL2700, LFL2700-5, LFL2700-10 an...*

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Chapter 10 Thorlabs Worldwide Contacts

For technical support or sales inquiries, please visit us at www.thorlabs.com/contact for our most up-to-date contact information.

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UNLEASHED